ICATCE

ICATCE 2022
1ST INTERNATIONAL CONFERENCE ON ADVANCED TECHNOLOGY IN CHEMICAL ENGINEERING

PROCEEDINGS
Volume 1
07 September 2022

https://icatce.com

PREFACE

Dear all participants,

Welcome to the 1st International Conference of Advance Technology in Chemical Engineering 2022. First of all, I would like to express my highest appreciation to Kemendikbud Ristek (Ministry of Education, Culture, Research and Technology) by Program Kompetisi Kampus Merdeka (PKKM) who generously help us so that the conference and the proceeding can be conducted. Special thanks for Mr. Agtisa who also support this conference.

A deepest gratitude is also given to Department of Chemical Engineering Universitas Muhammadiyah Jakarta, Department of Chemical Engineering Universitas Pamulang, Department of Chemical Engineering Universitas Bhayangkara for their sincere commitments to the conference.

The main topic for the conference is "Advance Material and Sustainable Engineering". Through this proceeding, I hope we can share ideas, and increase our students' knowledge about recent technology in chemical engineering. Thank you to all the invited speakers who have allocated their time to share knowledge and experiences in this event, and review all the papers for the proceeding. The invited Speaker topics presented are as follows

1. Prof. Osamu Niwa (Japan) : Metal Nanoparticles Modified Carbon Film Electrodes for Electrocatalytic Oxidation of Sugars and Alcohols
2. Prof. Hwai Chyuan ONG (Taiwan) : The Production of Microalgal Biochar and Its By-Product Using Thermochemical Conversion
3. Dr. Mochamad Chalid (Indonesia) : Roles of Polymer Engineering in Material Sustainability
4. Prof. H. J. Heeres (Netherland) : Fast Pyrolysis: A Promising Technology for Renewable Carbon Conversions)
5. Prof. Wan Azmi Bin Wan Hamzah (Malaysia) : Development of Advanced Technology in Nanofluids and International Research Collaboration Opportunities

I also honour all the paper presenters for participating in the parallel session. Last but not least, I would like to express a special acknowledgement to all scientific committees and the organizing committees for their time, efforts and contributions to this event. I hope this conference and proceeding are beneficial for all of us. we apologize if there are mistakes during the conference and the proceeding.

Best regards,
Prof. Dr. Ir. Joelianingsih, MT
Chairman of Organizing Committee

COMMITTEE

Indonesia) (ID Scopus 57212103892)
2. Yuri Delano Regent Montororing, S.T., M.T (Universitas
   Bhayangkara Jakarta Raya - Indonesia) (ID Scopus 57444985300)

Keynote Speaker **:** 1. Prof. Osamu Niwa (Jepang)
2. Prof. Hwai Chyuan ONG (Taiwan)
3. Dr. Mochamad Chalid (Indonesia)
4. Prof. H.J Heeres (Belanda)
5. Prof. Wan Azmi Bin Hamzah (Malaysia)

Secretary : Rita Fatimah Nuraini, S.KM

Financing Committe : Rini Andryani, S.T

Event Division
Coordinator : Dr. Ir. Kudrat Sunandar, M.T
Member : Adam Malik. S.T
   Budhi Indrawijaya, S.T., M.Si (Unpam)Ika
   Kurniaty, S.T., M.T (UMJ)

Administrator
Coordinator : Muhammad Ramli, S.T
Member : Yana Mulyana, S.Kom

Sponsorship
Coordinator : Dr. Ir. Sidik Marsudi, M.Si., IPM
Member : Ummul Habibah Hasyim, S.T., M.Eng (UMJ)

TABLE OF CONTENTS

PARALEL SESSION

**INTERNATIONAL CONFERENCE ON ADVANCED TECHNOLOGY
IN CHEMICAL ENGINEERING 2022**

TIME	ROOM A	NAME	TITLE
Moderator: Dr. Eng. Joni Prasetyo, M.T (UNPAM)			
14.10 - 14.25	A1	Suhendar I Sachoemar	Dissemination of Sustainable Integrated Multi Tropic Aquaculture (IMTA) as a Sato Umi Model to Improve Productivity and Environment of the Indonesian Coastal Area
14.25 - 14.40	A2	Yuri Delano Regent Montororing, S.T., M.T	Experimental Design Model to Reduce The Number of Emulsion Polymer Products Reject at PT. AHP
14.40 - 14.55	A3	Prof. Dr. Ir. Tri Yuni Hendrawati	The Effect of Comparative Materials and Solutions on The Levels of Avocado Leaf Extract Flavonoids (Persea americana mill)
14.55 - 15.10	A4	Fahrurrozi	The Effect of Additional Aloe Vera Flour on The Physical Properties of The Organoleptic Body Scrub of Cucumber
15.10 - 15.25	A5	Zakki Rosmi Mubarok, S.Si., M.T	Effect of Additional Bean Sprouts Extract on The Fermentation Time of Tempe Modification of Citric Acid
15.25 - 15.40	A6	Dr. Kudrat Sunandar, S.T., M.T.	Temperature Effect On Rami (Boehmeria Nivea L) Fibre-Based Nitrocellulose Synthetic
15.40 - 16.00	**Question and answer**		

TIME	ROOM B	NAME	TITLE
Moderator: Ika Kurniaty, S.T., M.T (UMJ)			
14.10 - 14.25	B1	Dwi Aprilliah	Analysis of Physical and Mental Workload on Finishing Operator using Nasa – Tlx Method And Work Sampling at PT. Passion Abadi Korpora
14.25 - 14.40	B2	Enjerika Kristivani	Business Feasibility Study of Manufacturing Paving Blocks From Plastic and Paper Waste
14.40 - 14.55	B3	Reza Putra Tanwey	Financial Risk Analysis of Bank BNI Persero (Tbk) Using Altman Z Score

TIME		NAME	
14.55 - 15.10	B4	Maika Putri	Utilization of Durian Pell Waste as Bio Absorbent for Lead (Pb) Removal in Battery Industrial Waste
15.10 - 15.25	B5	Alya Mutia Maharani	Quality Improvement using Six Sigma Method to Reduce Defects of Office Partition Products at PT. Inspira Multi Karya
15.25 - 15.40	B6	Dr. Ir. Sri Handayani, M.T	Economic Feasibility Study of MgSO4 From Saline Water Waste
15.40 - 16.00	Question and answer		

TIME	ROOM C	NAME	TITLE
Moderator: Ir. Linda Aliffia Yoshi, S.T., M.T (ITI)			
14.10 - 14.25	C1	Helmi Kharomatul Ambia	Analysis of Application of Material Requirement Planning (Mrp) in Helmet Production using Bill of Material (Bom) to Helmet And Bill of Material (Bom) Versus Pre Order Approach at PT. Poliprima Cipta Unggul
14.25 - 14.40	C2	Andre Frensiski Sinamo	Analysis of Physical And Mental Workload on Mechanical Employees at PT. Global Sawit Semesta
14.40 - 14.55	C3	Mad Yusuf	Analysis of Workload on Cutting Operator using Nasa - Tlx Method and Work Sampling in Cv Mulya Jaya Abadi
14.55 - 15.10	C4	Silvia Aprilingga	Strategy to Increase The Competitiveness of Production of Jamkrindo KCK Jakarta People's Business Credit Guarantee (KUR) using SWOT Analysis and QSPM Methods
15.10 - 15.25	C5	Rafi Muhammad Pasha	Determination of Ergonomic Assessment Method to Identify and Assess Ergonomic Hazards in Milling Activities that cause MSDS in PT. Putra Masa Depan
15.25 - 15.40	C6	Aulia Rahmadani, Muhammad Roofi	Raw Material Control for Packaging Coating Process with Economic Order Quantity (EOQ) Approach Method at PT. XYZ
15.40 - 16.00	Question and answer		

EXPERIMENTAL DESIGN MODEL TO REDUCE
THE NUMBER OF EMULSION POLYMER PRODUCTS REJECT AT PT. AHP

Yuri Delano Regent*, Mohamad Fajri
Engineering Faculty, Bhayangkara Jakarta Raya University, Indonesia
*yuri.delano@dsn.ubharajaya.ac.id

Abstract.
PT AHP is a chemical industry with the main product of emulsion polymer. The problem faced is the inconsistent product quality, especially the GP 31XXC product. PT AHP must immediately take action to reduce problem products, and increase productivity. The purpose of this study was to identify the cause of the problem, provide suggestions for improvement, and find out the decline in the no-good GP 31XXC product after repairs were made. This study uses an experimental design method, with SPSS17.0 statistical analysis. The results of the application of the experimental design show that the cause of the problem with the GP 31XXC product is the technical production process, namely, the cooling temperature parameters, feeding starting temperature, and inappropriate observation time. Proposed improvements made are changes to standardization and validation of temperature and time parameters. The cooling temperature is to 95°C - 96°C, the starting temperature is feeding on 80°C to 89°C, and the observation time is from 90 minutes - 120 minutes to a minimum of 93 minutes. The decline in the GP 31XXC no-good product after repairs were made was 90%, from 10 batches to 1 batch.

Keywords: *chemical industry, emulsion polymer, quality, experimental design.*

Introduction

PT AHP is a manufacturing industry whose main products are emulsion polymer, textile sizing powder, alkyd resins, acrylic resins, and car care products. To be able to produce consistent product quality can be achieved with a series of appropriate and effective process controls. Based on observations, it is known that there are still a large number of no-good products.

Table 1. *No-good product data 2019 – 2021*

No	Years	Reject Batch	GP31XXC Reject Batch	Percentage
1	2019	104	15	14%
2	2020	123	17	14%
3	2021	32	10	31%

Source: PT. AHP (2021)

Based on Table 1. GP 31XXC reject products have increased. In the period 2019 and 2020, GP 31XXC products accounted for 14% of the batch of total no-good products. Then the 2021production GP 31XXC accounted for 31% of the total batch of no-good products.

Table 2. *No-good batch measurement results*

Batch	%TS Initial (32.19-33.19)	%TS End of Aging (>=57)	%TS After P (>= 55)	%TS Final (55-57)	Particle size (0,210-0,235 μ)	Appearance	Status
876001	33.12	55.33	55.58	55.58	0.3170	White	NG
876002	32.83	56.96	56.30	56.08	0.2429	White	NG
876004	32.12	57.71	56.35	55.91	0.2487	White	NG
876005	31.89	56.98	57.57	56.34	0.2606	White	NG
876006	32.03	56.65	56.40	56.30	0.2603	White	NG
876007	32.18	57.68	56.33	55.74	0.2476	White	NG
876008	31.18	56.68	56.13	56.00	0.2487	White	NG
876010	30.74	56.60	55.62	55.77	0.2441	White	NG
876012	31.29	56.67	56.49	56.49	0.2545	White	NG

Based on table 1 and table 2, PT AHP should take quick action to deal with no-good products, and increase productivity. Corrective actions need to be taken because the target for no-good products in the last three years has fluctuated, so the improvements made do not take place continuously. To find out the root of the problem above, we need an appropriate method to be able to find out the root of the problem caused by the appearance that is not up to standard, as well as looking for alternative actions to reduce the level of no-good products in this company so that the target for no-good products can be achieved with permanent and continuous improvements. continuously.

The type of problem that often occurs in GP 31XXC products is a mismatch in appearance, which is white while the standard is milky white to bluish. The appearance obtained is influenced by the particle size value, if the particle value is more than the standard, the appearance is not standard, namely white. If this problem occurs, it is necessary to carry out a rework process so that the product can be adjusted to the standard. For this reason, the author intends to implement improvements by applying the basic steps of experimental design at the stage of the GP 31XXC product process with the aim of reducing the level of no-good products and hoping that it will have a positive impact on the company.

The aims of this research is to Identify the biggest possible cause of the problem with the GP 31XXC product, Provide suggestions for improvement with the aim of reducing the level of no-good GP 31XXC products, and knowing the problem of the GP 31XXC product decline after repairs were made with the experimental design method.

Results

This section describes the initial data collection of the GP 31XXC production process. Researchers took data on the production process carried out at PT AHP. The order of work, work steps, and how long the production process takes GP 31XXC. In the production process of the GP 31XXC, the process operator is provided with a work instruction sheet or generally called work instructions. Work instructions contain instructions and work steps and process parameters. Each production operator follows the instructions contained in the description of the work instructions and product formulas. However, in the production process, there are still process discrepancies or problems with the final product. The discrepancies found in the final product are viscosity, pH, appearance, product application, and product particle size.

The initial data collection of the suitable and unsuitable GP 31XXC production process was taken randomly to analyze the problem. This data will be used as a reference for comparison of the actual process. GP 31XXC process data collection by searching for past data stored in the production and quality control data files. Looking to collect and summarize other data related to the production process of the no-good GP 31XXC.
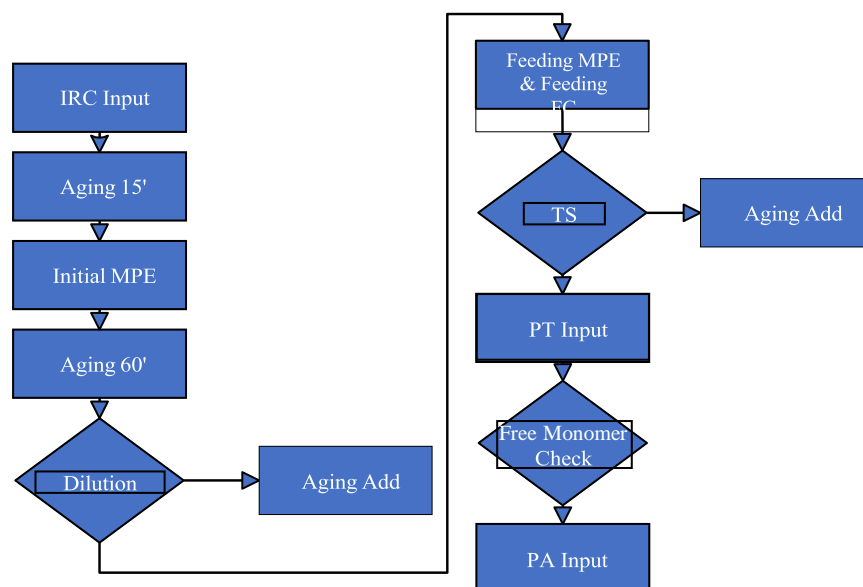

Figure 1. *GP 31XXC process flowchart*
Source: PT. AHP (2021)

Table 3. Physical properties and aplication test

Batch	Catalis Initial Temp(°C)	MPE Initial Temp(°C)	Feeding Start Tempt(°C)	Cooling Temp (°C)	Catalis Initial RPM	MPE Initial RPM	Feeding Start RPM	Catalis Initial Time (Minuts)	MPE Initial Time (Minutes)	Feeding Start Time (Minutes)
HA876001	79.3	78.7	89.6	93.0	23	27	23	10	12	93
HA876002	77.5	76.8	90.4	91.5	23	27	25	10	12	95
HA876004	77.6	77.2	85.0	93.8	23	25	25	10	12	94
HA876005	77.3	76.8	91.7	92.0	23	25	23	10	12	115
HA876006	77.1	76.9	79.9	92.0	23	27	23	10	12	98
HA876007	78.2	77.8	72.6	92.0	23	27	23	15	17	115
HA876008	77.7	77.6	85.9	93.0	23	27	23	10	12	98
HA876010	78.4	77.7	86.1	93.0	23	27	23	10	12	88
HA876012	76.0	75.7	88.2	90.2	23	27	23	10	12	93

Source: PT. AHP (2021)

a. GP 31XXC Problem Analysis

Analysis of the problem in this study was carried out using the 5 why method to find outthe causal relationship that became the root cause of the problem of product appearance discrepancies that emerged. The factors in table 4 are very influential on the results of the process. Based on the 5 why analysis that was reviewed, problems were found in the environment, machines, methods, and humans. However, the problems found can be resolved immediately, except for the method, namely the technical process method. So it is necessaryto take corrective action, namely validation and standardization of technical processes. However, to know in detail the technical parameters of the process that affect the problems that occur, further analysis is needed using failure mode and effect analysis (FMEA).

Table 4. GP 31XXC Analysis problem

Faktor	Why1	Why2	Why3	Why4	Why5	Action
Environment	Dirty reactor	Leftovers from previous products	Non-standard washing method	Non-standard cleaning tools	*Different cleaning operator skills*	Standardizationof cleaning methods, tools and operators
Machine	Reactor problem	Vibrating agitator	Mixing is not optimal	Unstable rpm rotation and noise	Teflon axle is thinning due to erosion	*Preventive Maintenance routine*
Method	Formula	Process technique is not detailed	Process parameters do not match	temperature and time	Improved temperature and time parameters	Validation and Standardization
Man	Not all operator process technical according to standard	Skills are not the same	Knowledge and not the same experience	Socialization of work instructions	Provided internal training	Operator assessment
Material	Main and supporting raw materials	No change in quality	No change in quality	No change in quality	No change in quality	No change in quality

Table 5. FMEA Analysis problem

No	Process Parameter	Root Cause	Problem Effect	S	O	D	RPN	Rank
1	Catalyst initial temperature	Initial temperature is too high	Inappropriate polymerization reaction	7	6	1	42	7
		Initial temperature is too low	*Initial reactor catalyst failed*	7	5	1	35	11
2	MPE initial temperature (75°C - 78°C)	Exceeded the maximum initial temperature limit of MPE	*High initial solid total*	5	5	1	25	12
		Exceeds the minimum initial temperature limit of MPE	*Low initial solid total*	5	3	1	15	16
3	Feeding start temperature (80°C)	Low starting feedingtemperature	High viscosity and larger particle size	7	10	1	70	2
		High starting feeding temperature	Dilute viscosity	7	6	1	42	6
4	Cooling temperature (93°C - 95°C)	Cooling temperature too low	*Particle size is bigger*	7	10	1	70	1
		Cooling temperature too high	*Particle size is not standard*	7	6	1	42	5
5	Initial rpm of catalyst (23)	RPM too low	The polymerization reaction tends to be slow	7	1	1	7	20
		RPM too high	The emergence of fish eyes	7	3	1	21	15
6	MPE initialsRpm (27)	RPM too low	The accumulation of monomers	7	5	1	35	10
		RPM too high	*Foaming on the product*	7	3	1	21	14
7	Rpm start feeding (23)	Rpm feeding too low	The accumulation of monomers	7	5	1	35	9
		Rpm feeding too high	Dilute viscosity	7	2	1	14	19
8	Initial catalyst time (10 minutes)	Time is too fast	Polymerization reaction is not optimal	7	3	1	21	13
		Time is too long	The polymerization reaction tends to be slow	7	2	1	14	18
9	MPE initial time (12 minutes)	Time is too fast	Polymerization reaction is not optimal	7	5	1	35	8
		Time is too long	The polymerization reaction tends to be slow	7	2	1	14	17
10	Observation time (90 - 120 minutes)	Time is too fast	Total solid product low	7	6	1	42	4
		Time is too long	Particle size is bigger	7	9	1	63	3

Based on the results of the FMEA analysis in table 5, the technical parameters of the process that have a high RPN value are cooling temperature, feeding temperature, and observation time. The technical parameters of this process will be the main parameters in this research experiment.

b. Identification of Experimental Data

Recording of data material at the time of the experiment was carried out to find variables and to reduce the level of no-good GP 31XXC products as well as information as evidence that could identify the identity of the problem in the study. Evidence in the form of process batch record data. Information on the batch record process will be used as the basisfor processing research data which will be used as reference material for drawing conclusions.In the experiment using experimental materials as many as 8 process batches. Where each experimental process uses the same raw materials, process equipment, and test parameters. The test parameters of the experimental results are total solid, pH, viscosity, particle size, and appearance.

Table 6. Experimental data atribute

Cooling Temperature (°C)	Feeding Start Temperature (°C)	Observation Time (Minutes)
91	94	89
92	93	90
93	92	91
94	91	92
95	90	93
96	89	93

The fixed variable of the production process is that the quantity of raw material is 20200 kg and rpm according to the product formula. The independent variables that became the experimental parameters were the cooling temperature, the starting temperature for feeding, and the observation time.

c. GP 31XXC trial results

The results of the GP 31XXC production process use production process equipment that has been prepared by the production operator. The experimental results of GP 31XXC in this study were divided into two, namely, the results of the experimental parameters and the results of the experimental measurements. The results of the experimental parameters are the results of checking process parameters, namely temperature, rpm, and time. The results of the experimental measurements are measurements of the specifications of the GP 31XXC productin the laboratory, namely total solids, pH, viscosity, and particle size in accordance with standard product specifications.

Table 7. Trial results

No Trial	Feeding Start Temperature (°C)	Cooling Temperature(°C)	Observation Time (Minute)	*Particle size (0,210-0,235 μ)*
1	94	91	89	0.2446
	94	91	89	0.2461
2	93	92	90	0.2496
	93	92	90	0.2437
3	92	93	91	0.2639
	92	93	91	0.2579
4	91	94	92	0.2501
	91	94	92	0.2542
5	90	95	93	0.2220
	90	95	93	0.2175
6	89	96	93	0.2285
	89	96	93	0.2233

d. ANOVA test results

The ANOVA test was carried out to test whether the three process parameters had the same average. The ANOVA output is the end of the calculation that is used to determine the analysis of the hypothesis to be accepted or rejected. In this case, the hypotheses to be tested are the cooling temperature parameters, feeding temperature, and observation time which will be described in each parameter.

- **Cooling temperature**
  In this case the hypothesis to be tested is:
  Ho: There is no significant effect of cooling temperature process parameters on theaverage particle size
  H1: There is a significant effect of cooling temperature process parameters on the averageparticle size

Table 8. Anova single factor temperature cooling test

Source of Variation	Sum of Square	df	Mean of Square	Fcount	Ftable	Sig
Between groups	0.002	2	0.001	57.87	4.26	0.000
Within groups	0.000	9	0.000			

Groups	Count	Sum	Average	Std Dev.
Temperature *Cooling* 91 - 92°C	4	0.98404	0.24601	0.0026147
Temperature *Cooling* 93 - 94°C	4	1.02610	0.25653	0.0058585
Temperature *Cooling* 95 - 96°C	4	0.89130	0.22283	0.0045265

Based on table 8, the Fcount value is 57.870 and Ftable 4.26, so Fcount is greater than Ftable, meaning that H0 is rejected and H1 is accepted. While the significant value orprobability is 0.000 <0.05, meaning that H0 is rejected. These results indicate that there is a significant effect of cooling temperature process parameters on the average average particle size results. The desired particle size standard is 0.210 - 0.235 , the average particle size value is 0.22283 at the cooling temperature parameter of 95°C - 96°C.

- **Feeding temperature**
  In this case the hypothesis to be tested is:
  Ho: There is no significant effect of temperature feeding process parameters on theaverage particle size
  H1: There is a significant effect of the feeding temperature process parameter on theaverage particle size

Table 9. Feeding temperature single factor anova test

Source of Variation	Sum of Square	df	Mean of Square	Fcount	Ftable	Sig
Between groups	0.002	2	0.001	57.87	4.26	0.000
Within groups	0.000	9	0.000			

Groups	Count	Sum	Average	Std Dev.
Temperature *feeding* 89 - 90°C	4	0.89130	0.22283	0.0045265
Temperature *feeding* 91 - 92°C	4	1.02610	0.25653	0.0058585
Temperature *feeding* 93 - 94°C	4	0.98404	0.24601	0.0026147

Based on table 9, the Fcount value is 57.870 and Ftable 4.26, so Fcount is greater than Ftable, meaning that H0 is rejected and H1 is accepted. While the significant value orprobability is 0.000 <0.05, meaning that H0 is rejected. These results indicate that there is a significant effect of temperature feeding process parameters on the average particle size results. The desired particle size standard is 0.210 - 0.235 , the average particle size value is 0.22283 at the feeding temperature parameter of 89°C - 90°C.

- **Observation time**
  In this case the hypothesis to be tested is:
  Ho: There is no significant effect of the observation time process parameter on theaverage particle size hasil 50
  H1: There is a significant effect of the observation time process parameter on the averageparticle size result

Table 10. Single factor anova test observation time

Source of Variation	Sum of Square	df	Mean of Square	Fcount	F table	Sig
Between groups	0.002	2	0.001	57.87	4.26	0.000
Within groups	0.000	9	0.000			

Groups	Count	Sum	Average	Std Dev.
Observation time 89 - 90 minute	4	0.98404	0.24601	0.0026147
Observation time 91 - 92 minute	4	1.02610	0.25653	0.0058585
Observation time 93 minute	4	0.89130	0.22283	0.0045265

Based on table 10, the Fcount value is 57.870 and Ftable 4.26, then Fcount is greater than Ftable, meaning that H0 is rejected and H1 is accepted. While the significant value orprobability is 0.000 <0.05, meaning that H0 is rejected. These results indicate that there is a significant effect of the observation time process parameters on the average particle size results. The desired particle size standard is 0.210 - 0.235 , the average particle size value is 0.22283 at the observation time parameter of 93 minutes.

e. Effectiveness and Value of Deteriorating GP 31XXC Products

After carrying out a series of experiments and evidence using the SPSS17.0 statistical method, the researchers summarized the results of the GP 31XXC production process after repairs were made to determine the effectiveness and value of the GP 31XXC product with problems. The results are as follows:

Table 11. Troubled GP 31XXC Product drop

Period	GP 31XX C Production Batch	GP 31XX C NG Batch
Nov 2021 - Jan 2022 (before improvement)	17 Batch	10 Batch
Feb 2022 - April 2022 (after improvement)	39 Batch	1 Batch

Conclusion

Based on the results of the analysis and discussion of the data, the authors obtain conclusions that can be drawn from research on Efforts to Reduce the Number of No-good GP31XXC Products Using Experimental Design Methods at PT AHP as follows:

1. The results of this study indicate that the cause of the no-good GP 31XXC product is the technical production process, namely the cooling temperature parameters, feeding starting temperature, and observation time. These parameters are variables that havethe most significant influence on product problems.
2. Proposed improvements with the aim of reducing the level of no-good GP 31XXC products at PT AHP are changes to standardization and validation of temperature and time parameters. The cooling temperature is from 93°C - 95°C to 95°C - 96°C, the starting temperature is feeding from 80°C to 89°C, and the observation time is from 90 minutes - 120 minutes to a minimum of 93 minutes.
3. The decrease in no-good GP 31XXC products after improvements were made with the experimental design method using SPSS17.0 was decreased by 90%, from 10 batches to 1 batch.

References

[1] Andiyanto, S., Sutrisno, A. (2016). Penarapan Metode FMEA (Failure Mode And Effect Analysis) Untuk Kuantifikasi Dan Pencegahan Resiko Akibat Terjadinya Lean Waste. Jurnal Online Poros Teknik Mesin, 6 (1). 45-55.
[2] Aprilyanti, S., Suryani, F. (2020). Desain Eksperimen untuk Meningkatkan Kualitas KekuatanProduk dengan Pendekatan Analisis Desain Faktorial. Undip: Jurnal Teknik Industri, 15 (2). 102-107.
[3] Aprilyanti, S., Suryani, F. (2020). Penerapan Desain Eksperimen Taguchi Untuk Meningkatkan Kualitas Produksi Batu Bata Dari Sekam Padi. Undip: Jurnal Teknik Industri, 15 (2). 103-106.
[4] Ariani, D.W., Pengendalian Kualitas Statistik (Yogyakarta, 2003). 126. Ibnu Idham, P. (2014). Failure Mode and Effect Analysis. Fakultas Teknik, Politeknik Negeri Bandung.
[5] Montgomery, D,C (2013). Design and Analysis of Experiments 8th Edition: John Wiley & Sons, Inc.
[6] Laska, Eugene & Siegel, Carole & Meisner, Morris & Galatzer-Levy, Isaac. (2017). Statistics and Experimental Design.
[7] Irwan, S., Desain Eksperimen Dengan Metode Taguchi (Yogyakarta: Graha Ilmu, 2009), 51. Rahmiati, R., Chalis, H. (2018). Analisis Faktor Yang Berpengaruh Terhadap Kualitas Beriket Ampas Kelapa Dengan Menggunakan Desain Eksperimen. Elkawnie: Journal of Islamic Science and Technolog, 4 (1). 55-65
[8] Krishnaiah, K. & Shahabudeen, P. (2012). Applied Design of Experiments and Taguchi Methods. PHI Learning Private Limited. New Delhi.

[9]   Salomon, L. (2018). Desain Eksperimen Untuk Meningkatkan Kualitas Kekuatan Produk Dengan Pendekatan Analisis Desain Faktorial. Jurnal Ilmiah Teknik Industri, 6 (3). 209- 220.

[10]   Oehlert, W. G. (2010). A First Course in Design and Analysis of Experiments. University Of Minesota.

[11]   Rahmatullah, S. (2018). Prediksi Alokasi Jumlah Produksi Minyak Sawit Dengan Metode Regresi Linier Berganda Pada PT Palm Lampung Persada. Jurnal Informasi dan Komunikasi, 6 (2). 61-69.

[12]   Siska, M., Salam, R. (2012). Desain Eksperimen Pengaruh Zeolit Terhadap Penurunan Limbah Kadmium (Cd). Jurnal Ilmiah Teknik Industri, 11 (2). 173-183. Sudjana. Desain Dan Analisis Eksperimen (Yogyakarta: Graha Ilmu, 2009), 97. Sudjana. Metoda Statistika (Bandung: Tarsito, 2005), 70.

[13]   Suwanda, A., Desain Eksperimen Untuk Penelitian Ilmiah (Bandung: Alfabeta, 2015). 115.

[14]   Triadi, A. (2018). Design For Six Sigma Pada Pengembangan Konseptual Sistem Informasi Terintegrasi Studi Kasus Pada Toko X Grosir dan Eceran Cianjur. Seminar NasionalInovasi dan Aplikasi Teknologi di Industri, 2085-4218. 141-150.

[15]   Tjitro, S., Santoso, M. (2003). Desain Eksperimen untuk Mengoptimalkan Proses Pengecoran Saluran Keluar Teko. Fakultas Teknologi Industri, Jurusan Teknik Mesin Universitas Kristen Petra, 5 (1). 5-10.

TEMPERATURE EFFECT ON RAMI (*BOEHMERIA NIVEA L*) FIBRE-BASED NITROCELLULOSE SYNTHETIC

Kudrat Sunandar[1*], Lin Marlina[1], Marcellinus Christwardana[1],
Rafi Ramanto[1], and Willy Dwi Novian[1], Hwai Chyuan Ong[2]
[1]Department of Chemical Engineering, Institut Teknologi Indonesia,
Jl. Raya Puspiptek Serpong, South Tangerang, 15320, Indonesia
[2]Future Technology Research Center, National Yunlin University of Science and Technology, Taiwan
* k_sunandar@iti.ac.id

Abstract.
Nitrocellulose as the basic component of a single base propellant type for rocket booster fuel has been developing for a long time, since 2010 the process of making nitrocellulose from pineapple leaves, palm frond, cotton fibers, and coconut fibers. Based on this, this research was directed to synthesize nitrocellulose from ramie (*Boehmeria nivea* L. Gaudich) fiber due to its cellulose content being relatively very high at around 97% through nitration reaction. The process of nitrocellulose synthesis was carried out in two stages. First, the process of separating cellulose from fiber, starting with the process of hydrolysis, delignin, and bleaching. Second, the reaction of nitration with nitric acid and sulfuric acid as a catalyst with temperature variation of 7°C, 12°C, 17°C, 22°C, and 27°C with nitration reaction time is 15-60 minutes. The final step is a analysis using the Fourier Transform InfraRed (FTIR) tool and analysis using the Kjeldahl method nitrogen content. The results showed that the highest absorption of Nitro (-NO2) groups at the temperature 7°C and the reaction time of 30 minutes with the percentage of Nitrogen in the cellulose is 10.791% N.

Keywords: *ramie, cellulose, nitration, nitrocellulose*

Introduction

Nitro cellulose can be used as a membrane, varnish in the paint manufacture, and a single base propellant [1]. Research on nitrocellulose has been developing for a long time, in 2010 the process of making nitrocellulose from pineapple leaves (*Ananas comosus*) was achieved yield is 86.2% with a nitrogen content is 11.56% at a ratio of 95% H2SO4 to 65% HNO3 of 3:1 and nitration time 90 minutes [2], from a palm brunch with a nitrogen content is 6.8% [3]. Research with cotton fibers states that the most produced nitro groups, at the reaction time is 30 minutes, reaction temperature 15°C, and the composition of the acid mixture 60 ml H2SO4 and 45 ml HNO3 [4]. In 2017, nitrocellulose from coconut fibers [5] showed optimum results at ratio of 7:3 acid mixture (H2SO4:HNO3) with 10.85% of nitrogen content. Some of the studies mentioned above are quite good achievements, the theoretical maximum nitrogen content in nitrocellulose is 14.14% [6]. Some of research encourages to increase nitrogen content of nitrocellulose and trying other raw materials for cellulose. Ramie plants (*Boehmeria nivea* L. Gaudich) is natural fibers that have characteristics similar to cotton and used as textile raw materials. Another advantage of ramie is its productivity per hectare is much higher compared to cotton [7]. The ramie fiber production is directed towards the main target as raw material for the textile industry (cotton substitution as an imported product). It cannot be fully absorbed by the existing textile industry, only less than 25% can be absorbed by the national textile industry. Ramie: plant, stem and fibers are shown in Figure 1.

Figure 1. Plant, stem and fiber
(sources: www.semanticscholar.or/ramie)

For export, Indonesian ramie fiber cannot compete because the processing of ramie fiber is generally traditional [8]. To anticipate the abundance of ramie fiber is use it as a pulp base to produces cellulose that processed into nitrocellulose (NC).

Research Methodology

Nitrocellulose is made by nitration reaction using nitric acid as raw material and H_2SO_4 catalyst. Based on this, this research is directed to synthesize nitrocellulose from ramie fiber through nitration reaction. The process consists of three stages, first, the process of isolating cellulose from ramie fiber. The process of cellulose isolation from flax fiber starts from the drying process, the blending and filtering process for 60 mesh sizes, the process of prehydrolysis, delignification with an alkaline solution (NaOH, 17.5%), and bleaching with H_2O_2. Second, the nitration process with H_2SO_4 and HNO_3 nitration solution, the water content of the sample should not be exceeded 10%. Third, testing with FTIR and Kjedal to determine NO_2 levels found in nitrocellulose, and nitrogen content. Through setting the temperature variation and the duration of the nitration reaction with a temperature of 7ºC, 12ºC, 17ºC, 22 ºC, and 27ºC and reaction times are 15 to 60 minutes.

Result and Discussion

The results of fiber analysis are quite high at 91.35% with 97.50% alpha cellulose, completely shown in Table 2, while the results of the analysis of nitrocellulose specifications are presented in Table 3. The amount of alpha cellulose content in fiber shows that it is very potential to be used as a source of cellulose in the production of nitrocellulose. The nitrogen content of the nitration reaction is still low because the delignification process was still incomplete as shown in Table 2. Lignin is very influential in the process of nitrogen penetration in cellulose.

Table 2. Ramie fiber composition

No	Parameters	Quantity (%)
1	Extractives	4.81
	Hemicellulose	1.92
	Alpha cellulose	97.50
2	Beta cellulose	2.32
	Gamma cellulose	0.18
3	Cellulose	91.35
4	Lignin	0.98
5	Ash Content	0.01

On the other hand, there was a possibility to use higher ratio of nitric acid and sulfuric acid, theoretically nitrogen would penetrate more to get higher nitrogen content. This is consistent with the phenomenon that occurs from the results of K. Hartaya's research in 2010 [9]. According to the Kjeldahl test, nitrogen content completed showed in Table 3 and FTIR result at 7ºC and 30 minutes showed at Figure 2.

Table 3. Nitrogen content

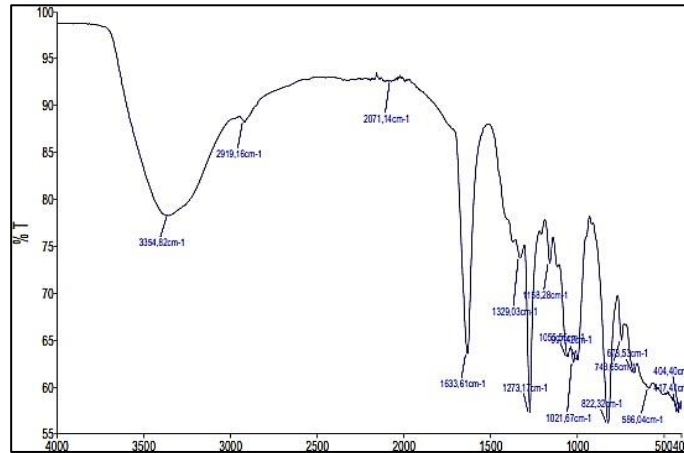| No	Temperature (ºC)	Times (minutes)	N (%)
1	7	15	6.6807
		30	10.791
		45	9.9925
		60	7.8798
2	12	15	9.8212
		30	9.707
		45	8.6221
		60	8.1082
3	17	15	4.4538
		30	9.5357
		45	9.0218
		60	5.4816
4	22	15	9.3644
		30	8.565
		45	9.6499
		60	9.1931
5		15	9.8212
		30	4.9677

| 27 | 45 | 6.3381 |
| | 60 | 8.1082 |

***Figure 2.** FTIR for Nitrocellulose at 7ºC and 30 minutes*

Meanwhile, the nitrogen content of nitrocellulose resulting from the reaction was still relatively low, which is 9.99 - 10.79% still below the nitrogen content requirement for propellant which is 12.7% as showed at Table 4.

***Table 4.** Nitrocellulose specifications*

No	Parameters	Units	Value	
			Research	Standard
1	Nitrogen Content	%	10.79	12.5 - 12.7
2	Viscosity	mPas	120	700 - 1500
3	Moisture	%	28.8	27-32
4	Acetone Insoluble	%	0.35	0.4 max
5	Ash Content	%	0.33	0.4 max
6	Fineness	ml/10 gr dry	75-80	80 - 110

Conclusion

The cellulose content of ramie fiber is 91.35% with alpha cellulose 97.50% which is very potential to be used as a sources of cellulose in making nitrocellulose as a propellant raw material. The highest level of nitrogen is produced from the nitration reaction process at 7°C for 30 minutes which is 10.79%.

Acknowledgment

References

[1]   Saragih, E., Padil, and Yelmida. (2014). Pembuatan Nitroselulosa Dari Selulosa Hasil Pemurnian Pelepah Sawit dengan Hidrogen Peroksida (H2O2) Sebagai Bahan Baku Pembuatan Propelan. presented at the Teknik Kimia Universitas Riau, Teknik Kimia Universitas Riau, 2014.

[2]   Tafdhila, B. P. I., Mahfud, and Prihatini, R. P. (2012). "Pembuatan Nitroselulosa dari Kapas (Gossypium Sp.) dan Kapuk (Ceiba Pentandra) Melalui Reaksi Nitrasi," *Teknik Pomits,* vol. 1, 1-6.

[3]   Nuraini, Padil, and Yelmida. (2012). "Proses Pembuatan Nitroselulosa Dari Limbah Pelepah Sawit Dengan Variasi Waktu Dan Temperatur Nitrasi," presented at the Laboratorium Kimia Organik, Universitas Riau.

[4]   Mudyantini, W. (2008). "Pertumbuhan, Kandungan Selulosa, dan Lignin pada Rami (Boehmeria nivea L. Gaudich) dengan Pemberian Asam Giberelat (GA3)," *Biodiversitas,* vol. 9(4), 269-274.

[5] Mulyadi, M., Setiadi, and Kusmartono, B. (2017). "Optimasi Proses Nitrasi pada Pembuatan Nitroselulosa dengan Memanfaatkan Limbah Serabut Kelapa Sebagai Bahan Baku dalam Upaya Mewujudkan Sumber Energi Bersih dan Terbarukan (Variabel Waktu Nitrasi dan Rasio Asam Penitrasi)," in *Prosiding Seminar Nasional XII "Rekayasa Teknologi Industri dan Informasi 2017*, Sekolah Tinggi Teknologi Nasional Yogyakarta.

[6] Suret, A. H. (2010). "Proses pembuatan pulp dari batang roella dengan proses soda "*Jurnal Teknik Kimia,*, vol. 17, 3.

[7] Tarmansyah, K. U. S. (2012). "Pemanfaatan Serat Rami Untuk Pembuatan Selulosa," presented at the Tim Puslitbang Indhan Balitbang Dephan.

[8] Setiadi, Y. Mulyadi, and Kusmartono, B. (2017). "Optimasi Pembuatan Nitroselulosa dari Daun Nanas dengan Proses Delignifikasi Dalam Upaya Mewujudkan Sumber Energi Bersih dan Terbarukan (Variabel Waktu Nitrasi dan Rasio Asam Penitrasi)," in *Prosiding Seminar Nasional XII "Rekayasa Teknologi Industri dan Informasi 2017*, Sekolah Tinggi Teknologi Nasional Yogyakarta.

[9] Hartaya, K. (2010). "Korelasi Kadar Nitrogen Dalam Nitroselulosa," *Majalah Sains dan Teknologi Dirgantara,* vol. 5(2), 74-85.

ANALYSIS OF APPLICATION OF MATERIALREQUIREMENT PLANNING (MRP) IN HELMET PRODUCTION USING BILL OF MATERIAL (BOM) TO HELMET AND BILL OF MATERIAL (BOM) VERSUS PRE ORDER APPROACH AT PT.POLIPRIMA CIPTA UNGGUL

Helmi Kharomatul Ambia, Ni Made Sudri
Industrial Engineering, Institut Teknologi Indonesia, South Tangerang, Indonesia, 15314

Abstract.
PT.Poliprima Cipta Unggul is a company in manufacturing which is a plastic injection molding company with one of its superior products is G2. The purpose of this research is to optimize the production process and ordering raw materials. Minimizing excess stock of materials and protecting out-of-stock safety. The first thing to do this research is the stocktaking of all materials starting from post 1 to post 4. List all existing POs, Next is the formation of future state mapping in identifying the type of waste that occurs in the company, the main typeof waste is the type of waste of overproduction, waste of inventory and waste of overprocessing

Keywords: *MRP (Material Requirement Planning), current state mapping, future state mapping, kaizen, BOM to Helmet, BOM vs PO, FIFO (First in First Out) process cycleefficiency, pull system, Stockopname*

Introduction

The manufacturing industry is a group of companies whose main activity is to produce and process raw or semi-finished materials into ready-to-use or finished goods. The goods are purchased by the company from other companies or providers. The purposeof the manufacturing industry is to produce goods economically so that they can make a profit and can deliver the product on time. In addition, the manufacturing industry also ensures that the production process can be continuous and develop so that the survival of the company is guaranteed. Currently, companies are also required to be more competitiveso that they can compete to seize the existing market.

PT. Poliprima Cipta Unggul is a manufacturing company which is a plastic injection molding company with one of its superior products being Helmet G2. PT. Poliprima Cipta excels which directly produces the helmet production process starting fromthe manufacture of helmet shells and visors, the buffing process, the painting process, the decall or sticker installation process, the varnish process and finally the assembly or assembly process. One of the efforts in increasing productivity and Optimizing Material Requirement Planning. In the production process there is some waste

Waiting, which does not require material items, or materials that are lacking. provide added value) among others in every production process so that it is not effective and efficient. The waiting time or waste waiting does not add value to the helmet production process. So there is a long lead time in each process which causes a lot of waste. Waste isan indication of resource utilization that is not optimal. Waste minimization efforts can produce efficiency and reduce product lead time so as to increase output.

Library Review

- Material Requirements Planning

    Material Requirement Planning (MRP) Is a technique or logical procedure for translatingthe induction production schedule (JPI) from finished goods or end items into netrequirements for several components needed to implement JPI. This MRP is used to determine the amount of material requirements to support the master production schedule and determine when the material requirements are scheduled.

- BOM To Helm

    The Bomb to Helm method is a stock monitoring method and the overall amount of material, to be able to conclude how many helmets will be ready to be made or ready tobe assembled, from here we can see the overall available helmet models.

Figure 1. BOM to helm

Research Methods
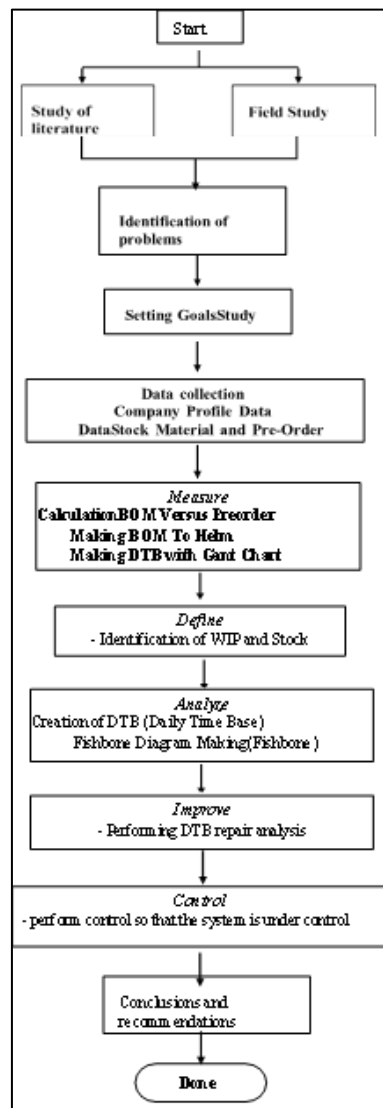
Figure 2. Research flow chart

Result and Discussion

A. Define

One of the efforts in increasing productivity and Optimizing Material Requirement Planning. In the production process there is some waste waiting, which does not requirematerial items, or materials are lacking. provide added value) among others in every production process so that it is not effective and efficient. The waiting time or waste waiting does not add value to the helmet production process. So there is a long lead timein each process which causes a lot of waste.

B. Measure

POLIPRIMA PT POLIPRIMA CIPTA UNGGUL	FORM	BY	DATE	27/10/2022
	MATERIAL REQUIREMENT, CONTROLLING STOCK HAND		UPDATE	22/07/2022

MODEL	PLANNING PRODUKSI
OPTIMAX	6738
KM 7	0
EXTERMINATOR	688
GMT DAN MR-J	6117
CENTRINO SV	1083
RETRO (VINTAGE)	
TOTAL	14626

PLANNING PRODUKSI (chart: OPTIMAX 6738, KM 7 0, EXTERMINATOR 688, GMT DAN MR-J 6117, CENTRINO SV 1083, RETRO (VINTAGE))

OPTIMAX

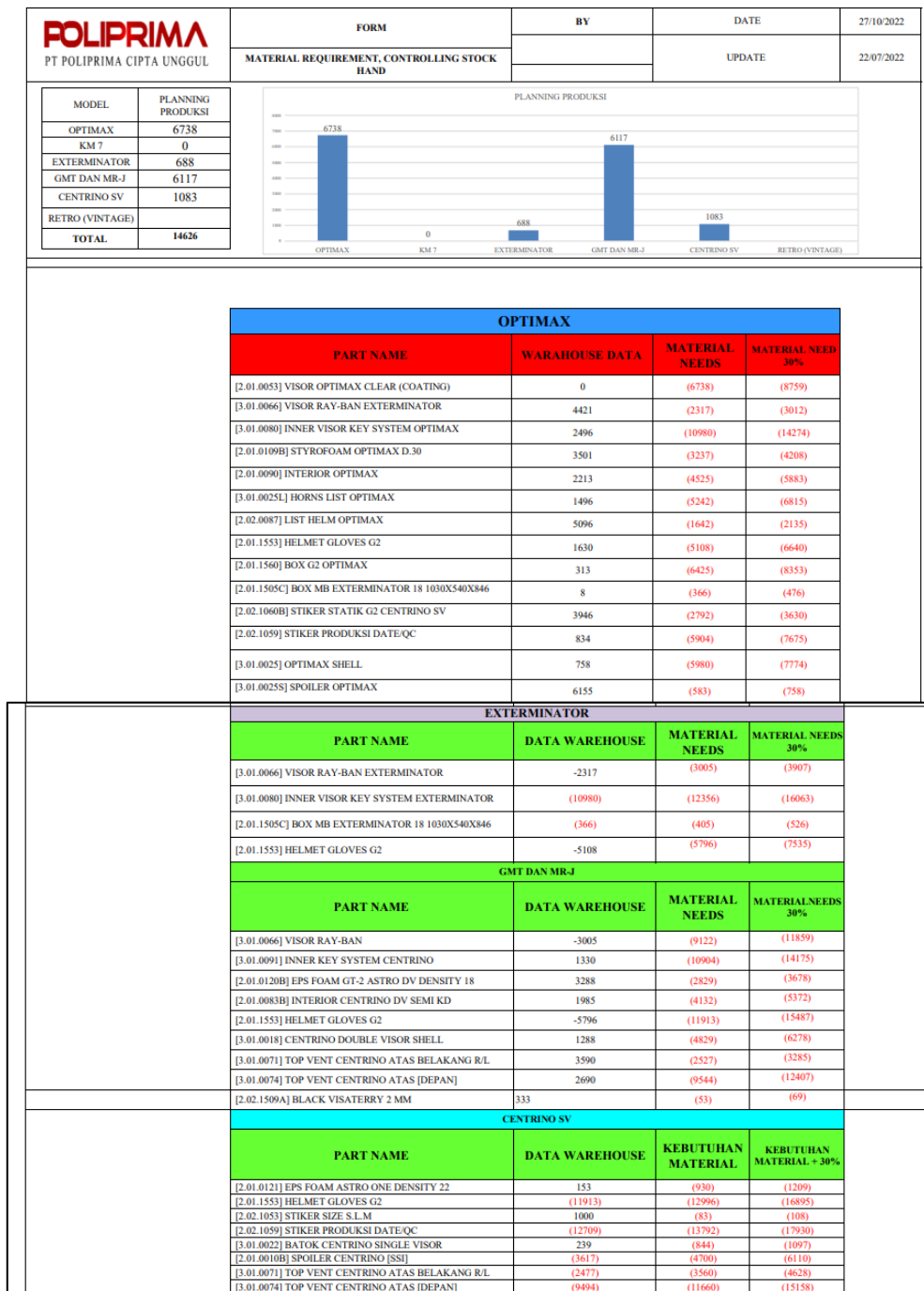| PART NAME	WARAHOUSE DATA	MATERIAL NEEDS	MATERIAL NEED 30%
[2.01.0053] VISOR OPTIMAX CLEAR (COATING)	0	(6738)	(8759)
[3.01.0066] VISOR RAY-BAN EXTERMINATOR	4421	(2317)	(3012)
[3.01.0080] INNER VISOR KEY SYSTEM OPTIMAX	2496	(10980)	(14274)
[2.01.0109B] STYROFOAM OPTIMAX D.30	3501	(3237)	(4208)
[2.01.0090] INTERIOR OPTIMAX	2213	(4525)	(5883)
[3.01.0025L] HORNS LIST OPTIMAX	1496	(5242)	(6815)
[2.02.0087] LIST HELM OPTIMAX	5096	(1642)	(2135)
[2.01.1553] HELMET GLOVES G2	1630	(5108)	(6640)
[2.01.1560] BOX G2 OPTIMAX	313	(6425)	(8353)
[2.01.1505C] BOX MB EXTERMINATOR 18 1030X540X846	8	(366)	(476)
[2.02.1060B] STIKER STATIK G2 CENTRINO SV	3946	(2792)	(3630)
[2.02.1059] STIKER PRODUKSI DATE/QC	834	(5904)	(7675)
[3.01.0025] OPTIMAX SHELL	758	(5980)	(7774)
[3.01.0025S] SPOILER OPTIMAX	6155	(583)	(758)

EXTERMINATOR

PART NAME	DATA WAREHOUSE	MATERIAL NEEDS	MATERIAL NEEDS 30%
[3.01.0066] VISOR RAY-BAN EXTERMINATOR	-2317	(3005)	(3907)
[3.01.0080] INNER VISOR KEY SYSTEM EXTERMINATOR	(10980)	(12356)	(16063)
[2.01.1505C] BOX MB EXTERMINATOR 18 1030X540X846	(366)	(405)	(526)
[2.01.1553] HELMET GLOVES G2	-5108	(5796)	(7535)

GMT DAN MR-J

PART NAME	DATA WAREHOUSE	MATERIAL NEEDS	MATERIALNEEDS 30%
[3.01.0066] VISOR RAY-BAN	-3005	(9122)	(11859)
[3.01.0091] INNER KEY SYSTEM CENTRINO	1330	(10904)	(14175)
[2.01.0120B] EPS FOAM GT-2 ASTRO DV DENSITY 18	3288	(2829)	(3678)
[2.01.0083B] INTERIOR CENTRINO DV SEMI KD	1985	(4132)	(5372)
[2.01.1553] HELMET GLOVES G2	-5796	(11913)	(15487)
[3.01.0018] CENTRINO DOUBLE VISOR SHELL	1288	(4829)	(6278)
[3.01.0071] TOP VENT CENTRINO ATAS BELAKANG R/L	3590	(2527)	(3285)
[3.01.0074] TOP VENT CENTRINO ATAS [DEPAN]	2690	(9544)	(12407)
[2.02.1509A] BLACK VISATERRY 2 MM	333	(53)	(69)

CENTRINO SV

PART NAME	DATA WAREHOUSE	KEBUTUHAN MATERIAL	KEBUTUHAN MATERIAL + 30%
[2.01.0121] EPS FOAM ASTRO ONE DENSITY 22	153	(930)	(1209)
[2.01.1553] HELMET GLOVES G2	(11913)	(12996)	(16895)
[2.02.1053] STIKER SIZE S.L.M	1000	(83)	(108)
[2.02.1059] STIKER PRODUKSI DATE/QC	(12709)	(13792)	(17930)
[3.01.0022] BATOK CENTRINO SINGLE VISOR	239	(844)	(1097)
[2.01.0010B] SPOILER CENTRINO [SSI]	(3617)	(4700)	(6110)
[3.01.0071] TOP VENT CENTRINO ATAS BELAKANG R/L	(2477)	(3560)	(4628)
[3.01.0074] TOP VENT CENTRINO ATAS [DEPAN]	(9494)	(11660)	(15158)

Figure 3. *Material requirement*

Table 1. *Support material*

Supporting Material		
[2.01.1553] SARUNG HELMET G2	1630	(12996)
[2.02.2001] LEM BATANG (SATUAN PCS)	2304	(1353)
[2.02.2002] LEM TETES	310	(275)
*	1000	0

Material Requirement Planning is a method which has a function to meet the material needed in a product, the method is very useful for increasing the quantity and tax time of the production pattern, not only that, this method also functions to reduce inventory waste, increase WIP behind. Material Requirement Planning can be seen from the total material needed. In Optimax the material that must be met is Visor OPtimax clear (coating) 8759, Visor Ray-Ban Exterminator 3012, Inner Visor key System Optimax 14274, Styrofoam Optimax D.304208, Interior Optimax 5883, List of Horns Optimax 6815, List of Helmets Optimax 2135, Holster Helmet G2 6640, Box G2 Optimax 8353, Box MB Exterminator 18 489, Static Sticker G2 Centrino SV 3630, Shell Optimax 7774, Spoiler Optimax 758, Exterminator Model Materials that must be fulfilled are Visor Ray Ban, Inner Visor KeySystem Exterminator, Glove G2 Helmet, For GMT and MRJ Models, Visor Ray Ban, Inner System Centrino 14175, Eps Foam GT-2 Astro DV Density 18 3678. Interior Centrino DV Semi KD 5372, Batok Centrino Double Visor 6278, Topvent Centrino TopRear 328 and Topvent Centrino Top (front) 12407. For Centrino Single Visor Eps FoamAstro Density 22 1209, Shell Centrino Single Visor 1097, Top Vent Top Rear and TopVent bag. For Supporting Materials, Helmet Holster 12996, Stem Glue (PCS Unit) 1353and Drip glue 275 are needed.

C. Analyze

Require Planning Analysis Using Daily Time Base is an overview of the overall material that comes, there is a visualization of when the material will come based on the existing DTB. In fulfilling or meeting the existing material needs, the pattern comes in rhythm with the existing production pattern, from Styrofoam, Interior, Shell and others as follows:

Table 2. Display

TASK	ASSIGNED TO	CAPACITY REQUIRED	SHIPPING POWER	STORAGE	LEADTIME	START	END
KEDATANGAN MATERIAL							
Task 1 INTERIOR OPTIMAX		5.883	400	2.600	2	7/28/22	8/26/22
OUTPUT DAILY		300					
BALANCE							
Task 2 INTERIOR CENTRINO DV		5.372	3000	900	2	7/28/22	7/31/22
OUTPUT DAILY		500					
BALANCE							
Task 3 INTERIOR CENTRINO SV		2.205	1750	1300	1	7/28/22	7/29/22
OUTPUT DAILY		1.000					
BALANCE							
Task 4 INTERIOR EXTERMINATOR		8.759	1000	1900	4	7/28/22	9/1/22
OUTPUT DAILY		300					
BALANCE							
Phase 2 Title							
Task 1 BOX G2 OPTIMAX		8.353	800	4200	4	7/28/22	9/7/22
OUTPUT DAILY		300					
Task 2 BOX G2 EXTERMINATOR		16.895	2800	1630	3	7/28/22	8/15/22
OUTPUT DAILY		1.000					
BALANCE							
Task 4 BOX MB EXTERMINATOR 18		526	210	8	5	7/28/22	8/9/22
OUTPUT DAILY		28					
BALANCE							
Task 5 BOX MB EXTERMINATOR 24		7.774	1008	758	1	7/28/22	8/4/22
OUTPUT DAILY		300					
BALANCE							
Phase 3 Title							
Task 1 SPOILER OPTIMAX		758	1550		1	7/28/22	7/28/22
OUTPUT DAILY		300					
BALANCE							
Task 2 EPS FOAM GT-2 ASTRO DV DENSITY 18		3.678	1500	3288	2	7/28/22	8/1/22
OUTPUT DAILY		500					
BALANCE							
Task 3 EPS FOAM GT-2 ASTRO DV DENSITY 22		1.209	1000	153	2	7/28/22	7/30/22
OUTPUT DAILY		100					
BALANCE							
TASK 4 CENTRINO DV SHELL		5.372	1008	1288	1	7/28/22	8/2/22
OUTPUT DAILY		500					
BALANCE							
TASK 5 CENTRINO SV SHELL		1.209	1008	239	1	7/28/22	7/29/22
OUTPUT DAILY		100					
BALANCE							
BAHAN PENDUKUNG							
Task 1 GLUE STICK		1.630	2000	2304	3	7/28/22	7/30/22
OUTPUT DAILY		250					
BALANCE							
Task 2 DRIP GLUE		275	310	310	3	7/28/22	7/30/22
OUTPUT DAILY		40					
BALANCE							

D. Analysis on Optimax Material Arrival Pattern
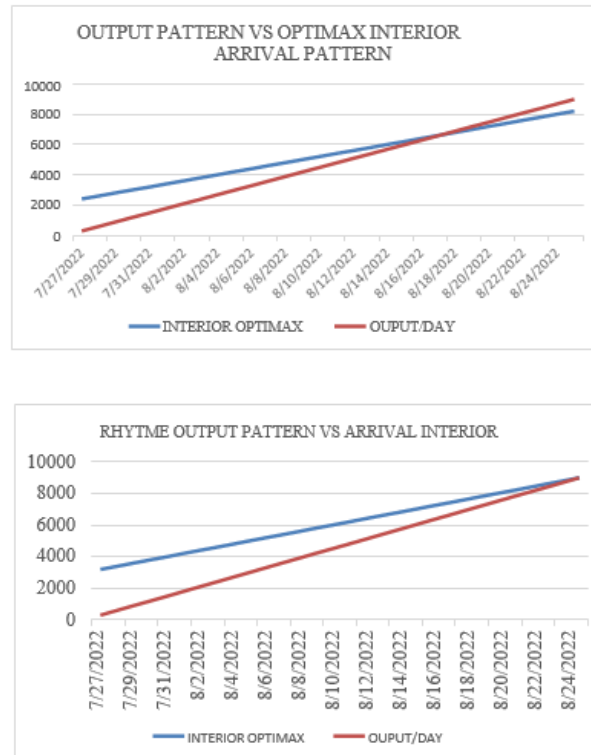

Figure 4. *Analysis on Optimax Material Arrival Pattern*

In the Optimax interior material arrival pattern to achieve material needs and rhythmicallyto the Optimax output pattern per day, on the graphic line it is shown that on 20/08/2022did not find the same rhythm pattern, then the daily output is reduced or hampered, because the material output pattern is not rhythmic. The solution to solve this rhythm problem, must have a buffer behind 3000 of the interior set and the resulting rhythm witha buffer of 3000.

E. Graphical Analysis of the Visot Optimax Pattern
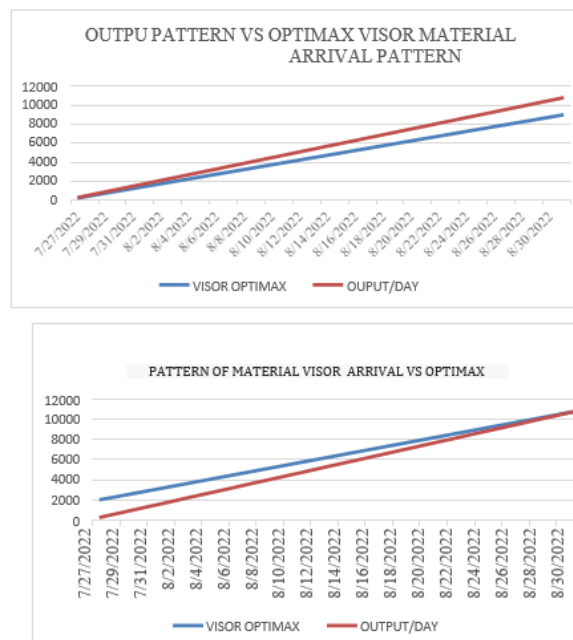
Figure 5. *Graphical Analysis of the Visot Optimax Pattern*

In the pattern of arrival of the Optimax Visor material to achieve material needs andrhythmically on the daily Optimax output pattern, the graphic line shows that on 02/08/2022did not find the same rhythmic pattern, then the daily output is reduced or hampered, becausethe material output pattern is not rhythmic. The solution to solve this rhythm problem, must have additional Vendors for buffers behind 1800 pcs of optimax visors following rhythm results with buffers.

F. BOX G2 Optimax Pattern Graphic Analysis
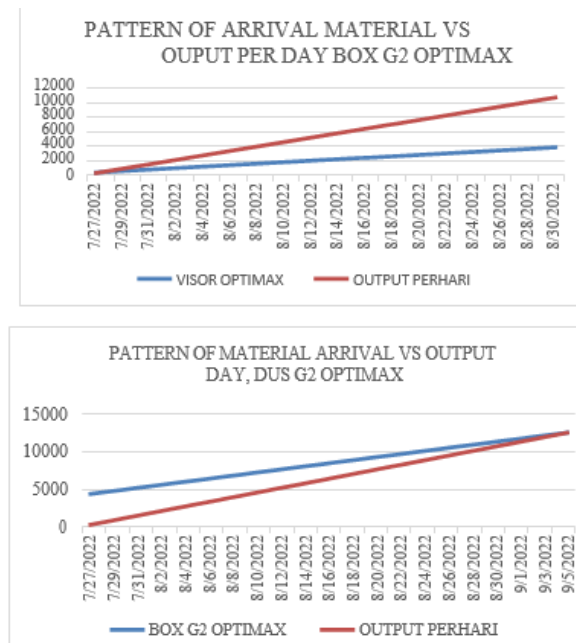
Figure 6. *BOX G2 Optimax Pattern Graphic Analysis*

In the pattern of arrival of the Optimax Visor material to achieve material needs andrhythmically on the daily Optimax output pattern, the graphic line shows that on 02/08/2022did not find the same rhythmic pattern, then the daily output is reduced or hampered, becausethe material output pattern is not rhythmic. The solution to solve this rhythm problem, must have additional Vendors for buffers behind 1800 pcs of optimax visors following rhythm results with buffers.

G. Improve

After the BOM (Bill Of Material) analysis was carried out, improvements were made to theBOM vs PO and BOM To Helm research, the following are the recommended steps towards increasing Production and improving Material Requirement Planning as follows:
1. Make a visualization of the pattern of material arrivals vs. output per day
2. Make material stock in order to know the age of the material.
3. Add or find new vendors so that daily time accumulates well
4. Reducing demand for materials that are in excess of what is needed
5. Implementing 3 M (Muda Mura Muri)

Conclusion
1. Based on the Visualized Bomb to Helmet from all available materials from Heading 1 and Heading 3 we can make Optimax 0, KM 7 200, Exterminator 1248, Centrino DV 665, and Centrino SV 153 from the total existing material accumulated we can produce 2,266 Helmets on 25/07/2022.
2. Based on the results of BOM Vs PO, the entire model has a Material RequirementPlanning Material Requirement that can be seen from the total required material. In Optimax the material that must be met is Visor OPtimax clear (coating) 8759, Visor Ray-Ban Exterminator 3012, Inner Visor key System Optimax 14274, Styrofoam Optimax D.30 4208, Interior Optimax 5883, List of Horns Optimax 6815, List of Helmets Optimax 2135, Holster Helmet G2

6640, Box G2 Optimax 8353, Box MB Exterminator 18 489, Static Sticker G2 Centrino SV 3630, Shell Optimax 7774, Spoiler Optimax 758, Exterminator Model Materials that must be fulfilled are Visor Ray Ban, Inner Visor Key System Exterminator, Glove G2 Helmet, For GMT and MRJ Models, Visor Ray Ban, Inner System Centrino 14175, Eps Foam GT-2 Astro DV Density 18 3678. Interior Centrino DV Semi KD 5372, Centrino Shell Double Visor 6278, Topvent Centrino Top Rear 328 andTopvent Centrino Top (front) 12407. For Centrino Single Visor Eps Foam Astro Density 22 1209, Shell Centrino Single Visor 1097, Top Vent Top Rear and Top Vent bag. For Supporting Materials, Helmet Holster 12996, Stem Glue (Unit PCS) 1353 and Drip Glue 275 are needed..

3. In the Optimax interior material arrival pattern to achieve material needs and rhythmically to the Optimax output pattern per day, on the graphic line it is shownthat on 20/08/2022 did not find the same rhythm pattern, then the daily output is reduced or hampered, because the material output pattern is not rhythmic. The solution to solve this rhythm problem, must have a buffer behind 3000 of the interior set and the resulting rhythm with a buffer of 3000

4. In the pattern of arrival of the Optimax Visor material to achieve material needs and rhythmically on the daily Optimax output pattern, the graphic line shows thaton 02/08/2022 did not find the same rhythmic pattern, then the daily output is reduced or hampered, because the material output pattern is not rhythmic. The solution to solve this rhythm problem, must have a buffer behind 1800 pcs of optimax visors along with rhythm results with buffers.

5. In the pattern of arrival of the Visor BOX G2 Optimax material to achieve material needs and rhythm it to the Optimax output pattern per day, the graphic line shows that on 31/07/2022 did not find the same rhythm pattern, then the dailyoutput is reduced or hampered, because the material output pattern is not rhythm. The solution to solve this rhythm problem, must have a buffer behind 4200 pcs Box G2 Optimax and have 2 different vendors along with rhythm results with buffers

6. BOM vs PO Is a Visual Description of all Material Requirements Needed plus 30% safety on the required materials, Bomb Vs Po is useful for reducing WasteInventory and reducing material Arrival Pattern errors, Material Arrival Patternerrors can cause production delays Due to materials running out at the time Production.

Table 3. *Material*

Material name	Causes of Unrhythm	Solution
Optimax interior	Too Little Warehouse Buffer, and Vendor strength does not meet the Daily Time Base Output Daily productionstandard	Adding a Warehouse Bufferat the back of at least 3000 or adding an Interior Vendor to be in tune withthe Production Pattern
Optimax Visor	No Warehouse Buffer or 0, due to Vendor not Sending or Late Request Process	Adding a Warehouse Bufferin the back (safety Stock) ofat least 1800, and using Stock Limit material so that requests are not late
Box G2 Optimax	Too Little Warehouse Buffer Due to Late Processing Requestsor Unmonitored Cartons, and Lack of Vendors	Adding a warehouse bufferbehind (safety stock) of at least 4200, funds using Stock Limit so that it is monitored and can be processed on box requests

References
[1] Heizer, Jay & Barry Render. 2009. Operations Management, Book 1 edition 9. Jakarta: Salemba Empat.
[2] Heizer and Render. 2014. Operations Management. Jakarta: Salemba EmpatGaspersz, V. (2005). Integrated Six Sigma Implementation Guidelineswith ISO 9001:2000. . Jakarta: PT. Main Library Scholastic.
[3] Rika Powerful Hadiguna. 2009. Factory Management: A Systems Approach to Efficiency and Effectiveness. Edition 1. Jakarta: Earth Literacy.
[4] Isnaini's Spirit. 2013. Analysis of Application of Material Requirement Planning (MRP) at Pennyellow Furniture. University of Jember Faculty of Economics. Accessed on April 15, 2019.

THE EFFECT OF ADDITIONAL ALOE VERA FLOUR ON THE PHYSICAL PROPERTIES OFTHE ORGANOLEPTIC BODY SCRUB OF CUCUMBER

Rozi Salsabila Ramadhani [1], Tri Yuni Hendrawati[1], Ummul Habibah Hasyim[1*], Fatma Sari[1], Wan Azmi bin Wan Hamzah[2]

Department of Chemical Engineering, Faculty of Engineering, Universitas Muhammadiyah Jakarta, Jakarta,Indonesia
[2]College of Engineering, Department of Mechanical Engineering,
Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Gambang, Kuantan
*ummul.hh@umj.ac.id

Abstract.
Aloe vera is believed to be able to moisturize the skin and refresh the skin, for that many people use Aloe vera as a scrub or skin care mask. The scrub can gently remove dirt and dead skin cells and refresh the skin is the key to the formation of collagen, which is a protein compound that plays a role in the formation of skin cells, and gives strength to the skin. This study aimed to obtain the effect of adding Aloe vera flour on the organoleptic properties of the cucumber body scrub and to get the best results from the Aloe vera powder body scrub formula. The method used in this study is the variation of the concentration of the addition of Aloe vera flour, namely 0%, 2.5%, 5%, 7.5%, 10% and 12.5%. The ingredients used to make Aloe vera scrub are Aloe vera flour, rice flour, cucumber flour, glycerin, methyl paraben, sodium lauryl sulfate, triethanolamine, stearic acid, propyl paraben, alpha tocopherol and propyl ethylene glycol. The tests in this study were organoleptic tests (color, aroma, texture and adhesion) and pH tests. This study obtained the results of color, aroma, texture and adhesion at a concentration of 7.5% and a pH ranging from 5.80-7.60 with a weight of Aloe vera flour of 3.75 grams and cucumber powder of 1.8 grams

Keywords: *Scrub, Bath Scrub, Aloe vera, Cucumber, Cucumber Flour*

Introduction

Air pollution and UV rays are sources of free radicals that are harmful to the body. Free radicals are produced in the body and neutralized by antioxidants that come from within the body. Free radicals are produced in the body and can be neutralized by antioxidants from within the body. If free radicals are very high from outside influences such as cigarette smoke,air pollution, and strenuous physical activity, the antioxidants in the body are no longer able to neutralize the antioxidants from outside the body that are needed.

Having healthy skin is everyone's dream, especially women. For women, everything is done to get healthy skin, such as by maintaining a healthy diet, not consuming fatty foods and even becoming a vegetarian. Skin care can be done in two ways, namely internal treatments such as limiting the consumption of unhealthy foods and external treatments such as using traditional and modern cosmetics. Traditional cosmetics are made from natural ingredients from plants. Traditional cosmetics are believed to be safe and do not cause side effects in use.

Aloe vera (Aloe vera) is a plant native to Africa, which belongs to the Liliaceae family. The development of science and technology today, expands the use of the benefits of aloe vera. The use of aloe vera is now not only limited to ornamental plants but also as a medicine and raw material in the cosmetics industry. The specialty of this aloe vera lies in its gel which can make the skin not dry quickly and always looks moist. This condition is due to the nature of aloe vera gel which is able to seep into the skin, so it can withstand the loss of too much fluid from the skin. The saponins contained in aloe vera gel can clean dirt from the skin, soften, moisturize and add to the smoothness of the skin [1,2].

Aloe vera is known as a plant that has multi-efficacy content with various active substances. The content in the form of aloin, emodin, resin, lignin, saponins, anthraquinones, vitamins, minerals, and so forth. In addition, it is known that aloe vera has substances that do not cause poisoning, so it can be used in industry by being processed into gels, powders, extracts, animal feed, or various other products. In the manufacture of aloe vera powder, the main ingredient used is Aloe Vera leaf type Chinese Baker from Pontianak. In addition, the chemical used is maltodextrin. The analysis in the manufacture of aloe vera powder is pH, microbiology, color, solubility [1,3].

Methods

The process of this research using: Aloe vera flour, Rice flour, Cucumber flour, Glycerin, Methyl paraben, Sodium Lauryl Sulphate, Triethanolamine, Stearic acid, Propyl paraben, Alpha tocopherol, Propyl Ethylene Glycol and using tools: Spatula, Analytical Balance, measuring pipette 5 mL, Ph meter, Beaker glass 100 mL, Waterbath, Dropper, Balp, Spray bottle and Stirring rod [4].

Research methods

The research method used is by varying the weight concentration of aloevera flour (0%, 2.5%, 5%, 7.5%, 10%, 12.5%) this research will be carried out with 20 panelists so that the resulting data is more accurate.

Analysis Method

The method to be used is Organoleptic Test with tests covering color, texture, aroma, and pH [5,6].

Result
Colour

Based on the results of a survey of 20 panelists, the color assessment of the material that the panelists liked the most was a concentration of 7.5% with a green color because the sample had a higher ratio of Aloe vera flour compared to cucumber powder, namely 3.75 grams of Aloe vera flour and 1.8 grams of cucumber powder. The preferred color result imageis shown in the Figure 1 image below.
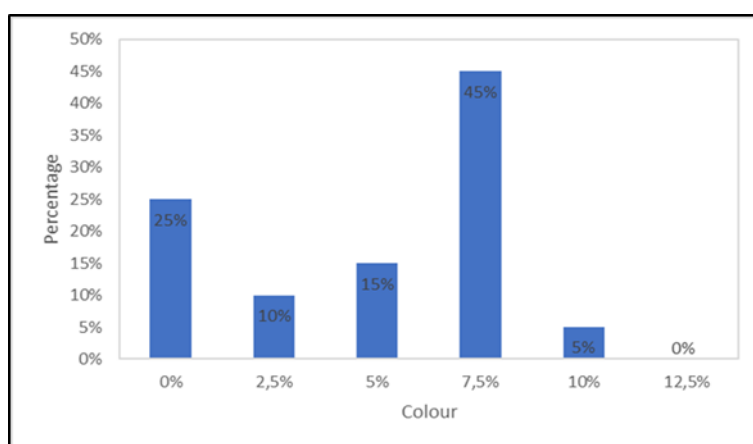
Figure 1. Colour assessment of the material that the panelists liked

Odor

Scent is important component for determining consumer acceptance and preference towards a product that describes the characteristics of the product [7]. Based on the results ofa survey of 20 panelists, the assessment of the aroma of the material that the panelists liked the most was a concentration of 7.5% with sufficient Aloe vera aroma and quite cucumber- scented, because the sample had a higher ratio of Aloe vera flour compared to cucumber powder, which was 3.75 grams of aloevera flour and 1.8 grams of cucumber powder. The preferred odor result image is shown in the Figure 2 image below.
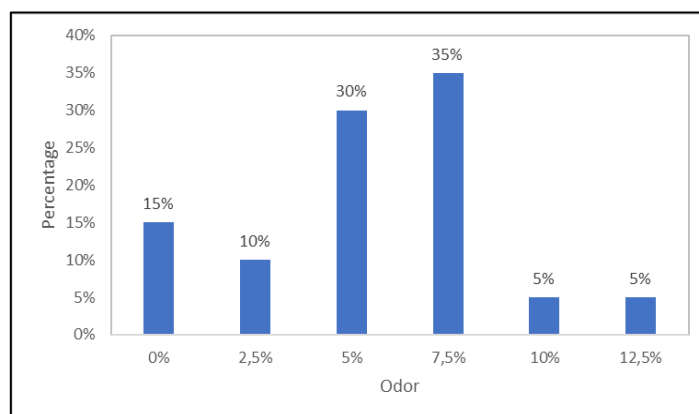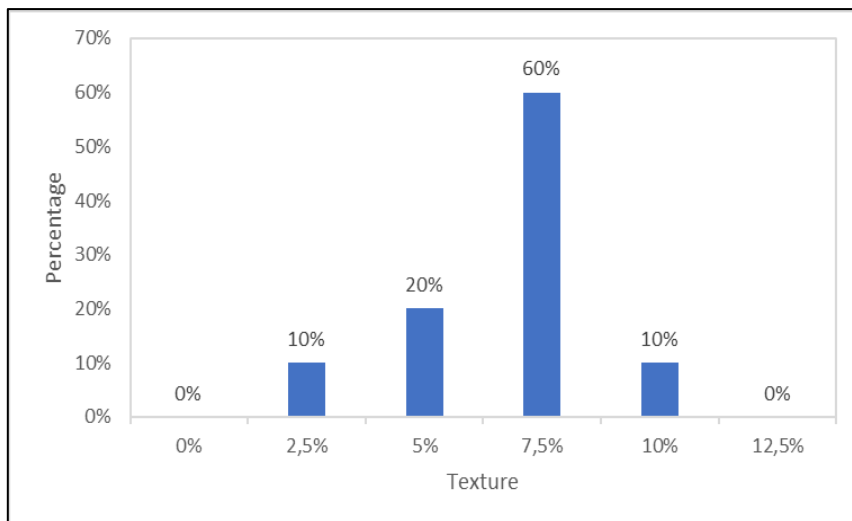

Figure 2. The preferred odor

Texture

   The difference in the amount of Aloe vera flour affects the texture of the scrub after adding water. The 7.5% concentration sample was quite fine compared to the other samples. Because the texture is quite smooth, the sample has a higher ratio of Aloe vera flour compared to cucumber powder, namely 3.75 grams of Aloe vera flour and 1.8 grams of cucumber powder. The preferred texture result image is shown in the Figure 3 image below.

Figure 3.The preferred texture

Adhesion

   So according to the panelists, the strongest adhesive power is a concentration of 7.5% with a waiting time of 10-15 minutes. The preferred adhesion result image is shown in the Figure 4 image below.
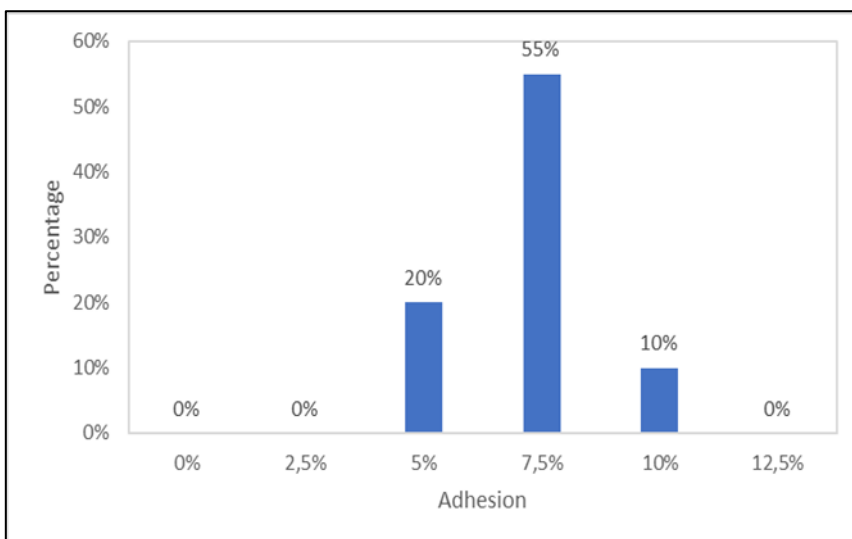
Figure 4. The Strongest adhesive power

pH

   The standard pH criteria for skin are 4.5-6.5 [6,8]. The following are the pH results obtained from each concentration:

Table 1*. pH Result*

pH percentage	0%	2,5%	5%	7,5%	10%	12,5%
pH	7.60	7.04	6.58	6.17	5.89	5.83

Discussion

In this research, Aloe vera flour and cucumber powder were made by varying the Aloe vera flour 0%, 2.5%, 5%, 7.5%, 10%, and 12.5%. In the observations, organoleptic tests were carried out which included color, aroma, texture and adhesion as well as pH tests [8]. In color assessment with Aloe vera concentration 0% has a percentage of 25%, 2.5% has a percentage of 10%, 5% has a percentage of 15%, 7.5% has a percentage of 45%, 10% has a percentage of 5% and 12.5% has a percentage of 0%. Of the six results, the highest percentage of the color of the material is the percentage of 45% at a concentration of 7.5%. The concentration of the scrub that was most preferred by the panelists in the color test was 7.5% because the scrub has a higher ratio of Aloe vera flour than cucumber flour, which is 3.75 grams of Aloe vera flour and 3 grams of cucumber flour.

On the aroma assessment with Aloe vera concentration 0% has a percentage of 15%, 2.5% has a percentage of 10%, 5% has a percentage of 30%, 7.5% has a percentage of 35%, 10% has a percentage of 5% and 12.5% has a percentage of 5%. Of the six results, the highest percentage of aroma ingredients is the percentage of 35% at a concentration of 7.5%. The concentration of the scrub that was most preferred by the panelists in the aroma test was 7.5% because the scrub has a higher ratio of Aloe vera flour than cucumber flour, namely 3.75 grams of Aloe vera flour and 3 grams of cucumber flour.

In texture assessment with Aloe vera concentration 0% has a percentage of 0%, 2.5% has a percentage of 10%, 5% has a percentage of 20%, 7.5% has a percentage of 60%, 10% has a percentage of 10% and 12.5% has a percentage of 0%. Of the six results, the highest percentage of the texture of the material is the percentage of 60% at a concentration of 7.5%. The concentration of the scrub that was most preferred by the panelists in the texture test was 7.5% because the scrub has a higher ratio of Aloe vera flour than cucumber flour, namely 3.75 grams of Aloe vera flour and 3 grams of cucumber flour.

In the assessment of adhesion with Aloe vera concentration 0% has a percentage of 5%, 2.5% has a percentage of 5%, 5% has a percentage of 20%, 7.5% has a percentage of 55%, 10% has a percentage of 10% and 12.5 % has a 5% percentage. Of the six results, the highest percentage of adhesion of these materials is the percentage of 55% at a concentration of 7.5%. The concentration of the scrub that was most favored by the panelists in the stickiness test was 7.5% because the scrub has a higher ratio of Aloe vera flour than cucumber flour, namely 3.75 grams of Aloe vera flour and 3 grams of cucumber flour.

The proportions of Aloe vera flour and cucumber powder which have organoleptic test results in the form of scrub color, aroma, texture and adhesion are the best at a concentration of 7.5% with a weight of Aloe vera flour of 3.75 grams and cucumber powder of 3 grams. In the pH test, the concentration of 0% was obtained with the result of 7.60; 2.5% the result is 7.04; 5%, the result is 6.58; 7.5% the result is 6.17; 10% got the result 5.89; and 12.5% the result is 5.83. From these data, it can be seen that the higher the concentration of the pH results, the lower the pH because the raw material for Aloe vera flour is acidic with a pH of 5 [9, 10].

Conclusion

Based on the results of the study it can be concluded as follows:

1. In this study, Aloe vera flour and cucumber powder were made by varying the Aloe vera flour 0%, 2.5%, 5%, 7.5%, 10%, and 12.5%.
2. The best results from Aloe vera scrub in the organoleptic test was a concentration of 7.5% and a pH ranging from 5.80-7.60.
3. From the results of using the scrub, the skin becomes moist and bright.
4. This research can be developed by examining microbial tests and sensitivity test

References

[1]   Hendrawati, T. Y. (2015). Aloe vera powder properties produced from aloe chinensis baker, Pontianak, Indonesia. *Journal of Engineering Science and Technology*, *10*, 47–59.

[2]   Ramadhia, M., & Ichsan, I. (2018). Pengolahan Lidah Buaya (Aloe Vera) Menjadi Granul Effervescent sebagai Minuman Kesehatan dan Analisis Peningkatan Nilai Ekonomisnya. *Jurnal Ekonomi Bisnis Dan Kewirausahaan*, *7*(2), 149. https://doi.org/10.26418/jebik.v7i2.25991

[3]   Eshun, K., & He, Q. (2004). Aloe Vera: A Valuable Ingredient for the Food, Pharmaceutical and Cosmetic Industries - A Review. *Critical Reviews in Food Science and Nutrition*, *44*(2), 91–96.

https://doi.org/10.1080/10408690490424694

[4] Ali, F., Stevani, H., & Rachmawaty, D. (2019). Formulasi Dan Stabilitas Sediaan Body Scrub Bedda Lotong Dengan Variasi Konsentrasi Trietanolamin. *Media Farmasi*, *15*(1), 71. https://doi.org/10.32382/mf.v15i1.852

[5] Usman, Y. (2022). Formulasi dan Uji Stabilitas Hand Body Lotion dari Ekstrak Etanol Rumput Laut (Eucheuma cottonii). *Journal Syifa Sciences and Clinical Research*, *4*(1), 83–91. https://doi.org/10.37311/jsscr.v4i1.13519

[6] Rusli, N., & Pandean, F. (2017). FORMULASI HAND AND BODY LOTION ANTIOKSKIDAN EKSTRAK DAUN MUDA JAMBU METE (Anacardium ocidentale L.). *Warta Farmasi*, *6*(1), 57–64. https://doi.org/10.46356/wfarmasi.v6i1.72

[7] Pratama, G., Novshally, A., Apriandi, A., Suhandana, M., & Ilhamdy, A. F. (2020). Evaluation of Body Lotion from Seaweed (Kappaphycus alvarezii) and Jicama (Pachyrhizus erosus). *Jurnal Perikanan Dan Kelautan*, *10*(1), 55. https://doi.org/10.33512/jpk.v10i1.8979

[8] Kusumawati, A. H., Munawaroh, A., & Fikayuniar, L. (2021). Formulation and Physical Evaluation of Body Lotion Preparation of Kacip Fatimah (labisia pumila) Ethanolic Extracts as Antioxcidant. *IOP Conference Series: Materials Science and Engineering*, *1071*(1), 012010. https://doi.org/10.1088/1757-899x/1071/1/012010

[9] Malik, I., & . Z. (2013). Aloe Vera: a Review of Its Clinical Effectiveness. *International Research Journal of Pharmacy*, *4*(8), 75–79. https://doi.org/10.7897/2230-8407.04812

[10] Kim, S. J., Kang, M., & Lee, T. (2019). Sensory evaluation of a body lotion formulated with hot spring water from Deokgu, Korea. *Journal of the Korea Academia Industrial Cooperation Society*, *20*(4), 420–427.

DISSEMINATION OF SUSTAINABLE INTEGRATED MULTI TROPIC AQUACULTURE(IMTA) AS A SATO UMI MODEL TO IMPROVE PRODUCTIVITY AND ENVIRONMENT OF THE INDONESIAN COASTAL AREA

Suhendar I Sachoemar[1,2*], Ratu Siti Aliah[3], Haryanti[1], Shinta Leonita[2], Agung Riyadi[1], Teguh Prayogo[1], Joko Prayitno Susanto[1],Muhami[2], Tetsuo Yanagi[4], Akihiko Morimoto[5],Mitsutaku Makino[6], Mak L Well[7]
[1]Research Center for Environment and Clean Technology,
National Research and Innovation Agency (BRIN),Indonesia
[2]Department of Agro-Industrial Technology, Institut Teknologi Indonesia, Tangerang Selatan, Indonesia
[3]Research Center for Fishery, National Research and Innovation Agency (BRIN), Indonesia
[4]Research Institute for Applied Mechanics, Kyushu University, Kasuga, 816-8580, Japan
[5]Center for Marine Environmental Studies, Ehime University, 2-5 Bunkyocho,
Matsuyama, Ehime 790-0826, Japan
[6]Atmosphere and Ocean Research Institute, The University of Tokyo, Chiba, 277-8564, Japan
[7]School of Marine Science, University of Maine, Orono, ME, 04469, USA
*suhendarsachoemar@yahoo.com

Abstract.
The dissemination of sustainable Integrated Multi Tropic Aquaculture (IMTA) Sato Umi model within coastal area of Indonesia has been applied by development the experimental model and socialization through workshop and training programs. The result of preliminary experiment that conducted in 2010 has shown the best performance on the biomass productivity of the IMTA Sato Umi model using 4 (four) species cultivated organism (fish, shrimp, algae and green muscle)compare with using 1 (one) to 3 (three) species model. The similar performance also shown on the water quality and the environmental stability. The application of sustainable IMTA Sato Umimodel currently has and is developing from the western (Sabang Aceh) to eastern part (Raja Ampat-Papua) of Indonesia. The model has expanded from the center of first experiment in the northern coastal area of west Java to central Java and Bantaeng in the South Sulawesi of central Indonesia. In the next 5 years, Indonesia is developing the Techno Parks Program in some areas, in which aquaculture and fisheries activities development on the base of Sato Umi concept in the coastal area are involves in this program. The development of Techno Parks are directed as a center application of technology to stimulate the economy in the regency, and a place of training, apprenticeship, technology dissemination center, and center business advocacy for the public. Hopefully the sustainable aquaculture model on the base of Sato Umi concept that has a similar spirit with Techno Park can be applied to support the implementation of Techno Park program in Indonesia

Keywords: *Dissemination, sustainable IMTA, Sato Umi model, Productivity, Environment,Coastal area, Indonesia*

Introduction

Fishery, coastal and marine resources are a potential, promising and can be relied to improve the economy of the people, especially fishermen. On the other hand, a logical consequence of fishery,coastal and marine resources as common property is open to the public access and often used by excessive pressure over the carrying capacity of the resource (over-exploitation) in almost all regions, especially in the Indonesia to the west and also began in eastern part of Indonesia. The existence of various threats and pressures against the existence of fishery resources, coastal and oceans show that the management and utilization has not been balanced by the rate of recovery. As a result, resources are increasingly threatened the existence and carrying capacity decreases in food supply.

Understand the threats and challenges to the existence of global natural resources and their environment, now has developed various concepts to manage and improve their condition by not only making them as an object of human activity, but the subject of human needs that necessary to be managed with a better and wise manner. In line with this thought, fisheries management, coastal and marine areas should be implemented by applying a harmony systems and technology with nature, integrated and engaging the public with respect to the system of values and local wisdom that grow and thrive in the community in accordance with the potential of local resourcesavailability.

To foster harmonious and mutually beneficial relationships between people and nature (symbiosis mutualistic), particularly in the management of fishery resources, coastal and marine, in 2007 the Japanese government has implemented a concept of wise management of natural resources between communities living around the forest, known as SATO-YAMA adopted a SATO-UMI, the relationships between community who life in the adjacent of the coastal fishery resources and marine areas. SATO-UMI is the new concept of sustainable management of fisheryresources in which human intervention in the management of fisheries resources in the coastal and marine areas can increase the productivity and diversity of fishery resources. In a broader scale, SATO-UMI basic concept can be applied to balance

the availability of natural resources as a source of food by maintaining the stability of ecosystems. In line with the growing global paradigm in the face of change and good environmental damage caused by excessive exploitation of natural resources and the consequences of climate change and global warming, it is time for Indonesia to implement the concept of management andutilization of natural resources taking into account the balance and stability of the natural resources and the environment, such as in the concept of SATO-UMI. To support those paradigms, it is necessary to develop a management and utilization concept of fishery, coastal and marine resources wisely, balanced, harmonious, integrated and more productive by developing sustainable aquaculture model as an "Integrated Multi-Trophic Aquaculture (IMTA)". This aquaculture technology was developed on the based bio-recycle system in the idle and marginal brackish water pond. By applying this concept, fisheries resources and the environmentespecially in the coastal areas that have been damaged can be recovered, more productive and biological resources diversity can be increased in a balanced and harmonious to improve the welfare of coastal community.

Material and Methods
- **Experimental design of sustainable Integrated Multi Trophic Aquaculture (IMTA)Sato Umi model.**

The preliminary experiment to clarify sustainable Integrated Multi Trophic Aquaculture (IMTA) Sato Umi model has been conducted in the marginal brackish water pond at the northern coastal area of Karawang, West Java, Indonesia in 2010 as shown in Fig.1 [1]. This experiment was designed on the base of Sato Umi concept by involving coastal community intervention to create the aquaculture sustainable model for improving productivity and increasing biodiversity of coastal area [2]. The experimental design of 4 (four) models using 500 m^2 pond of each model with 3 (three) replications (Fig.1). The model-1 (P-1) contains seed of black tiger shrimp with density 5 shrimp/m^2. Model-2 (P-2) contains seed of tilapia and black tiger shrimp with density 5fish and shrimp/m^2 of each. Model-3 (P-3) contains tilapia and black tiger shrimp with the same density with P-2, with additional algae/seaweed (*Gracillaria, sp*) in the long line system with density of 0.1 kg/m^2 per point. Model-4 (P-4) contains the same composition and density with P-3 of tilapia, black tiger shrimp and algae/seaweed (*Gracillaria, sp*) with additional benthic organism of oyster green mussel (*Pernapiridis, sp*) in the longline system with density 100 g per point, and as a control we used pond without organism.
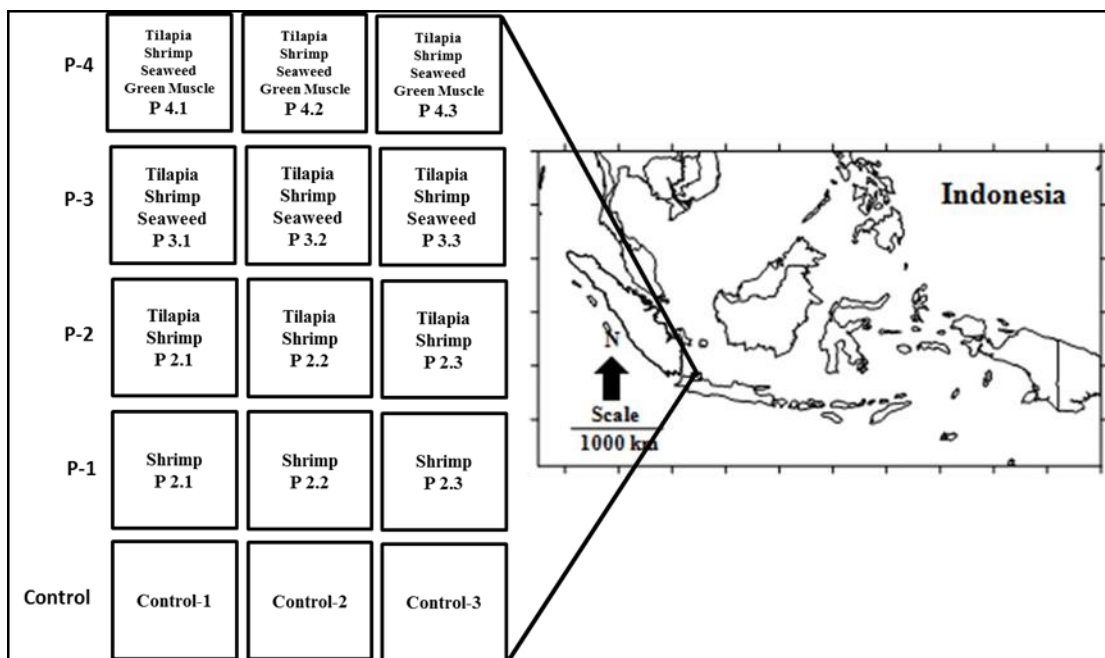

Figure 1. Location and design of preliminary experimental of sustainable IMTA Sato Umi model at the northerncoastal area of Karawang [1]

- **Dissemination method of sustainable IMTA Sato Umi model**

To socialize and disseminate sustainable IMTA on the base of Sato Umi concept in the coastal area of Indonesia, workshop and training to improve human capacity of coastal community has been conducted in some areas. Method of dissemination is by providing lecture in class, field trip to some areas of aquaculture and fisheries activities, laboratory

analysis and presentation on the seminar and workshop. Participant of the workshop and training come from various level organization of the local, regional and national level, and stake holder that associated with fishery,coastal and marine resources management such as scientist from Agency for the Assessment and Application of Technology (BPPT), Ministry of Marine Affairs and Fisheries (MMAF), Ministry of Research Technology and High Education, Ministry of Forestry and Environment, Ministry of Public Works, Coordinating Ministry for the Economy, Finance and Industry, Coordinating Ministry for People's Welfare, Ministry of Development of Disadvantaged Areas, Ministry for National Development Planning (Bappenas), Ministry of Cooperation and Small Medium Enterprises (UKM), Food Security Agency of the Ministry of Agriculture, Department of Fisheries and Marine Resources, Institute of Aquaculture, Fisheries entrepreneurs, community leaders, the farmers and other relevant stakeholders.

Workshop was also attended by experts from various research institute and university come from overseas that is coordinated by EMECS (Environmental Management of Enclosed Coastal Seas) center and PICES (North Pacific Scientific Marine Science). Research institute and university that was involved are MAFF (Ministry of Agriculture, Forestry and Fisheries), FRA (Japan Fisheries Research and Education Agency), Northwest Pacific Region Environmental Cooperation Center, Maine System University-USA, San Francisco State University, NOAA Fisheries, Kyushu University, Hiroshima University, Yokohama College of Commerce. The expected results of the workshops that organized by BPPT, PICES (North Pacific Marine Science Organization), EMECS (Environmental Management of Enclosed CoastalSeas), MAFF (Ministry of Agriculture, Forestry and Fisheries) and FRA (Fisheries Research Agency of Japan) is to provide inspire and give new spirit to various stake holders to manage and utilize fishery, coastal and marine resources optimally, harmonious, productive and sustainable toensure the sustainability of food supply from fishery, improving the community welfare and localincome.

Result and Discussions
1. **Result of the preliminary experiment of sustainable IMTA Sato Umi model**
   - **Water quality and the environmental stability**
   Based on the analysis and evaluation of water quality (temperature, salinity, pH, DO, turbidity, TSS, BOD5, DIN and DIP) of 4 models brackish water pond and control of the preliminary experimental result of 2010 as shown in Table 1, indicated that water quality for all models is in a good performance to support the aquaculture organism life. Though inland pond located a few hundred meters away from the coastline and there is a channel between pond and sea, but no significant water exchange occur between pond and sea, because water from channel was filled manually to the pond using pump. The interesting situation is seen on the model of P-4 where temperature and DO are relatively high, while salinity and pH are low. High DO concentration of P-4 model exposed the enrichment of DO as response to the availability of algae/seaweed (*Gracillaria, sp*) that produced DO through high intensity of photosynthesis and it is stimulated by high temperature. The almost similar situation was seen on P-3 in which DO concentration was higher than that in P-1 and P-2. High turbidity in P-4 model seems due to high chlorophyll-a, because TSS is low. From this situation it can be concluded that the presence of seaweed in P-4 and P-3 model has improved the water quality.

Table 1. *Water qualities of each brackish water pond model (Sachoemar et al, 2014)*

Brackishwater pond model	Temperature (° C)	Salinity (ppt)	pH	DO (ppm)	Turbidity (NTU)	TSS (mg/l)	BOD5 (mg/l)
P-1	30.81	24.94	7.92	6.28	121.83	36.50	1.66
P-2	30.77	23.11	7.87	6.27	127.46	22.33	0.71
P-3	30.92	22.48	7.90	6.74	157.08	22.83	0.24
P-4	30.94	22.91	7.91	7.11	177.67	18.00	1.18
Control	30.60	20.30	8.05	6.65	197.00	38.00	0.71

Moreover, based on the data shown in Fig.2, the DIN concentration of P-4 is the lowest even compared to the control. This situation indicates that P-4 containing green muscle as the organic consumer organism and seeweed as an inorganic consumer has contributed on the reduction of DIN concentration through bio-recycle system. In this system, organic material derived from residual feed, fish waste and other sources will be used for seaweed and green muscle growth. As the result, water quality of P-4 to be more stable compare to the other models. It means that bio-recycle system in the integrated multi trophic aquaculture model worked well on the reduction of DIN concentration of P-4 model. The similar situation was seen on the DO concentration in which P-4 is significantly different with the other models and control. High DO concentration of P-4 is stimulated by availability of seaweed and high temperature that contributed on the intense of photosynthesis. High DO concentration was also shown by P-3 compared with P-1, P-2 and control.The availability of seaweed in P-3 has also contributed on the enrichment of DO concentration. The

different situation was seen on the DIP that is no significant different among the models even with control Fig.2. It is indicated that DIP was not a major element that affects aquaculture system in the northern coastal area of Karawang compare to DIN.
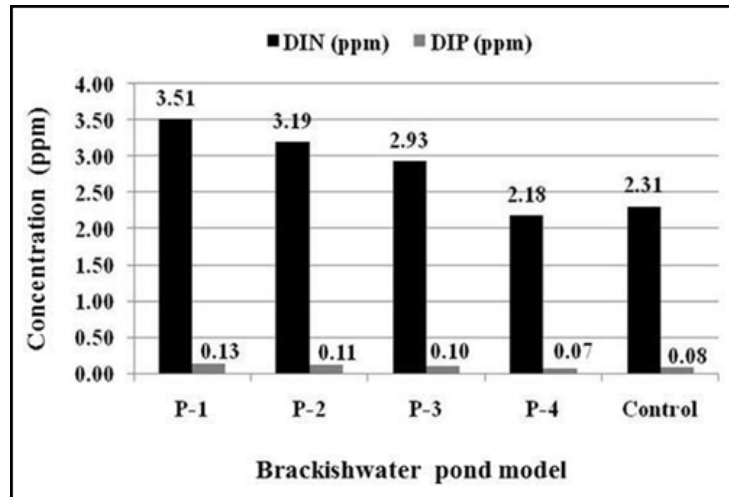

Figure 2. Mean average of DIN (Dissolve Inorganic Nitrogen) and DIP (Dissolve Inorganic Phosphorus) of each brackish water pond model (Sachoemar et al, 2014)

- **Productivity performance of the sustainable IMTA Sato Umi model**

Performance of the biomass productivity of each experiment model in Fig.3 shows that model of P-4 is the most productive followed by P-3 model, while the water quality stability as shown on Table 2 and Fig. 2 indicated the excellent condition for P-4 model with the lowest concentration of DIN compared to the other models. This condition shows that bio recycle system worked well on P-4 model with containing multi trophic organism to reduce and minimize the organic and inorganic waste from the remaining feed, feces and the other sources on the aquaculture system. The model also was more productive on the biomass production compared to the mono culture or poly culture system as shown on the P-1 and P-2 models with no algae and benthic organism.
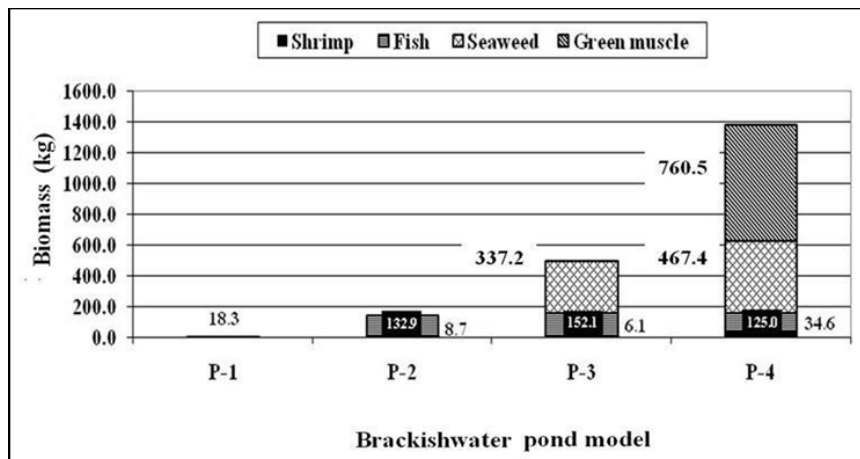

Figure 3. Productivity performance of each brackish water pond model (Sachoemar et al, 2014)

- **Dissemination of sustainable IMTA Sato Umi model.**

To socialize and disseminate of sustainable IMTA Sato Umi model in Indonesia, the first International Workshop on Sato Umi have implemented in March 2013 and the International Training in March 2014 at Karawang. The second workshop was held in November 2014 at Pekalongan, Central Java, and the third workshop was held on 7-8 October 2015 in Jakarta that isfollowed by field trip to marine aquaculture and fisheries activities at Seribu Islands of the Northern Coastal Area of Jakarta (Fig.5). Results from the workshop are expected will inspire and give new spirit to the various stakeholders to manage fisheries, coastal and marine resources optimally, harmonious, productive and

sustainable to ensure the stability of the fishery-food supply and ecotourism to improve the coastal community welfare and economic growth of local government. In the next 5 years programs, Indonesia is developing the Techno Parks in some areas with aquaculture and fisheries activities in the coastal area involves in this program. Development of the Techno Parks are directed as a center application of technology to stimulate the economy activity in the regency/city, and a place of training, apprenticeship, technology dissemination center, and center business advocacy for the public. Hopefully, Sato Umi concept that has a similar spirit with Techno Park can be applied to support the implementation of TechnoPark program in Indonesia. To be more socialized concept of Sato Umi as well as to determine the future development of the sustainable aquaculture, the workshop and training was also held atBantaeng (South Sulawesi) in November 2016. This concept and the model of integrated sustainable aquaculture also will be expanded to the eastern part of Indonesia, such as Sabang (Aceh) and Anambas Island (Riau) in the western and Raja Ampat (Papua) in the eastern part of Indonesia (Fig.6).   While in the Java Island has been expanded to the northern part of coastal Java.

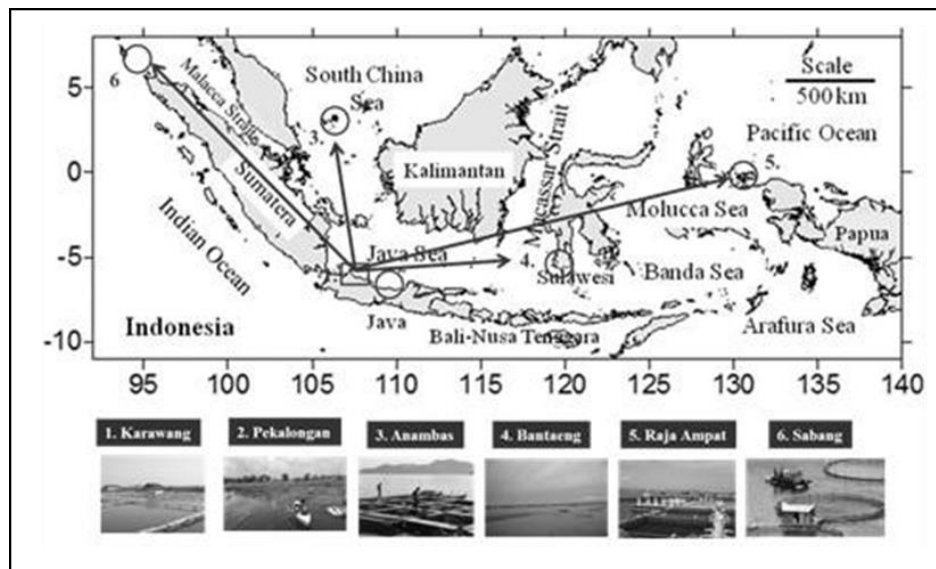*Figure 5.* Workshop and training of sustainable IMTA Sato Umi model

Figure 6. The development and expanded of sustainable IMTA Sato Umi model in Indonesia

Discussion

- **Development of sustainable IMTA Sato Umi model**

Sustainable aquaculture model of Integrated Multi Trophic Aquaculture (IMTA) that is developed based on Sato Umi concept is the environment friendly aquaculture (green technology)with zero or minimize waste. Coastal brackish water and marine aquaculture productivity can be improved by using the IMTA technology, in which various commodities such as finned fish, seaweed, sea cucumbers and oyster reared in the similar area and water quality was stable. In this system, organic waste come from food remains and fish feces will be used by oyster and sea cucumber for their growth, while seaweed utilize inorganic nutrients for growing and create an ecosystem balance [3,4]. As the result, productivity of cultivated integrated commodities grows and develop in an optimal and efficient in utilization of marine resources. The integrated sustainable aquaculture technology on the base of Sato Umi, if successfully applied in a whole coastal marginal area of Indonesia, the income of the coastal community of the region and the country's economy as a whole will increase.

Development of the integrated sustainable aquaculture technology on the base of Sato Umi by using high economics value varieties of aquaculture commodities such as tilapia, milkfish, shrimp, snapper and grouper that is combined with seaweed, sea cucumbers and oyster in the coastal marine aquaculture area is a strategic activity to be promoted. The Integrated Multi Trophic Aquaculture (IMTA) technology that is developed on the base of bio recycle system and Sato Umi concept is a model that is suitable to be developed, to support the revitalization program for increasing aquaculture export product, public consumption and protection of fishery resources. Green Technology in the field of aquaculture was developed to overcome the problem of environmental degradation. By developing a model of environmentally friendly aquaculture as an integrated multi-trophic aquaculture, the productivity of marginal brackish water pond in the coastal area is expected can be improved and quality of the environment can be well maintained and sustained. In the integrated multi-trophic aquaculture (IMTA) with bio recycle system, the organic material from remaining feed, fish waste and the other sources can be reused for oyster growth, while inorganic material for seaweed growth. The integrated multi trophic aquaculture is expected to solve the problems in maintaining the stability of aquatic ecosystems and improve productivity of marginal brackish water ponds within Indonesian coastal waters. It is already evident in the pond of P-4, where algae/seaweed (*Gracillaria sp*) and oyster green mussel (*Pernapiridis, sp*) that were cultivated with black tiger shrimp and tilapia grew well as well as water quality was stable. In this system, inorganic and organic wastes from remaining feed and feces of tilapia and shrimp are reused for seaweed and oyster growth. The existence of seaweed has also enriched the dissolved oxygen and made the aquatic ecosystem more health and stable tomaintain the cultivated organism.

In the view point of cultivated organism quantity, applying the integrated multi trophic aquaculture model using polyculture system has provided good performance on the optimize utilization of marginal brackish water pond improving productivity. Moreover, water quality andaquatic ecosystem health can also be maintained naturally compared to the monoculture and non-integrated multi trophic aquaculture system. The similar models using different organisms of the integrated multi trophic aquaculture model, is expected to be developed to improve and increase the productivity of marginal brackishwater pond in a sustainable manner. The result of experiment has shown that P-4 containing 4 cultivated organisms as an integrated multi trophic aquaculture model was the most productive aquaculture system with the most stable water qualitycompared to monoculture and polyculture non integrated multi trophic aquaculture system. This result indicates that the aquaculture system with integrated multi trophic polyculture will be morebenefit to sustain the aquaculture system in the coastal area and more productive to provide financial benefits for the coastal community compared to the monoculture and polyculture without algae and benthic organism as shown in P-1, P-2 and P-3. With integrated multi trophic aquaculture models, the risk of failure aquaculture business is expected to be reduced, because at least one or more cultivation organisms are still expected to be harvested. The farmer can also reduce the risk of capital farming and maintain the coastal area to sustain aquaculture activities with the natural balance.

- **Dissemination and development of sustainable aquaculture model of Sato Umi**

Indonesia has 1.2 million ha of brackishwater pond area, but only 37.5% of them are used for aquaculture activities. While marine aquaculture area which can be developed for cultivation of seaweed in the shoreline area up to 4 miles and cage for area over 4 miles with commodity snapper, grouper, pomfret stars, abalone or tuna reached 4.58 million hectares is only used about2 percent. The low utilization of brackishwater pond is generally caused by environmental damage due to the excessive exploitation by intensive aquaculture activities during the period of 1980s. It is well known that more than two decades ago, the northern coastal Area of Java was to be a center of shrimp production and an important region for the economic growth of the western Indonesia. However, the rapid development of shrimp farming, industry and housing in the region has caused environmental damage [5]. Since 1985, area along the northern coastal of Java have gradually been converted into shrimp ponds with intensification system. In the early stages, this system has contributed greatly to the production of shrimp for the region with an average productivity of more than 4 tons/ha. However, after a decade, shrimp productivity decreases dramatically to less than 1.5 tons/ha.

Rapid development of shrimp farming that was followed by massive mangrove deforestation which actually serves as a buffer zone to degrade an organic waste as well as an intensified used of feed and drugs has caused an excess on the decreasing of water quality, aquatic environmental and the carrying capacity in the region. As a result, various diseases threatened of shrimp lives from early stage to pre-harvest. Various environmental damage caused by intensive shrimp farming in some areas have been reported [6]. In line with the growing global paradigm in the face of change and good environmental damage caused by excessive exploitation of natural resources and the consequences of climate change and global warming, it is time for Indonesia to implement the concept of management and utilization of natural resources taking into account the balance and stability of the natural resources and the environment, such as in the concept of Sato Umi as promoted by Yanagi (2008). To support those paradigms, it is necessary to develop a management and utilization concept of fishery, coastal and marine resources wisely, balanced, harmonious, integrated and more productive by actively involving the community as in the concept of Sato Umi to improve productivity of the marginal brackish water pond and marine aquaculture in the coastal area. An integrated and environmentally friendly farming technology model such as the Integrated Multi- Trophic Aquaculture (IMTA), can be applied to improve the productivity of marginal brackishwater pond and marine aquaculture by increasing the diversity product through biorecycle system to ensure the sustainable utilization of brackishwater pond and marine aquaculture in the coastal area. A sustainable model of Integrated Multi-Trophic Aquaculture (IMTA) which is applied in the brackishwater pond and marine aquaculture in the coastal area is shown in Fig.4. The model for brackish water has been applied at breackishwater pond area at Karawang (West Java) and Pekalongan (Central Java), while for marine culture area will be applied at Bantaeng (South Sulawesi), and will be expanded to Sabang in the west and Raja Ampat in the eastern part of Indonesia.
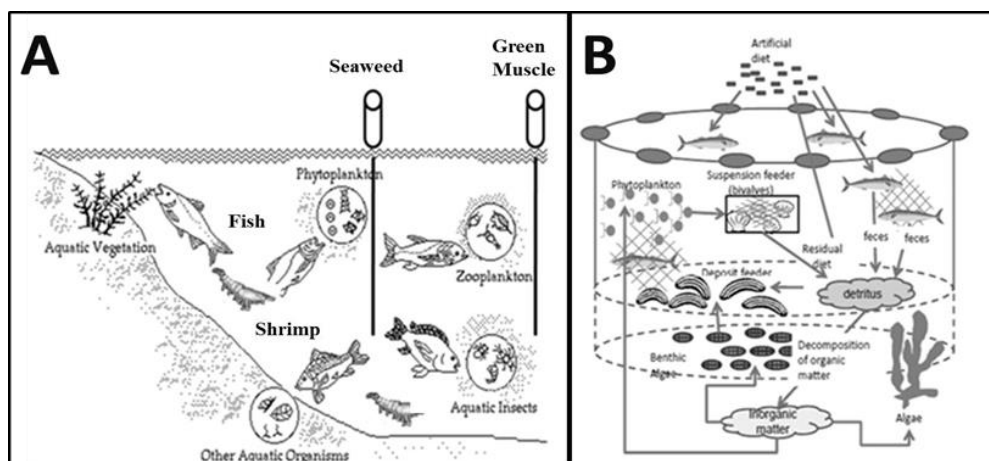

Figure 4. Sustainable model of IMTA for brackish water (A) and marine aquaculture (B)

The sustainable aquaculture model by applying Sato Umi concept has been applied within coastal area of Indonesia from the center of first experiment in the northern coastal area of west Java to central Java (western Indonesia), Bantaeng in the South Sulawesi of central Indonesia. The similar program has also been proposed for Sabang (Aceh) in the western and Raja Ampat (Papua) in the eastern part of Indonesia. In the near future, the sustainable model of aquaculture is expected to be applied in the Techno Parks which is developed by government and can be expanded to whole coastal area of Indonesia to stimulate and accelerate the economic growth and improving human well-being within the Indonesian region.

References

[1]   Sachoemar, S. I., Yanagi, T., Aliah, R. S. 2014. Sustainable Aquaculture to ImproveProductivity and Water Quality of Marginal Brackish water Pond. Journal of Coastal Marine Science. AORI. Tokyo University.

[2]   Yanagi, T. 2012. Japanese Commons in the Coastal Seas; How the Satoumi concept harmonizes human activity in coastal seas with high productivity and diversity. Springer, Tokyo, 113p.

[3]   Chopin, T. 2006. Integrated multi-trophic aquaculture. What it is and why you should care and don't confuse it with polyculture. Northern Aquaculture. Vol. 12.No. 4. pp. 4.

[4]   Neori, A., Shpigel, M., Scharfstein, B. 2001. Land-based low-pollution integrated mariculture of fish seaweed and herbivores: principles of development design operation andeconomics. European Aquaculture Society Special Publication 29: 190-191.

[5]   Nurdjana, M. L. 1997. Development of shrimp culture in Indonesia. Papers presented at Bangkok FAO Technical Consultation for Sustainable Shrimp Culture. FAO Fisheries Report No.572, Supplement, 68-76.

[6]   Flaherty, M, and Karnjanakesorn, C. 1995. Marine Shrimp Aquaculture and NaturalResources Degradation in Thailand. In: Environmental Management Vol.19, No.l, 27-37.

[7]   Yanagi, T. 2008. Sato-Umi-A New Concept for Sustainable Fisheries. Fisheries for Global Welfare and Environment, 5 World Fisheries Congress. Terrapub. 351-358 pp.

ANALYSIS OF PHYSICAL AND MENTAL WORKLOAD ON MECHANICAL EMPLOYEESAT PT. GLOBAL SAWIT SEMESTA

Andre Frensiski Sinamo, Ni Made Sudri
Industrial Engineering, Institut Teknologi Indonesia, South Tangerang, Indonesia

Abstract.
Study analysis burden work physical and mental for employees mechanic at PT. Global PalmUniverse addressed for knowing is operator job required repair or no, as well as for knowing amount employee optimal mechanics for workers and also for knowing is burden mental workon employees mechanic is have optimal mental load for worker as well as knowing is burden employee mental work mechanic moment before and after work is have difference or no . Based on results study with Cardiovascular Load (CVL) method, found that all employee mechanic experience fatigue physical at the moment where do you work need repair work however nature no soon. So from that, proposed for company give training about use machines in accordance with useful procedure for repair machine factory moment machine currently in repair. Goal is so that the operator does not easy feel tired at the moment work. Temporary that, based on results the calculation of the sampling test is obtained amount optimal employeesof 7 people. This means the operator must added 1 helper mechanic so that all employee have burden even work, and for calculation burden mental work using NASA – TLX method, the most dominant aspect moment before work are mental demand and own performance, namely confidence mechanic will success at work. Temporary the most dominant aspect at the time measurement after work is mental demand and effort, i.e where mechanic feel that the work he does need focus for solution as well as need effort high mental and physical work

Keywords: *Workload Physical, Mental Workload, Cardiovascular Load (CVL), Sampling Test, NASA – TLX, Total Optimal Employees*

Introduction

A job will be said to be completed efficiently if the completion time is the shortest.The measure of success of a production system in an industry is usually expressed in terms of the amount of productivity or the amount of output *and* input *produced* (Wignjosoebroto,2003). Planning and management of human resources can be done through workload analysis. Workloads that are distributed unequally can result in an uncomfortable working atmosphere because employees feel that the workload they are doing is too excessive or even lacking (Moekijat, 2008).

PT. Global Palm Universe is company scale industry big focused to making or processing oil coconut palm for needs processing industry from fruit Becomes oil raw. Because of the machine factory with various constraint for system automation of aproduction line, machine or tool support production. Manufacturing process or assembly conducted from step design in accordance repair or request other until with commissioning stage, even until by monitoring the production process.

Based on results observation through observation by direct, found that many complaining mechanic because too many station repair work, mechanic others do too work outside *jobdesk* each for help other mechanics outside station work alone and there are also some idle mechanic during working hours. This thing normal occur because no equally his distribution burden work for every mechanic. See results observation it is required existence measurement burden work physically and mentally forknowing is each mechanic's job required repair or no, as well as for determine amount employee optimal mechanics for company.

Library Review

- Cardiovascular Load (CVL)
  The *Cardiovascular Load* (CVL) method through heart rate is able to observe heart rateor pulse rate variations as a cognitive function and balance the workload physically (Luque-Casado et al, 2016).
- Work Sampling
  Work Sampling is a technique for estimating the total time contributed by various activities on the job by taking a set number of observations at random intervals. *Work Sampling is* also an approach method that can be used to measure productivity easily. *Work sampling* can also be used to determine the operator's productive and unproductiveactivities. In addition, *Work sampling* can also be used for discrete observations.
- NASA – TLX
  The National *Aeronautics and Space Administration Task Load Index* (NASA-TLX) method was chosen to analyze the mechanical mental workload. NASA-TLX is a subjective mental workload assessment technique to get an overall workload score based on the average calculation of 6 subscales; *mental demand, physical demand, temporal demand,*

performance, frustration level, and *effort.* The usefulness of the 6 subscales is to calculate the overall workload score (Hart & Staveland, 1988).

Research Methods
Description of the Flowchart (Flowchart)
1. **Start**
   Is step beginning start research at PT. Global Sawit Semesta.
2. **Studies Introduction**
   Preliminary study is to find out the general description of the themes raised in research related to general conditions that occur in the company first, a preliminary study is carried out. In the study, the themes discussed were Physical Workload and Mental.
3. **Studies Field**
   Studies field conducted with see by direct state worker as well as the activities that take place on the mechanics at PT. Global Sawit Semesta. Based on interview and measurement by direct, there is problems that must be analyzed in the company that.
4. **Library Studies**
   Studies references conducted for find theory, reference and literature related with activity study among other things regarding draft burden work physical and mental, *cardiovascular load (cvl), work sampling,* and NASA- TLX. Literature study done for made base think in to do study for complete problem which has been identified accompanied with base theory supported by references and literature for get the best solution for company.
5. **Formulation Problem**
   After to do observation then is known problems that occur in the company that is many operators found to do work outside *jobdesk* each for help other operators outside station work alone.
6. **Destination Study**
   Destination could determined after knowing problems that exist in the company so that research this get results and something that will obtained for be delivered to company.
7. **Data Collection and Processing**
   At stage next is to do collection and processing of data concerning with research that will discussed. Data processing is based on the foundation existing theory. Collected and processed data is as following:
   1. Profile Company
   2. Plot Production
   3. Employee Data
   4. Working Hours Employee
   5. Pulse Data Pulse Employee
   6. Observation Data *Work Sampling*
   7. Previous NASA-TLX Questionnaire Work
   8. NASA-TLX Questionnaire After Work
8. **Analysis**
   Analysis of the stages of the results of data processing. Analysis of the results of this data processing will be used as consideration in problem solving, drawing conclusions and testing suggestions which are then carried out with steps and strategies that need to be done with problem solving.
9. **Conclusion**
   After processing data and analyzing data, steps next is conclude existing problems in accordance with destination from making report this. From result analysis the it is hoped that the company could notice burden work future employees for createenvironment comfortable and healthy work.

Results and Discussion
- Cardiovascular Load (CVL)

     Result of calculation Cardiovascular Load (CVL) method used for measure burdenwork physique with measurement pulse heart using an oximeter is as following:

Table 1. Comparison table %CVL

Name	Age (year)	Gender	Place of Work	% CVL	Description
Bambang Suheri	43	Male	Mechanical	57.58	Need improve his work
Riki Andika	35	Male	Mechanical	50.00	Need improve his work
Berju Saraan	32	Male	Mechanical	43.36	Need improve his work

Derita Siketang	27	Male	Mechanical	51.85	Need improve his work
Jainudin Sitaka	28	Male	Mechanical	43.48	Need improve his work

Bambang Suheri have score by 58%, this caused because profession his that is as Coordinator the mechanic who becomes reference from servant mechanics and other mechanics, and come along work in repair or making which machine profession his use many power physical. Suryadi have score by 50%, this caused because her job that is as the 2nd mechanic coordinator who also became reference from servant mechanic, and also come work in repair or making which machine profession his use many power physical. While on the maid mechanic fight advice have score by 52%, this caused because her job that is help mechanics which are in dire need power physical, and do repair and manufacture of engine parts. Where as Riki andika and suffering Skewers have score by 43%, this caused because her job that is focus help in Thing repair and manufacture of machine parts many factories, to do taking engine parts from warehouse workshop. Jainudin Sitaka has a Value of 47%, this caused because her job that is to do repair, manufacture machine, and help mechanic other. The high % CVL is also caused because machine factory belonging to already old cause need alot repair machinery and manufacture machine new, and because around hot engine occur evaporation air that causes mechanic and assistant mechanic deficiency oxygen and trigger experience fatigue moment work.

- Work Sampling

Calculation result work sampling method is used for determine level productivity employee mechanic could seen as following:

a. Determination of Productivity Level Every Mechanic

Calculation result work sampling method is used for determine level productivity employee mechanic could seen as following:

Table 2. *Comparison of productivity levels mechanic*

Name	Place of Work	% Productivity	Description
Bambang Suheri	Mechanical	57.58	Very Productive
Riki Andika	Mechanical	50.00	Very Productive
Berju Saraan	Mechanical	43.36	Very Productive
Derita Siketang	Mechanical	51.85	Very Productive
Jainudin Sitaka	Mechanical	43.48	Very Productive

b. Determination Amount Optimal Employees

The determination of the number of employees aims to determine whether the number of employees is in accordance with the type and workload being carried out. This can be used as a basis for adding or removing employees. Based on the calculation, the result of determining the optimal number of employees is 7 workers. Where there are currently 6 mechanics working in the workshop mechanic.

c. Impact Analysis Environment

1. Temperature room

Temperature room in workshop mechanic is $\pm 27°C$, at place production not enough over 30°-32°C. While the temperature is comfortable for work or activity is between 24°-27°C (Sutalaksan, 1993). Then, temperature room workshop mechanic declared not enough good because rated too hot, so mechanic easy feel tired at the moment work.

2. State Air Circulation

Circulation air in workshop mechanic enough fine, because an open and shady room so that make mechanic work optimally at the time of the workshop mechanic. However, at the time work in the middle medium machine light up there is many steam hot from machines factory. This thing cause mechanic easy feel tired at the moment work.

3. Cleanliness

Cleaning in the workshop mechanic not enough good because open stateand with used oil produced result in floor slippery, sandy. This thing cause mechanic feel not optimal at the moment work.

4. Lighting

Lighting in the workshop mechanic enough good because workshop mechanic is room open, so light sun could enter to room with good.

5. Noise

Noise in the workshop mechanic not enough good because at the time machine turned on, engine Secrete

enough sound hard so that disturb concentration mechanic.

6. Color Room

Room in the workshop mechanic colored green, which one could interpreted color green which symbolizes the safe zone, so make mechanic feel safe when work in the workshop mechanic and deliver impression more free at the moment work.

d. NASA - TLX

At stage this use rating and comparison on 6 indicators, namely Mental Demand, Physical Demand, Temporal Demand, Own Performance, Effort, and Frustration.
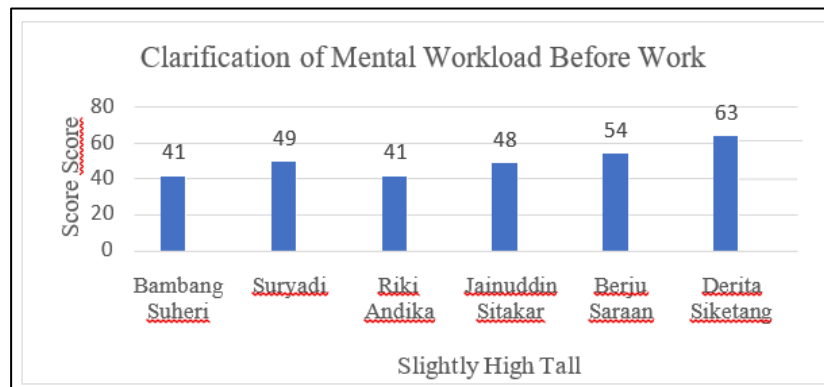
1. Clarification of Mental Workload Prior Work

Figure 2. Recapitulation of NASA – TLX before working

Can be seen in the graph above that there are 4 mechanic namely Bambang Suheri, Suryadi, Riki Andika, and Jainuddin Sitaka included in the category of rather high mental workload with scores of 41, 49, 41, and 48. Meanwhile, there are 2 operators, namely Berju Suffering and Suffering Skewers included in the category of high mental workload with a score between 5 8 and 63. Between 6 mechanic that, mechanic suffering Siketang has the highest mental burden fatigue with a score of 6 3, followed by the Berju operator advice with a mental load score of 54.

2. Comparison Weight Aspects of NASA – TLX Before Work
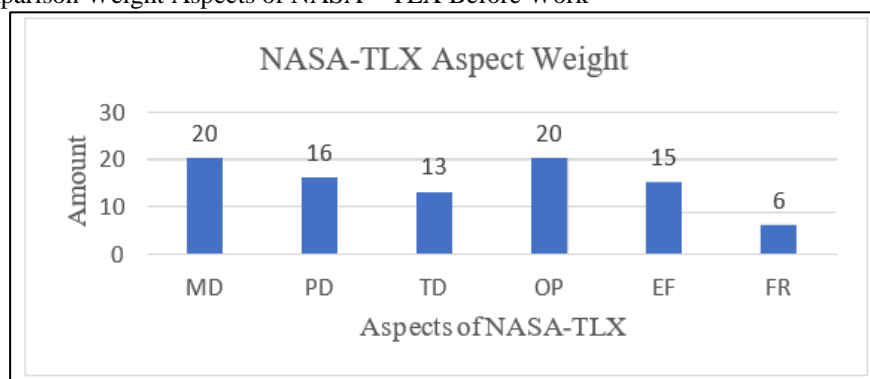
Figure 3. Comparison weight aspects of NASA – TLX before working

Between The 6 NASA-TLX aspects above, the *Performance* and *Mental Demand aspects* have the highest number chosen by the operator before work, which is 0. This shows that the operators believe in success in their work and are satisfied with the results of their work and need a good mentality. While the *Frustration* aspect is the lowest aspect chosen by the operator before work, which is 6. This shows that the operators do not feel insecure, hopeless, offended, and disturbed before starting their work.

3. Mental Workload Clarification After Work

Figure 4. *Recapitulation of NASA – TLX after working*

Picture above shows the classification of mental workload after work. Where are all mechanic included in the category of high mental load with a score between 50 – 70. Among 6 people worker, mechanic Riki Andika and Suryadi who have the highest mental burden fatigue when after working with a score of 7 5, then followed by mechanics Bambang Suheri, Berju Saraan, Suffering Siketang, and Jainuddin Sitakar with a score of 74.

4. Comparison Weight Aspects of NASA – TLX After Work

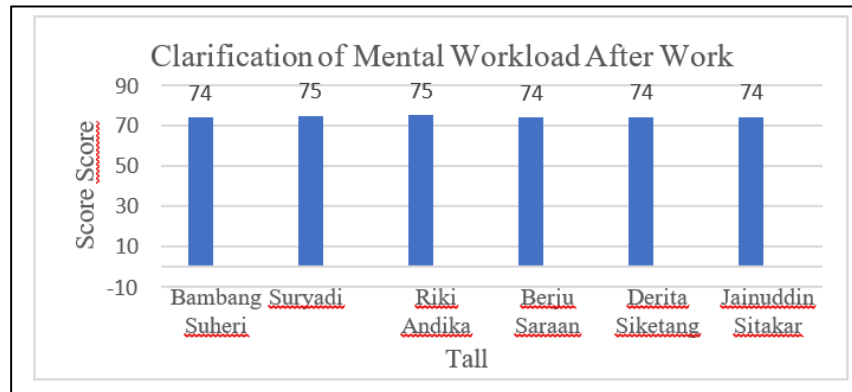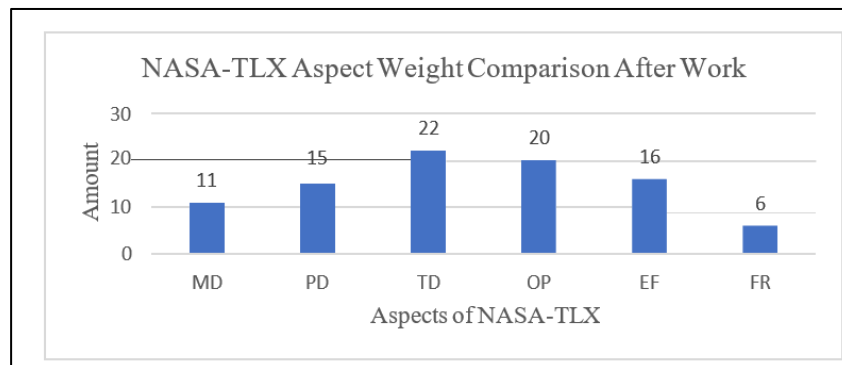*Figure 5. Comparison weight aspects of NASA – TLX after working*

Among the 6 NASA-TLX aspects above, the *temporal demand* and *effort aspects* have the highest number chosen by the operator after work, namely 22 and 20.This shows that the operators complete their work with time stressed by superiors and with high mental and physical labor effort. While the *frustration aspect* is the lowest aspect selected by the operator when after work is as much as 6. This shows that the operators did not feel insecure, hopeless, offended, and disturbed after finish his job.

5. Suggestion Repair
    As for the proposal repairs in the workshop mechanics, including as following:
    o   M paying attention health mechanic with do medical check-up once a day a year. Destination his is for knowing is mechanic have disease certain or no. So that the work given can customized with condition physique her
    o   Added 1 mechanic to the workshop in accordance with the results of the calculation of determining the optimal number of employees. The goal is that the operator does not have an excessive workload
    o   Add rule for wear PPE and always clean used spill existing oil, so that mechanics and other workers always feel safe moment work
    o   For reduce fatigue eye mechanic looking for tool small. So required existence place (table) for arrange alignment. Who aims for make it easy mechanic look for tools especially tool small is used. Like eye drills, screwdrivers, weldingtools, and others. So that mechanic feel easy and not eat many time, so

required existence addition table work for operators. Design table work this naturally with pay attention to anthropometric data so that the operator feels comfortable moment work. Anthropometric data used got from the Indonesian anthropometry website with range age started of 43 years. This thing done so that the design table work follow the average size of Indonesians for make it easy design.

The data selected for the proposed work desk design are as follows:
a. Hip height (P5) is 94.14 cm. Used for determine tall table work.
b. Range Length Hand To The front (W50) is 65.69 cm. used for determine wide table work.

Figure 6. *Design suggestion table work*

Conclusion
1. Based on results observations and calculations score burden work physical of each employee with use Cardiovascular Load (CVL) method, there are all mechanic needed repair work however nature no quick or in time short. Mechanic the is Bambang Suheri, Suryadi, Riki Andika, Berju Saraan, Suffering Siketang, and Jainuddin Sitakar, with each value (58%, 50%, 43%,52%, 43%, and 47%).
2. After observe activity employee mechanic and do calculation with Work Sampling method, obtained results amount optimal number of employees 7 people. Meanwhile, employees mechanic what's in the workshop mechanic at the moment this amount 6 people. So, company need addition employee as muchas 1 person.
3. Measurement subjective done with method measure burden mental work or psychological employee with use NASA-TLX method. Based on results measurement, suffering Skewers have score highest that is 63. This thing because mental and physical effort required for complete profession his belong to high. The performance aspect becomes aspect highest selected mechanic moment before work, thing this because mechanic convinced will success in to do profession her. Temporary aspect temporal is aspect highest selected mechanic moment after work because mechanic feel that need time high mentaland physical work in complete profession her.
4. After to do data analysis, suggestions that can given for company is do a medicalcheck-up at least once a week a year for ensure health mechanic, add 1 mechanic to the workshop, as well as add table storage tools in the workshop mechanic to mechanic no difficulty moment look for small tools that cause fatigue eye on mechanics.

References
[1] Kiran , DR (2020). Work Organization and Engineering Methods for Productivity . Chapter 17, 233-246.
[2] Arasyandi ., Arfan . Mental Workload Analysis With NASA TLX Method on CargoOperators at PT. Dharma Bandar Mandala (PT. DBM). Diponegoro University .Semarang .
[3] Rusli ., Syahrudin ., Ruslan. (2018). *Analysis Of Energy Expenditure, Energy Consumption, And Training Load Of Sepaktakraw Athletes. Advances in HealthScience Research* (AHSR). Vol. 7.
[4] Nur., Iskandar., Ade. (2020). *The Measurement Of Nurses' Mental Workload Using*NASA-TLX *Method (A Case Study).* Malaysian *Journal of Public Health Medicine.* Vol. (1): 60-63.
[5] Rino ., Suparno ., Adi. (2018). *Analysis Of Mental Workload With Integrating* NASA-TLX *And Fuzzy Method. International Journal of* ASRO. Vol. 1, Numbers. 1, pp.37-45.

EFFECT OF ADDITIONAL BEAN SPROUTS EXTRACT ON THE FERMENTATION TIME OF TEMPE MODIFICATION OF CITRIC ACID

Zakki Rosmi Mubarok[1], Wiwik Indrawati[1], Kirana Tisa[1], ̦Yudhi Nugraha[2]
[1]University of Pamulang, Indonesia
[2]Spanish National Cancer Research Center (CNIO), Madrid Spanyol

Abstract.
Indonesia is the largest produced tempe country in the world and the largest soybean market in Asia. Tempe is in demand by the public, besides being cheap, tempe also has good nutritional value, contain by highly vegetables protein. The addition of citric acid in the tempe soaking process can affect the tempe fermentation time. Previous research shown that the optimal soaking time in the tempe production process using citric acid 10%. However, residual citric acid was 0.1-0.2% (standard WHO: 0.3%). This study is continued research for search another agent to accelerate fermentation such as bean sprout extract. Tempe soaking process used citric acid and bean sprout extract as additives that contained many minerals. Sprout extract is obtained by boiling or blending. Soybean soaking was carried out for 2 hours to obtain a result of 21.25 hours, fermentation efficiency 55.73% for combination-B and 23 hours fermentation efficiency 52.08% for BSE-NB. Test the citric acid content in tempe by using the HPLC (High Performance Liquid Chromatography) method and obtain the result that the residual citric acid content in tempe is 0.03% for combination-B and 0.11% hours for combination-NB. Moreover, organoleptics show combination-B preferred than conventional Tempe

Keywords: *Tempe, Fermentation, Bean Sprouts Extract, Citric Acid, HPLC*

Introduction

Indonesia is the largest tempe comodity country in the world and the largest soybean market in Asia. As much as 50% of soybean consumption in Indonesia as the form of tempe, 40% tofu, and 10% in the ingredient of other products (such as tauco, soy sauce and others). The consumption tempe per person per year in Indonesia is currently estimated to be around 6.45 kg [1]. So that the most desirable and easy prospect of processed soybeans is tempe. Tempe was a processed food product made from fermented soybeans or several other ingredients [2]. Tempe was in demand by the public, besides being cheap. Tempe also has good nutritional value, contain by highly vegetables protein. That every 100 g of tempe fulfill with 20.8 g of protein, 8.8 g of fat, 1.4 g of fiber, 155 mg of calcium, 326 mg of phosphorus, 4 mg of iron, 0.19 mg of vitamin B1, and 34 mg of carotene [3]. Meanwhile, before being processed into tempe, it contains 3.2 g of fiber [1] and then enters the process of making tempe. Tempe production normally need 48 hours and it is need much time. Previous research result that tempe production can be accelerated by added citric acid 10% (with pH 4) with soaking within 4 hours need time 21.33 hour or 55.56% from normal hours [4]. The optimal soaking time in the tempe production process will be able to reduce the tempe production costs, because the time is more controlled and also affects the quality level of the tempe product which requires the ability to create an acidic atmosphere. However, the citric acid content in tempe modification has limited about 0.3% [5] and the previous research has 0.1-0.2% so this research focus on other alternative agent to replace citric acid with bean sprouts extract. Bean sprout extract is famous with acceleration on fermentation process because it has high nitrogen, carbon for microorganism growth.

Formulation of Problem
1. Can the addition of bean sprouts extract in the soybean soaking process accelerate on tempe production/fermentation time
2. Can the addition of citric acid and bean sprout extract in the soaking process affect the quality of tempe and fermentation time
3. Can bean sprout extract replace the citric acid

Research Purposes
1. To determine the effect of adding citric acid and sprout extract replace in the soybean soaking process to accelerate the fermentation of tempe.
2. Knowing the exact content of natural substances from bean sprouts by extraction to make additional substances.
3. Knowing the quality of tempe which has good nutritional value.

Benefits of Research

The benefits that are expected to be obtained from this research include: For science, it is hoped that this research can contribute to providing information on the method of accelerating tempe fermentation using citric acid and knowing the levels of substances in bean sprouts extract by direct or boiled methods. For other researchers, it is hoped that this research can be used as a reference in further research using the same raw materials and using different methods

Body of Paper

Tools

1. Tempe making tools: Stove, Digital scales, Tampah (webbing filter made by bamboo), Pan, Basin, Filter, Tray, Spoon, Universal pH, Plastic, Glass, Blender
2. Tools for Testing Organoleptic Properties and Acceptability: Test form, Fork, spoon, and plate

Ingredients

1. Tempe Ingredients : Soybeans, Yeast brand Raprima, Water, Bean sprout extract, Citric Acid
2. Ingredients for Testing Organoleptic Properties and Acceptability Tempe samples according to the treatment at the time of testing are presented, each of which is coded:

Table 1. Research experiment design

Variation	Pretreatment	Extract	Addition	Soaking Time
bean sprout extract (BSE)	Boiled (B)	50 Gram	BSE+Citric Acid (Combination-B)	2 Hour
				4 Hour
				6 Hour
			BSE (BSE-B)	2 Hour
				4 Hour
				6 Hour
	Non Boiled (NB)		BSE+Citric Acid (Combination- NB)	2 Hour
				4 Hour
				6 Hour
			BSE (BSE-NB)	2 Hour
				4 Hour
				6 Hour
Conventional (control)				8 Hour

Results

The researcher conducts an environmental interest that is made in such a way that it becomes ideal and fulfills the expected conditions for further studying the behavior of the object's behavior. Ideal conditions and deliberate arrangements have their advantages and disadvantages.
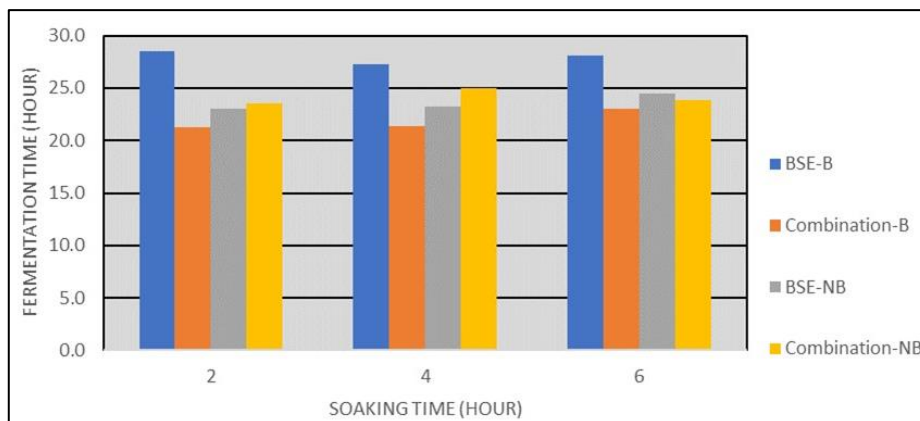
Figure 1. *Effect soaking time on fermentation process*

The figure shows that soaking time has effect on fermentation time. The best treatment for boiling treatment is Combination-B (BSE+Citric Acid with boiling) about 21.3 hour and for non boiling treatment is BSE-NB (BSE non boiling) about 23 hour. And the soaking time is effective for 2 hour. It probably the optimum content absorbtion can absorb 2 hour.

Table 2. *Total time tempe production comparation*

	Treatment	Boiling	Soaking	Fermentation	Total Time	efficiency Fermentation
Mubarok (2019)	Soaking	2.00	4.00	21.33	27.33	55.56
	Soaking and Boiling	2.00	4.00	21.75	27.75	54.69
Experiment	Soaking BSE-NB	2.00	2.00	23.00	27.00	52.08
	Soaking Combination-B	2.00	2.00	21.25	25.25	55.73
Control	Conventional	2.00	8.00	48.00	58.00	00.00

The data above shows that there is a significant effect of the addition of citric acid of the tempe fermentation process in the soybean soaking treatment with the addition of citric acid for 2 hours. This is because the acid plays a good role in the fermentation process so as to get the desired results. That acid used suitable for the growth of tempe mushrooms as well as a good and natural preservative so that in a certain ratio. It is used in the soybean soaking process using citric acid and the addition of bean sprout extract in the soybean soaking process. The soaking using citric acid and bean sprout extract in soybeans can accelerate the fermentation process. In this study, effective soaking of soybeans took 2 hours with a fermentation process of 21.25 hours.
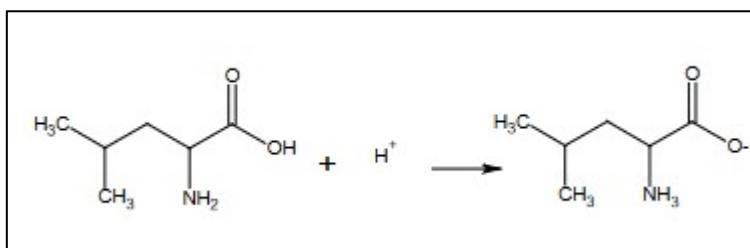

Figure 2. *Citric acid role on fermentation process*

Citric acid will donor proton H^+ to attack leusin (tempe protein) to decompose into amino acid and bean sprout extract will provide nitrogen for microorganisme growth [6].

Residual Citric Acid on Tempe

The best treatment will check citric acid content of tempe using HPLC (High Performance Liquid Chromatography) method at the PT. Qualis Indonesia, and the following are the results of the analysis that has been carried out:
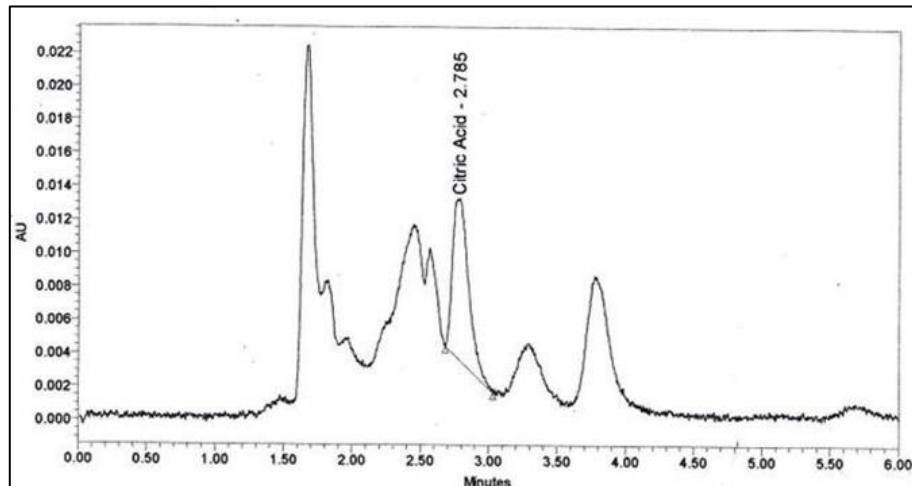
Figure 3. Citric Acid content for Combination-NB

Figure 3 shows that sample has residual citric acid content at peak of 2.785 with concentration 0.11%.
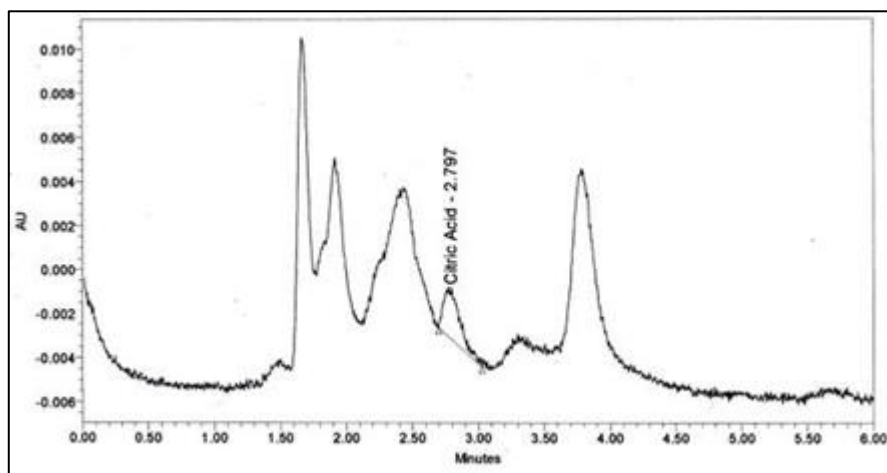
Figure 4. Citric Acid content for Combination-B

Figure 4 shows that tempe which has been added with ordinary bean sprouts extract has residual acid content at peak of 2,797 with concentration 0.03%. It decrease probably because citric acid consumed by microorganism.

Table 3. Residual citric acid on tempe

	Treatment	**Residual Citric acid (%)**
Mubarok (2019)	Soaking	0.1-0.2
Experiment	Soaking Combination-NB	0.11
	Soaking Combination-B	0.03
	BSE-NB	0
Control	Conventional	0

Judging from the citric acid content above, all samples has 0.03 and 0.11% residual citric acid. It shown the sprout extract can reduce residual citric acid. It is declared safe for consumption based on the consumption limit for the use of citric acid in foodstuffs set by WHO (World Health Organization) which is 3,000 mg/kg or 0.3% [7].

Organoleptic Test Results

After going through the citric acid test and the results were that the citric acid content was suitable for consumption, to be more sure, an organoleptic test was carried out which was assessed by 15 trained panelists. The results of the analysis are as follows:

Figure 5. *Organoleptic test*
Scoring: 5 = *Excellent*. 4= Very *Good*. 3=*Good*. 2= Fair. 1=*Poor*

The organoleptic result shows tempe with citric acid added (combination-B) and BSE prefer than conventional tempe because citric acid can repair tempe texture within fermentation by changed protein (denaturation) [8].
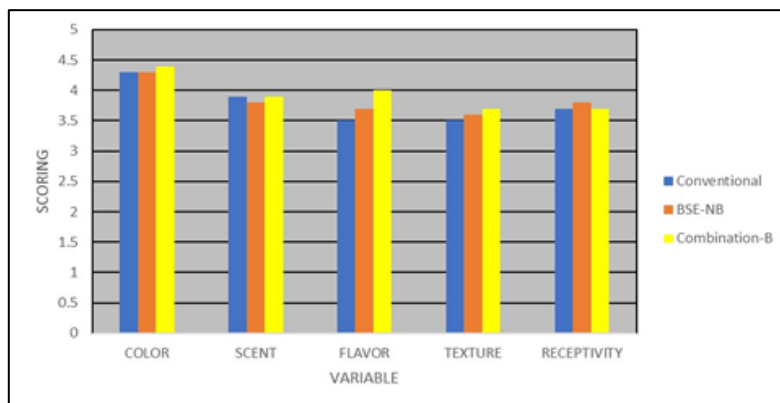
Conclusion

From some data it can be concluded that soaking using citric acid and bean sprout extract in soybeans can accelerate the fermentation process. In this study, effective soaking of soybeans took 2 hours with a fermentation process of 21.25 hours with higher fermentation efficiency 55.73% than without sprout extract 55.56%.

The citric acid content of tempe has been tested using the HPLC (High Performance Liquid Chromatography) method and obtained the result that the citric acid content of tempe is safe for consumption about 0.03% (lowest than others for combination-B). In this study, bean sprout extract was also added as an additional substance that contains many minerals in it. The organoleptic test that has been carried out on tempe results is superior to tempe with citric acid added (combination-B) and BSE than conventional tempe.

Acknowledgment

References

[1]   Badan Standarisasi Nasional. (2012). Tempe: Persembahan Indonesia untuk Dunia.Jakarta

[2]   Rawanti, Hana, et al. (2018) "Upaya Peningkatan Konsumsi Tempe Melalui Diversifikasi Olahan", State Polytechnic Lampung, Lampung.

[3]   Bastian, F, et al. (2013) "Daya Terima Dan Kandungan Zat Gizi Formula Tepung Tempe Dengan Penambahan Semi Refined Carragennan (SRC) Dan Bubuk Kakao", Hasanuddin University, Makassar

[4]   Mubarok, Zakki rosmi, et. al. (2019). The Effect of Citric Acid Addition in Boiling and Soaking Process of Soybean on Accelerating of Tempe Fermentation. Jurnal Ilmiah Teknik Kimia UNPAM, Vol. 3 No. 1, Tangerang Selatan.

[5]   WHO. (2019). FAO/WHO Standards Codex Alimentarius. GSFA. Online. https://www.fao.org/gsfaonline/additives/details.html?id=173

[6]   Yurliasni, Zakaria Y.(2013). Kajian Penambahan Khamir Kluyveromyces Lactis, Candida Curiosa dan Brettamonyces Custersii Asal Dadih terhadap konsentrasi Asam- Asam

[7]   Budiasih, Kun Sri. (2009). Studi Bioanorganik : Mineral Runutan dalam Metabolisme

Tubuh. Jurdik Kimia FMIPA UNY. Fakultas MIPA, State University Yogyakarta.

[8] Rosyida, Fathia. dan Lilis, Sulandari. (2014) "Pengaruh Jumlah Gula dan Asam Sitrat Terhadap Sifat Organoletik, Kadar Air dan Jumlah Mikroba Manisan Kering Siwalan", State University Surabaya, Surabaya.

ANALYSIS OF PHYSICAL AND MENTAL WORKLOAD ON FINISHING OPERATOR USING NASA TLX METHOD AND WORK SAMPLING AT PT. PASSION ABADI KORPORA

Dwi Aprillah, Ni Made Sudri
Industrial Engineering, Institut Teknologi Indonesia, South Tangerang, Indonesia

Abstract.
PT. Passion Abadi Korpora as one of the producers of the jewelry retail industry, every company must pay attention to the balance of the workload of its employees. PT. Passion Abadi Korpora has many departments in it, although it is not easy to do but the company must be able to balance the two burdens. One of the departments that also has a workload imbalance is the finishing production department. To measure the workload, you can use the NASA-TLX method on mental workloads, for physical workloads using the Work Sampling method which then produces the optimal amount of productivity. There are six indicators in the NASA-TLX method, namely mental needs, physical needs, time requirements, work performance, frustration levels, and physical and mental effort. In the finishing production department there are 20% for work performance indicators, 7% for time requirements indicators, 20% for physical and mental effort indicators, 20% for mental needs indicators, and 13% each for indicators of physical needs and frustration levels. Based on the calculation results, the highest productive working hours were obtained, the first being Nurman with 146 hours/month, followed by Rahma Purnomo with 145 hours/month, and Dwi Rian S, Andri Andrianto with 144 hours/month. The results of these calculations can be caused by the heavy workload of operators who are rarely found unemployed when observing for 5 working days. There are 3 (three) factors that cause mental workload, namely lack of training and understanding of work for operators, poor time management and inadequate work environment. The most dominant thing felt by finishing operators on the production floor is the demands of work from a human point of view. Because the work demands given by the company are evenly distributed between new employees and old employees. For the old employees, it is suggested to use headphones so as not to disturb the concentration of the new employees. Furthermore, the proposed improvement that can be made by the company is to design a product, namely a box that can be used in finishing work so that the gold flakes that are filed or sanded do not scatter on the table and can be collected for smelting so that there is a retrun which can reduce the loss of grams of gold. The most dominant thing felt by finishing operators on the production floor is the demands of work from a human point of view. Because the work demands given by the company are evenly distributed between new employees and old employees. For the old employees, it is suggested to use headphones so as not to disturb the concentration of the new employees. Furthermore, the proposed improvement that can be made by the company is to design a product, namely a box that can be used in finishing work so that the gold flakes that are filed or sanded do not scatter on the table and can be collected for smelting so that there is a retrun which can reduce the loss of grams of gold. The most dominant thing felt by finishing operators on the production floor is the demands of work from a human point of view. Because the work demands given by the company are evenly distributed between new employees and old employees. For the old employees, it is suggested to use headphones so as not to disturb the concentration of the new employees. Furthermore, the proposed improvement that can be made by the company is to design a product, namely a box that can be used in finishing work so that the gold flakes that are filed or sanded do not scatter on the table and can be collected for smelting so that there is a retrun which can reduce the loss of grams of gold. Because the work demands given by the company are evenly distributed between new employees and old employees. For the old employees, it is suggested to use headphones so as not to disturb the concentration of the new employees. Furthermore, the proposed improvement that can be made by the company is to design a product, namely a box that can be used in finishing work so that gold flakes that are filed or sanded do not scatter on the table and can be collected for smelting so that there is a retrun which can reduce the loss of grams of gold. Because the work demands given by the company are evenly distributed between new employees and old employees. For the old employees, it is suggested to use headphones so as not to disturb the concentration of the new employees. Furthermore, the proposed improvement that can be made by the company is to design a product, namely a box that can be used in finishing work so that the gold flakes that are filed or sanded do not scatter on the table and can be collected for smelting so that there is a retrun which can reduce the loss of grams of gold.

Keywords: *NASA – TLX, Sampling Test, Physical Workload, Mental Workload, Productivity.*

Introduction

Humans are one of the important components in organizations and industrial activities (both those that produce products or services). Human activities can be classified into two main components, namely physical work is a workload that involves muscle work, and mental work is a workload that involves the brain (Pracinasari, 2013). This physical and

mental activity can have consequences, namely the emergence of workloads.

Fatigue is one of the causes of decreased employee productivity. Fatigue can occur due to the workload imposed on the operator. The workload received by a person must be appropriate and balanced with the physical and mental abilities of the workers who receive the workload so that fatigue does not occur. (Hart in Ramadan, et al, TT). The workload imposed on a person can occur in three conditions, First, the workload according to standards. Second, the workload is too high. Third, the workload is too low.

PT. Passion Abadi Korpora is a retail company engaged in diamond jewelry retail which is divided into three trademarks, namely Passion Jewelry, Passion Prive, and Diamond & Co. To make a jewelry product, you need to go through several production processes that must be carried out starting from 2D Design, Jewel CAD 3D, Casting, Finishing, Polishing and Diamond Installation. Based on the 4M+E analysis, the man factor is the main problem causing the workload because the operator feels symptoms of excessive fatigue, causing feelings of sluggishness, sleepiness, dizziness, lack of accuracy, lack of concentration, slow response and loss of enthusiasm for work in the presence of this fatigue. productivity of employees that affect the finishing process. In this process there is a decrease in gram weight before and after finishing. Based on the finishing productivity data, there are 5 operators who have a total value of gold gram losses exceeding the rate provided by the company. For operators who have a gram loss value that exceeds the rate, punishment will be given. So that the finishing production operator does not get punishment, therefore it must produce optimal output.

To overcome this problem, it is necessary to conduct a study to determine the mental workload and productivity of the operator's work on the production floor in the finishing section, namely the measurement of physical work is carried out with a work sampling approach. The work sampling method is an approach method used to measure productivity. The work sampling method can also be used to determine the operator's productive and non-productive activities, while the mental workload measurement uses the NASA-TLX workload analysis method.

Library Review
Workload

Workload is one aspect that must be considered by every company, because workload can have an effect on employee productivity results. Workload as a concept that arises due to limited capacity in processing information.

Nasa – TLX

NASA-TLX (National Aeronautics And Space Administration Task Load Index) is a method that evaluates subjective workloads, where workers are asked to give their opinion on the work being carried out. In the NASA-TLX method, workers are asked to rate between 0 and 100 on 6 aspects of the job. The NASA-TLX method was developed by Sandra G. of the NASA-Ames Research Center and Lowell E. Staveland of San Jose State University in 1981 (S. Hart et al., 1999).

Number	Range of Value	Category of Workload
1	0% - 9%	Very Low
2	10% - 29%	Low
3	30% - 49%	Moderate
4	50% - 79%	High
5	80% - 100%	Very high

Figure 1. Classification of workload value rating

Work sampling

Work sampling is a technique for conducting a large number of observations on the performance activities of machines, processes or workers / operators (Sritomo Wignjosoebroto, 2003). Work measurement with the work sampling method can be classified as direct work measurement because the implementation of measurement activities must be carried out directly at the work place under study.

Fishbone Diagram

Fishbone diagram is often called Cause and Effect diagram is a diagram that resembles a fishbone that can show the cause and effect of a problem (John Bank, 1992). The fishbone diagram consists of 4M+E, man (human), method (method), machine (machine), material (production material), and environment (environment). These factors are useful for grouping the types of root causes into a category.

Adjustment Factor

The adjustment factor is to maintain and normalize the work shown by the operator. After the measurement takes place, if it is not normal to work, there is no seriousness shown by the operator (Sutalaksana, 2006). The adjustment factor in the measurement of working time is used to determine the normal time until the operator is in a certain process. If something unusual happens, the measurer needs to know and give a value according to the conditions that occur.
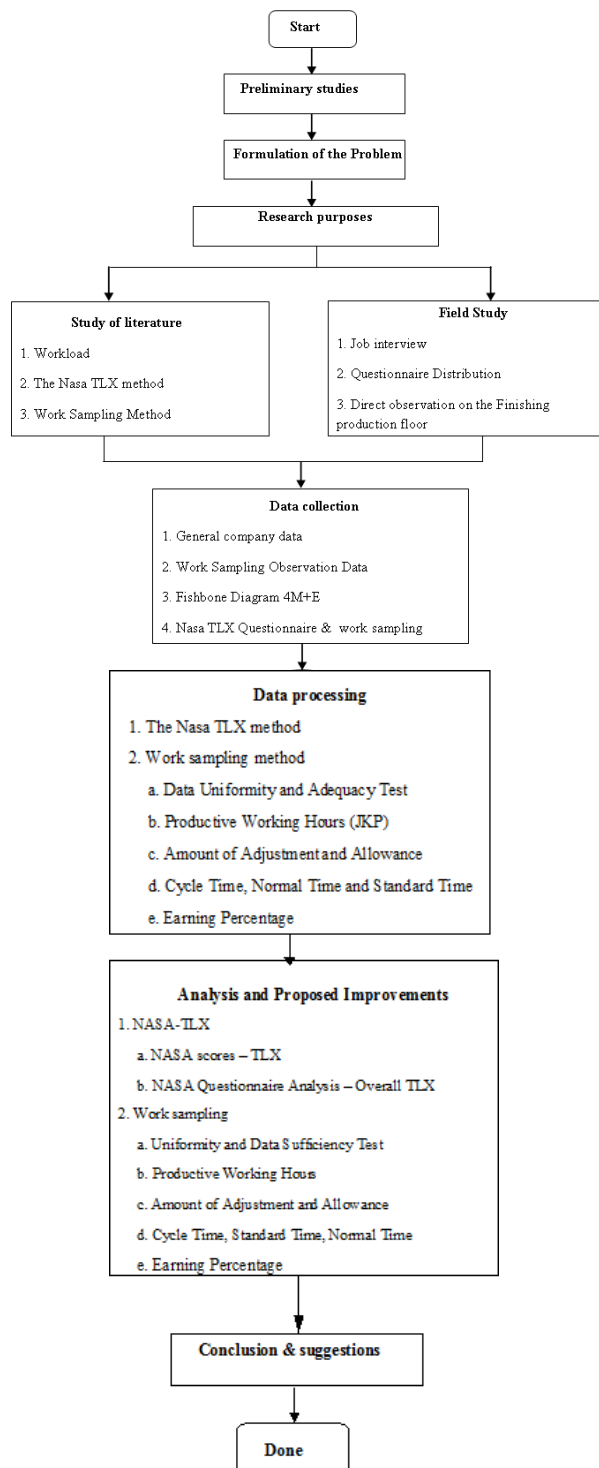
Research Methods

Figure 2. *Research flow chart*

Results and Discussion

NASA – TLX

After the workers fill out the weighting and rating questionnaires, the next step is to calculate the value of each indicator by multiplying the rating by the factor weight and calculating the Weight Workload (WWL).

Table 1. Calculation of indicator values and WWL

Stasiun Kerja	Nama	Aspek	Bobot	Rating	Rating x Bobot	WWL
Operator Finishing	Dede Nurholis	MD	3	100	300	1280
		PD	3	80	240	
		TD	3	90	270	
		OP	2	90	180	
		EF	1	80	80	
		ER	3	70	210	
Operator Finishing	Nurman	MD	2	70	140	960
		PD	4	50	200	
		TD	1	60	60	
		OP	1	80	80	
		EF	2	90	180	
		ER	5	60	300	
Operator Finishing	Rahma Purnomo	MD	1	90	90	1070
		PD	3	80	240	
		TD	3	80	240	
		OP	2	70	140	
		EF	3	50	150	
		ER	3	70	210	
Operator Finishing	Ryan Dwi S	MD	2	70	140	1050
		PD	5	50	250	
		TD	1	80	80	
		OP	3	90	270	
		EF	1	70	70	
		ER	3	80	240	
Operator Finishing	Andri andrianto	MD	2	60	120	1010
		PD	3	70	210	
		TD	4	60	240	
		OP	2	80	160	
		EF	2	70	140	
		ER	2	70	140	

Workload

The mental workload is calculated based on the results of distributing questionnaires that have been filled out by the respondents through 2 stages, namely the scale-matching stage and the scoring stage. Indicators on the questionnaire include Mental Demand, Physical Demand, *Temporal Demands, Effort, Own Performance* and Frustration. It can be seen in the graph below that there is 1 finishing operator, namely Dede Nurholis, which is included in the category of very high mental workload with a score of 85. Meanwhile, there are 4 operators included in the category of high mental workload, namely Nurman with a score of 64, Rahma Purnomo with a score of 71, Dwi Rian S with a score of 70 and Andri Andrianto with a score of 67. Of the 5 finishing operators who have the highest mental workload fatigue, Dede Nurholis.
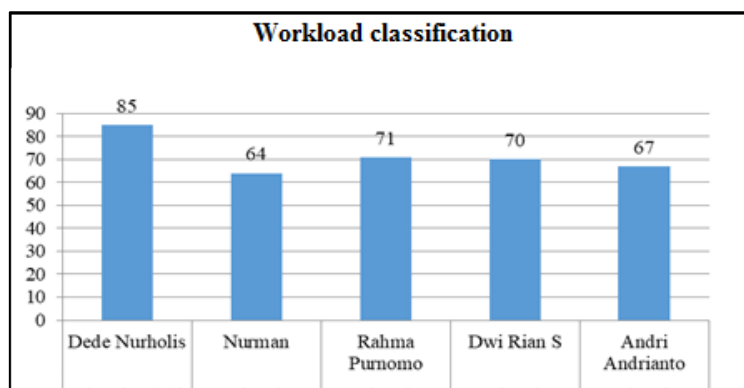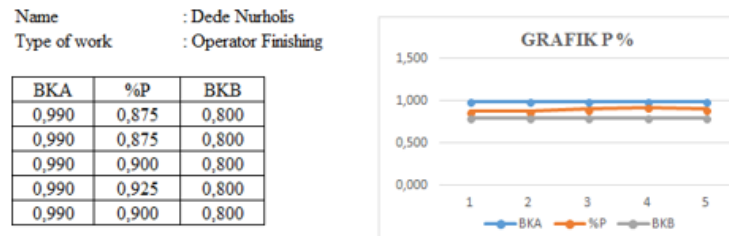

Figure 3. Graph of mental workload classification

Uniformity Test and Data Sufficiency Test

The data uniformity test was carried out to determine whether the data obtained were uniform or not. The data is said to be uniform if it does not exceed the upper control limit (BKA) and lower control limit (BKB). In this study, 95% confidence level and 5% accuracy level were used.

Name   : Dede Nurholis
Type of work : Operator Finishing

BKA	%P	BKB
0,990	0,875	0,800
0,990	0,875	0,800
0,990	0,900	0,800
0,990	0,925	0,800
0,990	0,900	0,800

Name Operator	Work Station	N'	N	Description
Dede Nurholis	Operator Finishing	180.27	200	enough data
Nurman	Operator Finishing	151.97	200	enough data
Rahma Purnomo	Operator Finishing	161.30	200	enough data
Ryan Dwi S	Operator Finishing	170.73	200	enough data
Andri Andrianto	Operator Finishing	170.73	200	enough data

Figure 4. *Uniformity test and operator data sufficiency test*

From the measurement results of the data adequacy test in chapter 4 the data of 5 operators is declared sufficient because N' < N. Where N is 200 which is obtained from the observation time data of 5 working days. Because the data is sufficien, it is not necessary to add data. The calculation data is continued to the next stage.

Determination of Productive Working Hours (JKP)

Table 2. *Determination of productive working hours (JKP)*

Name Operator	Work Station	Productive Working Hours (JKP)	Description
Dede Nurholis	Operator Finishing	142	Hours/Month
Nurman	Operator Finishing	146	Hours/Month
Rahma Purnomo	Operator Finishing	145	Hours/Month
Dwi Rian S	Operator Finishing	144	Hours/Month
Andri Andrianto	Operator Finishing	144	Hours/Month

Based on the calculation results, it was found that the highest productive working hours were Nurman with 146 hours/month, followed by Rahma Purnomo with 145 hours/month, and Dwi Rian S, Andri Andrianto with 144 hours/month. The results of these calculations can be caused by the heavy workload of operators who are rarely found unemployed when observing for 5 working days.

Determination of the Amount of Adjustments and Allowances

Table 3. Operator adjustments and allowances

No	Work Element	P	All
1	Take the Production order form in admin	1.1	0.28
2	Cleaning the work station desk	1.08	0.28
3	Take cutting pliers	1.05	0.19
4	Cutting the remaining supporting rods	1.06	0.20
5	Filing the remaining cuttings with a small rattan split file	1.07	0.28
6	Weigh the jewelry before sanding	1.13	0.29
7	Smooth the surface of the jewelry with sandpaper	1.06	0.28
8	Weighing jewelry after sanding	1.05	0.19
9	QC Checking Process on jewelry	1.04	0.19
10	Give From order QC to admin	1.05	0.19
11	Operate the soldering machine	1.05	0.19
12	Warming up the jewelry to be soldered	1.05	0.19
13	Take a stenlis container and alum water	1.05	0.19
14	Do the soldering process on jewelry	1.05	0.19
15	Inserting satong iron rod jewelry	1.05	0.19
16	Weighing jewelry after soldering	1.05	0.19

The adjustment used in this study is objective. Objective Method, there are two factors that must be considered for this method, namely the speed and difficulty of the work. These two factors are considered together to get normal time. Speed of work is speed in doing work in the usual sense. If the operator works normally, then p1=1. The speed is too high p1>1 and the speed is too slow p1.

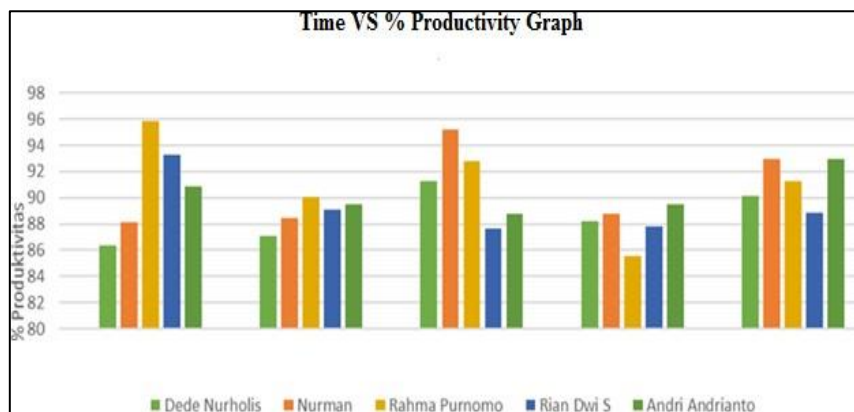**Comparison of Finishing Operator Productivity Distribution**

Figure 3. Comparison graph of finishing operator productivity distribution

In the graph above, it can be seen the difference in productivity between 5 operators during 5 days of observation. Where the highest graph occurs in operator Rahma Purnomo with an average value of 95%, then followed by Rian Dwi S with an average value of 93%, Nurman and Andri Andrianto have the same average value with a value of 92%.

Fishbone Diagram

Fishbone diagram is used to determine the factors that affect the workload experienced by finishing operators. The following will explain the causal relationship of the workload using a fishbone diagram. *Man* become the main factor in the fishbone diagram, due to the high level of fatigue due to work demands causing the operator to not be able to fully concentrate on doing his job, the high level of fatigue resulting from poor time management by the operator, causing operator work performance that is not optimal. *Method* being the second factor in the fishbone diagram, SOPs that are not fully implemented as a whole can result in some work not being carried out properly so that production results are not optimal. Work that is not optimal will certainly require re-examination which causes additional working hours. The method aspect also refers to the workload that must be completed quickly due to requests from consumers. *Material* third

factor in fishbone diagram which discusses the limitations of machine tools repair. Limited tools like workers have to give more effort because some work must be done manually. Work that is done manually and coupled with the number of orders or requests from consumers will certainly be burdensome or put a burden on workers. *Machine* is the fourth factor in the fishbone diagram which refers to the use of machine overhead. This can make the worker's time longer because workers are required to repair the system of the machine used and if it causes damage to the machine, the quality of the product will also be affected. The mismatch of product expectations with work related to product quality is due to the machine used by workers. *Environment* be the last factor in the causal analysis using a fishbone diagram. In the Environment aspect, it discusses the state of the work environment that is too noisy and the state of the room is messy. The work environment must of course always be considered in order to provide comfort to workers when carrying out activities. A noisy and dirty environment will cause an uncomfortable feeling when the operator is working. Decreased concentration will certainly result in lowering the performance of workers.

Conclusion

1. In the NASA-TLX method, it is known that there is 1 finishing operator, namely dede nurholis which is included in the category of very high mental workload with a score of 85 due to poor time management as seen from the number of non-productive work carried out so that the daily targets given by the company are not achieved. While there are 4 operators included in the category of high mental workload, namely Nurman with a scoreof 64, Rahma Purnomo with a score of 71, Dwi Rian S with a score of 70 and Andri Andrianto with a score of 67.

2. Fatigue is one of the causes of decreased productivity in employees. Based on the 4M+E analysis on the fishbone diagram, the man factor is the main problem causing the workload because the operator feels symptoms of excessive fatigue causing feelings of sluggishness, sleepiness, dizziness, lack of accuracy, lack of concentration, slow response and loss of enthusiasm for work with this fatigue. a decrease in employee productivity that affects the finishing process. In this process there is a decrease in gram weight before and after finishing. Based on the finishing productivity data, there are 5 operators who have a total value of gold gram losses exceeding the provisions given by the company.

3. There are 3 (three) factors that cause mental workload, namely lack of training and understanding of work for operators, poor time management and an inadequate work environment. The most dominant thing felt by finishing operators on the production floor is the demands of work from a human point of view. Because the work demands given by the company are evenly distributed between new employees and old employees. For the old employees, it is suggested to use headphones so as not to disturb the concentration of the new employees. Furthermore, the proposed improvements that can be made by PT. Abadi Korpora's passion is to design a product, which is a box that can be used in finishing work so that the gold flakes that are filed or sanded don't scatter on the table and can be collected for smelting so that there is a retrun which can reduce the loss of grams of gold. The following is a picture of the product proposal.
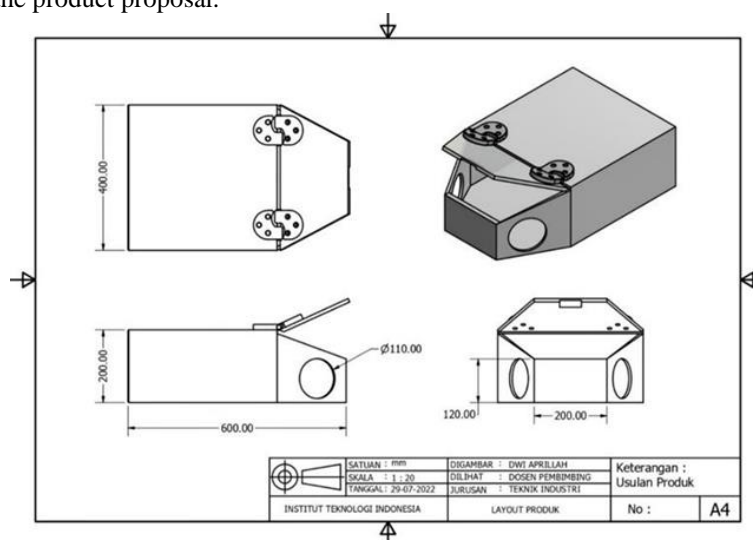
Reference

[1] Anita Pramesti, ES (2021, April 3). Workload Analysis Using the NASA - TLX Method on Cv. Happy Jaya Alsindo. Industrial Engineering, 5, 7.
[2] Theresia linda, R. g. (2021). The Influence of Age on Mental Workload in High Difficulty Assembling Plant

A Case Study at PT Surya Toto Indonesia. industrial engineering.

[3]   Gisya Amanda Yudhistira, MA (2020). Analysis of Worker Mental Load for Improvement of Work System on XYZ Convection with NASA-TLX Method.

[4]   Afma, VM (2016). Analysis of Inspection Operator Workload Using the NASA-TLX Method. Industrial Engineering.

[5]   Muharram, IM (2020). Analysis of the Effect of Shift Work on the Mental Workload of Nurses at the General Hospital of the University of Muhammadiyah Malang (Doctoral dissertation, University of Muhammadiyah Malang).

FACE MASK WASTE: NEW ENVIRONMENTAL PROBLEM DURING COVID-19 PANDEMIC

Sophia Shanti Meilani, Muhammad Fahmi Dharmawan and Dovina Navant
Environmental Engineering Department, Universitas Bhayangkara Jakarta Raya, Indonesia

Abstract.
Wearing mask is very essential in doing activities during COVID-19 pandemic. Many studies have revealed that wearing mask could prevent infection of COVID-19. However, single use face mask created new problem, which is discarded mask waste. This study aims to identify discarded mask quantity and public knowledge in mask waste management, particularly in Sumber Jaya Village, Bekasi District. The majority of resident in mentioned location are industrial and retail sector workers. The study was performed by distributing questionnaire concerning the quantity of discarded waste daily, mask waste disposal method, and knowledge of mask waste disposal. Selected respondents were workers who actively worked outside the house every day. Commonly used mask types were KN-95, KF 94, duckbill, medical mask, and fabric mask. Based on this study result, mask waste quantity based on the type were 0.16 kg/day for KN-95, 0.19 kg/day for KF94, 0.09 kg/day for duckbill waste, and 0.29 kg/day for 3-ply medical waste. Most of the respondents (92%) did not know that mask waste should be disposed in dedicated waste container. Majority of respondents (93%) have not known that mask waste should be disinfected prior to disposal. Mask waste was commonly disposed of without being destroyed first. Considering that the quantity of mask waste is increasing and knowledge in mask waste management is still low, many efforts shall be conducted to prevent negative impact to the environment.

Keywords: *Face mask, Waste, COVID-19, Management, Disposal*

Introduction

COVID-19 pandemic has changed people's daily routine all over the world. Face mask, disposable gloves, personal protective equipment, and hand sanitizer become mandatory. Face mask is essential to reduce the risk of COVID-19 infection from droplets. During COVID-19 pandemic, there is also significant increase of waste quantity, which was caused by the use of disposable face mask, gloves, plastic packaging, etc. in Jakarta, the amount of medical waste was expected to increase to 212,000 kg/day (Tripathi et al., 2020). Disposable face mask is commonly made of polypropylene, high density polyethylene, and other polymers (Prata et al., 2021). It has been reported that face mask waste was disposed incorrectly causing plastic pollution worldwide (Prata et al., 2021). Face mask, which mainly derived from petrochemical polymers, is not easily decomposed in open environment (Silva et al., 2021). Such materials will cause problems to wildlife, such as disruption in food intake, reproduction, and furthermore will cause death (Selvaranjan et al., 2021). If only 1% of face mask wastes are disposed directly to the environment, it would result in 40,000 kg plastic waste per month in nature (WWF, 2020).

In Indonesia, infectious waste has increased by 30% during COVID-19 pandemic (Ministry of Environment and Forestry, 2020). Face mask waste has become problems in many cities in Indonesia. Bekasi is an urban area in Indonesia, where many people works for industrial sector. Due to pandemic condition, it is compulsory to wear mask during work to avoid COVID-19 infection. The study was performed in Sumber Jaya village, Bekasi Region where 87,147 people resides and most of the resident work for industrial and retail sector.

This study aims to identify the quantity of face mask waste generated from daily activities, especially in area where most of the residents were active workers. The study also involved face mask waste management during COVID-19 pandemic.

Methods

Data was collected through online survey to maintain physical distancing during COVID-19 pandemic. Simple random sampling was used as sampling technique. The number of respondents for this research was 135 people. All of respondents were active workers who work daily and wear face mask during work. The survey was conducted to identify the type of mask that were used, the number of masks used per day, how people disposed of face mask waste, and their knowledge concerning face mask waste management.

Result and Discussion

Online survey result indicated that the range of respondents' age were between 18-36 years old, detail percentage of each age group is shown in Figure 1. The respondents wear mask every day when they went to work. The type of face mask that the respondents used daily were 3-ply mask, duckbill mask, KN-95, and KF-94. The most commonly used type pf face masks were 3-ply mask and duckbill mask. A study in several countries (Australia, America, UK,

Singapore, Sri Lanka, and India) shown that 40% of people used surgical mask, 9% of people used N95 mask, and 15% of people used both surgical and N95 mask (Selvaranjan et al., 2021). Surgical mask or 3-ply mask are frequently used as they provide protection against droplet and are cheaper than N95 mask.
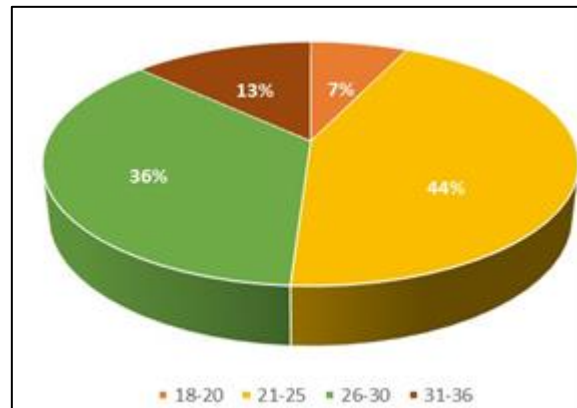
Figure 1. Age group of online survey respondents

Duration for wearing a piece of face mask was ranged from 2 to more than 8 hours. Most of the respondents (51%) used face mask for 8 hours, as detailed in figure 2. A study about the use of face mask in Poland also revealed that the most common duration of mask used per day is more than 5 hours (Matusiak et al., 2020).
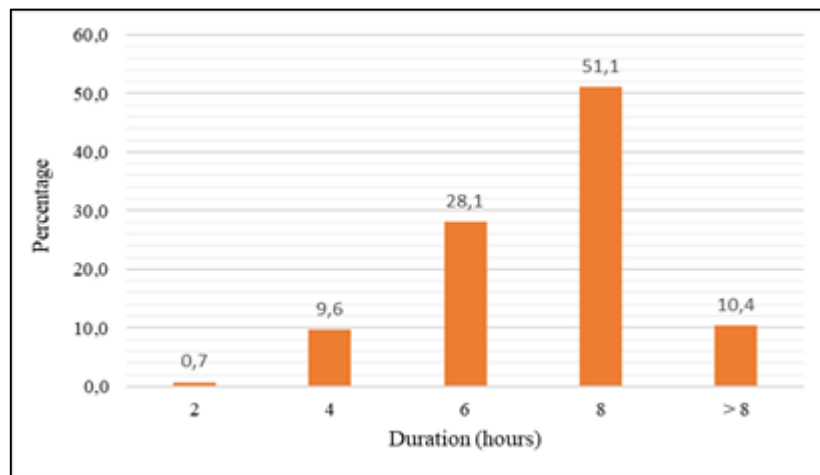
Figure 2. Duration of wearing face mask

Based on the survey, the number of face mask waste generated from 135 people on daily basis was 231 pieces. The quantity of each type of face mask waste is described in Table 1. Total face mask waste quantity from 135 respondents was 0.735 kg/day or 0.005 kg/person/day.

Table 1. The quantity of face mask waste

Type of Mask	Number of Used Mask (pieces/day)	Face Mask Waste Weight (kg/day)
KN95	31	0.155
KF94	40	0.192
Duckbill	47	0.094
3-ply Face Mask	113	0.2938

According to regulation (Ministry of Environment and Forestry, 2021), infectious waste and COVID-19 related waste shall be managed as follows:

1. They shall not be mixed with other domestic waste
2. Face mask waste shall be destroyed (by cutting or tearing) prior to disposal
3. Face mask waste shall be disinfected
4. The waste shall be stored in closed and safely fastened trash bag

The majority of respondents (92%) stated that face mask waste was disposed of in the regular trash bin and mixed with other waste. Survey in another city in Indonesia, i.e. Surabaya, also revealed that 83,6% of respondents did not segregate infectious waste and domestic waste (Juwono & Diyanah, 2021). Many people were still not aware of the importance of segregating COVID-19 related waste from other domestic waste. COVID-19 related waste is required to be segregated to allow specific treatment, i.e. thermal treatment, and avoid pathogen contamination (Prata et al., 2021). There were also people who just throw away face mask waste due to lack of knowledge. Significant increase of face mask waste was found in two rivers in Jakarta Bay during COVID-19 pandemic which raised health and environmental concerns (Cordova et al., 2021).

This study also indicated that 72% of respondents destroyed face mask waste by cutting or tearing but 93% of respondents did not disinfect face mask waste prior to disposal. Many people are knowledgeable to destroy waste face mask but still unaware to disinfect the waste. It is compulsory that COVID-19 related waste is disinfected and segregated from other waste prior before being discarded to waste disposal facilities (Amuah et al., 2022). Destruction and disinfection of face mask waste are required to avoid reuse of face mask waste and prevent the spread of the virus (Tripathi et al., 2020).

The significant quantity of face mask waste and lack of knowledge in COVID-19 related waste management generate health and environmental problems. Tons of disposable face mask accumulated in natural environment with the potential to cause disruption in ecosystem. Proper containment, collection, and thermal destruction for COVID-19 related waste are needed to avoid waste contamination to the environment. Information dissemination and education program related to the proper mask disposal shall be performed to resolve the current condition.

Conclusion

There is significant change in waste quantity during COVID-19, particularly face mask and PPE waste. Based on this study, face mask waste generation rate from active workers was 0.005 kg/person/day. Face mask waste from active workers in Indonesia may reach up to 720,000 kg/day. Most of COVID-19 related waste was still mixed with other waste and discarded directly to the environment. This practice shall be resolved to prevent further problems to the environment. Management of COVID-19 related waste shall be improved and public awareness shall be promoted.

References

[1]   Amuah, E. E. Y., Agyemang, E. P., Dankwa, P., Fei-Baffoe, B., Kazapoe, R. W., & Douti, N. B. (2022). Are used face masks handled as infectious waste? Novel pollution driven by the COVID-19 pandemic. *Resources, Conservation and Recycling Advances*, *13*. https://doi.org/10.1016/j.rcradv.2021.200062

[2]   Cordova, M. R., Nurhati, I. S., Riani, E., Nurhasanah, & Iswari, M. Y. (2021). Unprecedented plastic-made personal protective equipment (PPE) debris in river outlets into Jakarta Bay during COVID-19 pandemic. *Chemosphere*, *268*. https://doi.org/10.1016/j.chemosphere.2020.129360

[3]   Juwono, K. F., & Diyanah, K. C. (2021). Analisis pengelolaan sampah rumah tangga (sampah medis dan non medis) di kota Surabaya selama pandemi COVID-19. *Ekologi Kesehatan*, *20*(1), 12–20.

[4]   Matusiak, Ł., Szepietowska, M., Krajewski, P. K., Białynicki-Birula, R., & Szepietowski, J. C. (2020). The use of face masks during the COVID-19 pandemic in Poland: A survey study of 2315 young adults. *Dermatologic Therapy*, *33*(6), 3–5. https://doi.org/10.1111/dth.13909

[5]   Ministry of Environment and Forestry. (2020). *KLHK Perkuat Regional Untuk Respon Limbah Infeksius COVID-19*. http://ppid.menlhk.go.id/siaran_pers/browse/2477

[6]   Ministry of Environment and Forestry. (2021). *Pengelolaan Limbah B3 dan Sampah Dari Penanganan Corona Virus Disease-19 (COVID-19)* (pp. 1–5).

[7]   Prata, J. C., Silva, A. L. P., Duarte, A. C., & Rocha-Santos, T. (2021). Disposable over reusable face masks: Public safety or environmental disaster? *Environments - MDPI*, *8*(4), 1–10. https://doi.org/10.3390/environments8040031

[8]   Selvaranjan, K., Navaratnam, S., Rajeev, P., & Ravintherakumaran, N. (2021). Environmental challenges induced by extensive use of face masks during COVID-19: A review and potential solutions. *Environmental Challenges*, *3*. https://doi.org/10.1016/j.envc.2021.100039

[9]   Silva, A. L. P., Prata, J. C., Mouneyrac, C., Barcelò, D., Duarte, A. C., & Rocha-Santos, T. (2021). Risks of Covid-19 face masks to wildlife: Present and future research needs. *Science of the Total Environment*, *792*. https://doi.org/10.1016/j.scitotenv.2021.148505

[10]   Tripathi, A., Tyagi, V. K., Vivekanand, V., Bose, P., & Suthar, S. (2020). Challenges, opportunities and progress in solid waste management during COVID-19 pandemic. *Case Studies in Chemical and Environmental Engineering*, *2*(November). https://doi.org/10.1016/j.cscee.2020.100060

[11]   WWF. (2020). *In the disposal of masks and gloves, responsibility is required*. https://www.wwf.it/pandanews/ambiente/nello-smaltimento-di-mascherine-e-guanti- serve-responsability/

THE EFFECT OF COMPARATIVE MATERIALS AND SOLUTIONS ON THE LEVELS OF AVOCADO LEAF EXTRACT FLAVONOIDS (Persea americana mill)

Rismayenti[1], Tri Yuni Hendrawati[1], Ummul Habibah Hasyim[1*], Wan Azmi bin Wan Hamzah[2]
[1]Department of Chemical Engineering, Department of Chemical Engineering, Faculty Of Engineering, Universitas Muhammadiyah, Jakarta, Indonesia
Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Gambang, Kuantan
*ummul.hh@umj.ac.id

Abstract.
Avocado leaves (Persea americana mill) contain flavonoid compounds rich in antioxidants and can be used as raw materials for making natural antibacterial hand sanitizer. This study aims to extract the content of flavonoid compounds contained in avocado leaves and get the best yield from 5 comparisons of materials and solvents as well as the highest flavonoid levels. The method used in this study was the extraction of maceration using ethanol solvents 96 % then made a comparison variation of materials and solvents (1:5, 1:10, 1:15, 1:20, 1:25 b/v) with a length of soaking of the material for 24 hours. The obtained maceration results are filtered and glued with rotary vacuum evaporator. The extract is then analyzed flavonoid levels with kuersetin as a standard comparison that has been known with certain flavonoid content. In this study obtained the best yield on the comparison of dried avocado leaves and ethanol 1:25 which is 6,267 %. The highest total flavonoid content obtained in the comparison of dried avocado leaves and ethanol 1:5 is 3.1724 mgQE/gram extract with the equation $y = 0.07173x – 0.00213$, and $R^2 = 0.99998$.

Keywords: *ramie, cellulose, nitration, nitrocellulose*

Introduction

Indonesia is a tropical country that is rich in various plants that have many benefits. Almost all parts of the plant can be used for various needs. One of the plants that are rich in benefits is the avocado plant. Avocado is a fruit plant that belongs to the Lauraceae family which is easy to find, especially in highland areas with high rainfall. The part of this plant that is often used is avocado fruit or flesh as various preparations that are rich in protein, fat and vitamins. In addition, avocado leaves and seeds also have benefits that are no less far than the fruit. Avocado leaves and seeds are often used as traditional medicine (Duarte et al., 2016).

In this study, the authors used avocado leaves as a raw material for making natural antibacterial hand-sanitizers. Avocado leaves contain bioactive components such as flavonoids, phenols, saponins, tannins and alkaloids. The compounds with the highest content in avocado leaves are flavonoids (Arukwe et al., 2012).369 / 5.000 Flavonoids are polar compounds because they have a number of unsubstituted hydroxyl groups. These flavonoid compounds can be used as anti-microbial, wound infection medicine, anti-fungal, anti-viral, anti-cancer, and anti-tumor. In addition, flavonoids can also be used as anti-bacterial, anti-allergic, cytotoxic, and anti-hypertensive (Sriningsih, 2008).

Methode

This research was conducted at the Chemical Engineering Laboratory, Faculty of Engineering, University of Muhammadiyah Jakarta for 3 months. The materials used include: avocado leaves, 96% ethanol, HCl, aquades, Mg powder, quercetin standard, AlCl3, CH3COONa, whatman filter paper, and aluminum foil. The tools used include: blender, analytical balance, glass bottles 500 and 700 Ml, funnel, 500 mL erlenmeyer, rotary evaporator, oven, evaporating dish, desiccator, water bath, test tube, watch glass, measuring cup 50 mL and 500 mL , 250 mL beaker glass, 10 mL measuring pipette, 1, 2, 3, 4 and 5 mL volumetric pipettes, dropper pipettes, 10, 25, 50 mL volumetric flasks, and spray bottles.

The stages of Avocado Leaf Extraction and Yield Obtaining were carried out in several stages, including: the avocado leaf refining process was carried out by cleaning the avocado leaves with water and then drying them by aerating. The dried avocado leaves are mashed using a blender. Avocado leaf extraction was carried out with a mass of 20 grams and added 96% ethanol solvent, then the solution was put into a glass bottle. Repeat 5 times. Add 96% ethanol solvent.

Table 1. Comparison of 96% ethanol solvent

Ratio	Solvent (mL)
1 : 5	100
1 : 10	200
1 : 15	300
1 : 20	400
1 : 25	500

The entire side of the glass bottle is wrapped with aluminum foil to prevent oxidation. Then let stand for 24 hours at room temperature while occasionally shaking. The solution was filtered through Whatman filter paper until a clear solution was obtained. Concentration and drying of avocado leaf extract was carried out by evaporating the filtrate with the solvent using a rotary evaporator. This process is stopped when there is no more condensed solvent. The liquid extract obtained was then evaporated using a water bath to obtain a thick extract. The thick extract was weighed to determine the best yield from each comparison and tested for flavonoid content. The method of analysis of the results was carried out using the Spectrophotometric Analysis method to determine the maximum wavelength and the levels of flavonoid compounds in avocado leaf extract were tested by means of a UV-Vis Spectrophotometer.

The analysis equation is as follows:

Yield Percentage Calculation

$$\text{Yield} = \frac{\text{Extract weight}}{\text{Avocado left weight}} \times 100\%$$

Calculation of Levels of Flavonoid Compound

Measurement of the spectrum of flavonoid compounds using a UV-Vis Spectrophotometer instrument with a wavelength of 435 nm. Then compared with standard quercetin.

$$Y = a + bX$$

Y = Dependent variable (prediction value) X = Independent variable
a = Constant (intercept on graph)
b = Regression coefficient (slope on graph)

$$\text{Total rate}: \frac{\text{Concentration}\left(\frac{mg}{L}\right) \times Vol\ spl\ (L)}{\text{weight}\ spl\ (gr)} \times FP$$

Qualitative Testing of Flavonoid Compounds

This is done by weighing 50 mg of avocado leaf extract. Add 5 drops of hot water then stir.
Add 1 mL of concentrated HCl. Add 10 mg of Mg powder. Avocado leaf extract is positive for flavonoids if there is a change in color from red orange to red purple.

Quantitative Testing of Flavonoid Compounds

Quercetin standard solution 10 mg of quercetin standard was carefully weighed and put into a 100 ml volumetric flask. 96% ethanol solvent was added to the mark, then homogenized (100 ppm). Prepare 5 50 mL volumetric flasks to make standard series with concentrations of 2, 4, 6, 8 and 10 ppm. Pipette solutions of 1, 2, 3, 4, and 5 mL each were added to a 50 mL volumetric flask. 96% ethanol solvent was added to the mark, then homogenized. 1 mL of each concentration was pipetted, then 1 mL of 10% AlCl3 and 1 mL of 1 M sodium acetate were added. The solution was incubated for 30 minutes at room temperature.

Sample solution

Weighed 15 mg of each avocado leaf extract and dissolved in 10 mL of 96% ethanol. 1 mL of each solution was pipetted and 1 mL of 10% AlCl3 and 1 mL of 1 M sodium acetate were added. The solution was incubated for 30 minutes at room temperature.

Blank solution

Pipette 1 mL of 96% ethanol then add 10% AlCl3 and 1 mL of 1 M sodium acetate. Incubate for 30 minutes at room temperature

Assay with UV-Vis Spectrophotometer

Measure the maximum of the standard solution at a wavelength between 300–600 nm. Measure the absorbance of the standard solution and the sample solution at a wavelength of ±435 nm.

Result and Discussion

Avocado Leaf Extract Yield Results

The results of the extraction of avocado leaves which were carried out by the maceration extraction method were tested for the yield, namely comparing the results of the avocado leaf extract obtained with the initial weight of the avocado that was weighed.

Tabel 2. Yield results on various comparison of materials and solvents

No.	Ingredient: Solvent	Dried Avocado Leaf Weight (gram)	Extract Weight (gram)	Yield (%)
1.	1 : 5	20.0000	0.5442	2.7210
2.	1 : 10	20.0000	0.8250	4.1250
3.	1 : 15	20.0000	0.9142	4.5710
4.	1 : 20	20.0000	1.1883	5.9415
5.	1 : 25	20.0000	1.2534	6.2670

Qualitative Testing of Flavonoid Compounds

To determine the presence of flavonoid compounds in avocado leaves, a qualitative identification test was carried out. Avocado leaf extract is positive for flavonoid compounds if the color changes to red orange to red purple.

Table 3. Observation results of qualitative testing of flavonoid compounds of avocado leaf extract in various comparison of materials and solvents

Step	Ratio	Observation
Hot water	1 : 5	Fixed color (brown yellow)
	1 : 10	
	1 : 15	
	1 : 20	
	1 : 25	
HCl	1 : 5	Brown yellow
	1 : 10	
	1 : 15	
	1 : 20	
	1 : 25	

Flavonoid Quantitative Test

Quantitative testing is in the form of absorbance measurements to calculate the levels of flavonoids in avocado leaf extract. The wavelength of 435.0 nm is the maximum wavelength of flavonoids. The following is the test data from the avocado leaf extraction research that has been carried out:

Table 4. *Measurement results of quercetin standard series*

No.	Concentrate	Absorbance
1	0 ppm	0.0000
2	2 ppm	0.3408
3	4 ppm	0.3337
4	6 ppm	0.2725
5	8 ppm	0.1493
6	10 ppm	0.1410

This research was conducted to utilize the flavonoid compounds contained in avocado leaves by extraction with the maceration method. Avocado leaves were soaked in 96% ethanol solvent for 24 hours and then continued with the filtering and concentration process. The viscous extract obtained was then calculated its yield, tested for qualitative identification and determined using the spectrophotometric method. The yield in question is the ratio between the weight of the extraction results and the weight of the raw materials used for the extraction process.

Table 5. *Test results for avocado leaf extract flavonoid levels*

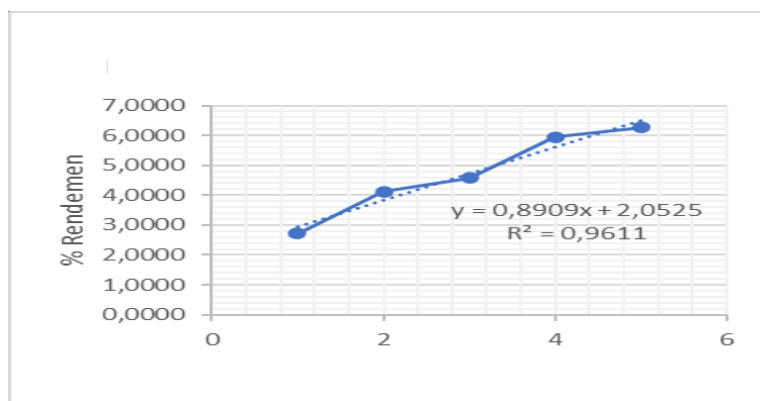| No	Ingredient: Solvent	Yield of Flavonoid (mgQE/ grain ekstrak)
1	1 : 5	3.1724
2	1 : 10	3.0944
3	1 : 15	2.5339
4	1 : 20	1.4027
5	1 : 25	1.3241

Figure 1. *Effect of comparison of dried avocado leaves with ethanol on yield*

From Figure 1, the results of the linear regression Y = 0.0089X + 2.0525 with R2 = 0.9611. Where X is the ratio of dried avocado leaves with ethanol and Y is the percentage yield. The best yield is found in a ratio of 1: 25 with the amount of ethanol 500 mL, which is 6.267%. From the graph, it can be seen that the more the amount of ethanol used, the greater the yield obtained. This is because the more volume added, the stronger the solvent penetrates the cell wall and enters the cell cavity containing the active substance. To determine the content of avocado leaf extract, quercetin standard was used as a comparison solution whose wavelength measurement was determined first. From the measurement results, the maximum wavelength is obtained at 435.0 nm. Then the standard absorbance measurement was carried out using the maximum wavelength. From Figure 4.2, we get the linear regression equation Y = 0.07173X – 0.00213 with R2 = 0.99998.

Conclusion
From this research it can be concluded as follows
1. Flavonoid compounds can be obtained by extracting avocado leaves using the maceration method to produce a thick, brown extract.
2. From the results of the comparison study of dried avocado leaves and ethanol solvent, the best yield was obtained at a ratio of 1: 25, which was 6.267%.
3. Positive avocado leaf extract contains flavonoid compounds because the color changes to red-orange.
4. From quantitative testing, the highest flavonoid content was 3.1724 mgQE/gram extract, namely the ratio of dried avocado leaves to ethanol 1: 5.

References
[1] Antia, B.S., J. Okokon dan PA Okon. 2005. Hypoglycemic activity of aqueous leaf extract of Persea Americana Mill. Research Letter, 37 (5): 325-326.
[2] Arukwe, B.A., M.K. Duru, E.N. Agomuo, E.A. Adindu. 2012. Chemical Composition of Persea Americana Leaf, Fruit and Seed. International Journal of Recent Research and Applied Studies. 11 (2):346-349.
[3] Asolu, M.F., S.S. Asaolu, J.B. Fakunle, B.O. Emman, Okon, E.O. Ajayi, R.A Togun.2010. Evaluation of in-vitro Antioxidant Activities of Methanol Extracts of Persea americana and Cnidosculus aconitifolius. Pakistan Journal of Nutrition. 9 (11) : 1074-1077.
[4] Darwis, D. 2000. *Teknik Dasar Laboratorium Dalam Penelitian Senyawa Bahan Alam Hayati, Workshop Pengembangan Sumber Daya Manusia Dalam Bidang Kimia Organik Bahan Alam Hayati.* Padang : Universitas Andalas.
[5] Departemen Kesehatan. 2020. *Parameter Standar Umum Ekstrak Tumbuhan Obat.* Cetakan 1,10,17-19. Jakarta : Dirjen POM, Depkes RI.
[6] Duarte, J., Rodriguez, F., Caleya, D., Valdivelso, M.A., Antoranz, J.C., Rubio, M.A., Barreno, P., Canizo, J.F. 1989. Blood Biochemistry Values of Sheep.Comp. Biochem. Physiol. Vol 94 A, No. 4:717-71.
[7] Lopez, V.M.G. 2002. Fruit Characterization of Hight Oil Content Avocado Varieties. Scientia Agricol 59(2):403-406.
[8] Marjoni, R. 2016. *Dasar-Dasar Fitokimia untuk Diploma III Farmasi.* Jakarta : Trans Info Media.
[9] Markham, K.R. 1988. Techniques of Flavonoid Identification. London: Academic Pr.Markham, K.R. 1988. Techniques of Flavonoid Identification. London: Academic Pr.
[10] Marzouk, M.M. (2016). Flavonoid Constituents And Cytotoxic Activity Of Erucaria Hipanica (L.) Druce Growing Wild In Egypt. Arabian Journal Of Chemistry, 9, 411– 415.
[11] Nuramalia, W. (2019). *Evaporator Design Pada Pabrik Sorbitol Menggunakan Bahan Baku Dekstrosa Dengan Proses Hidrogenasi Katalitik.* Semarang: Universitas Negeri Semarang.
[12] Paramawati, R. 2016. Khasiat Ajaib Daun Avocad. Penebar Swadaya : Jakarta.
[13] Putri, E. T., & Afriliana, C. (2018). *Pra Rencana Pabrik Pembuatan Etil Asetat Dari Etanol Dengan Kapasitas 77.000 Ton/Tahun.* Palembang: Universitas Sriwijaya.
[14] Qinghu, W., Jinmei, J., Nayintai, D., Narenchaoketu, H., Jingjing, H., Baiyinmuqier, B. (2016). Anti-Inflammatory Effects, Nuclear Magnetic Resonance Identification And High-Performance Liquid Chromatography Isolation Of The Total flavonoids From Artemisia Frigida, Journal Of Food And Drug Analysis, 24, 385-391.
[15] Sari, Mei Ambar. 2015. *Aktivitas Antioksidan Teh Daun Alpukat (Persea americana mill) dengan Variasi Teknik dan Lama Pengeringan.* Surakarta : Universitas Muhammadiyah Surakarta.
[16] Sembiring, B. 2007. Teknologi Penyiapan Simplisa Terstandar Tanaman Obat. Warta Puslitbangbun Vol 13 No 12 .Balitro.litbang.depta.go.id
[17] S hakhashiri. 2009. Chemical of the Week : Ethanol.Scifun Online. Home page online. Available from : http://scifun.chem.wisc.edu/chemweek/pdf /ethanol.pdf. Internet; accessed 1 Juni 2021.
[18] Sriningsih. 2008. Analisa Senyawa Golongan Flavonoid Herba Tempuyung (*Sonchusarvensis* L) : www.indomedia.com/intisari/ 1999/juni/tempuyung. htm. Diakses tanggal 1 Juni 2021
[19] Sunarjo, H. 1998. Prospek Berkebun Buah. Penebar Swadaya : Jakarta.

[20]   Supriatna, A. (2008). *Uji Performansi Dan Analisa Teknik Alat Evaporator Vakum.* Bogor: Institut Pertanian Bogor.

[21]   Vanessa, M. Munhoza, R. L., José R.P., João, A.C., Zequic, E., Leite, M., Gisely, C., Lopesa, J.P., Melloa. (2014). Extraction Of Flavonoids From Tagetes Patula: Process Optimization And Screening For Biological Activity. Rev Bras Farmacogn, 24, 576-583.

ANALYSIS OF WORKLOAD ON CUTTING OPERATOR USING NASA - TLX METHOD ANDWORK SAMPLING IN CV MULYA JAYA ABADI

Mad Yusuf, Ni Made Sudri
Industrial Engineering, Institut Teknologi Indonesia, South Tangerang, Indonesia, 15314

Abstract.
CV Mulya Jaya Abadi is engaged in the bag industry. In this study, the workload analysis of the cutting section is carried out to analyze the level of physical workload and mentalworkload and whether the workload needs to be improved. The method used in this study using the NASA-TLX method and sampling test. The NASA - TLX method is used to measure mental workload objectively, while the dimensions of mental workload on NASA- TLX are mental needs, physical needs, time requirements, performance, effort, and stress levels. Sampling test is a technique for conducting a large number of observations on work activities. Complaints for operators where the work is done standing up, feeling sluggish, sleepy when working not concentrating so that the operator experiences fatigue and results ina workload for the operator. Based on the results of the study using a sampling test where observations were made five working days, from the calculation of the uniformity test and the data adequacy test, the data was uniform and sufficient. The results of the average calculation that cutting operators are indicated in the category of productive workers with Gunawan percentage 88.44%, Segat 89.33%, Ariyadi 88.00%, and Parid 87.55%, the results of the physical workload for Gunawan operators get the results 128%, Segat operators 153%, Ariyadi operators 138%, and for Parid operators 136%. and for the calculation of workload using the NASA-TLX method, the most dominant aspect is the physical requirement of 26%, because of the physical activity required in the work, so that the operator experiences fatigue. For mental needs due to the operator in his work requires concentration.

Keywords: Physical Workload, Mental Workload, NASA – TLX, Sampling Test

Introduction

At work, it is often associated with feeling tired and stress which can reduce the concentration of workers when doing work so that it can cause the risk of work accidents. Everyone has a different workload. Manual work causes physical and mental workloads, therefore mental and physical workloads are needed for workers to be able to find out whetherthe work performed by workers includes a safe workload over a long period of time. CV Mulya Jaya Abadi is engaged in the bag industry, in this production section the workers consist of: cutting, preparing, sewing, qc, and packing. In this study of process workers cutting, which consists of 4 people. Problems that occur in process employees cutting. This is the amount of work that must be completed by the operator to achieve the target, complaints for operators where the work is done standing up, feeling sluggish, sleepy when working, not concentrating so that the operator experiences fatigue and results in a workload for the operator. To find out this problem, it is necessary to research the mental workload and productivity of operator workers cutting. The method in this study uses the Nasa TLX method (Task Load Index) Nasa TLX is a subjective method of measuring mental workload. This method is divided into two parts, namely the stage of scale comparison and giving value tothe work. The Nasa TLX method has the advantage that it is suitable for various types of work and each assessment factor is able to provide information about workloads. Work sampling is a technique for conducting a large number of observations of work activities. Workload measurement using work sampling used to calculate the standard time, standard production, workload and the amount of labor required. Method work sampling can be used to determine productive and non-productive activities. This study analyzes the level of physical and mental workload experienced by section operators cutting for evaluation and improvement solutions.

Literature Review
a. NASA – TLX

The NASA-TLX method (NASA*Task Load Index*) is a method used to measuremental workload subjectively based on six dimensions, namely mental needs, physical needs, time requirements, performance, effort, and frustration levels. The measurement ofthis method is divided into two stages, namely the comparison of each scale and the valueof the work. The following is the measurement of the NASA-TLX method:

- Weighting
  At this stage, respondents are asked to choose one of the two indicators that are felt to be more dominant in causing mental workload to the work done. The NASA- TLX questionnaire was given to workers in the form of pair wise comparisons and thencalculated the number of tallies for each indicator that workers felt was the most influential.

- Rating
  At the rating stage, respondents were asked to rate the six indicators of mentalload. The rating given is subjective depending on the mental burden felt by the workerrespondents. To get the NASA-TLX mental load score, the weights and ratings for each indicator are multiplied and then added and divided by 15.

- Calculating Product Value

    Calculating the value of this product is obtained by multiplying the rating by the weight factor for each descriptor. Thus, 6 product values are produced for 6 indicators, namely mental needs, physical needs, time requirements, performance, frustration levels, and effort:

$$Product = Rating \; X \; Weight \; factor$$

- Count Weighted Workload (WWL)

    Obtained by adding up the six product values

$$WWL = \sum Product$$

- Calculating the average WWL

    Obtained by dividing WWL by the total weight

$$Score = \frac{\sum Product}{15}$$

- Score Interpretation

    The interpretation of the mean score of WWL is referring to the categories definedby Hart and Staveland (1988).

Table 1. Score interpretation

Load Range Work	Load Category Work
0-9	Very low
10-29	Low
30-49	Currently
50-79	Tall
80-100	Very high

b. Work Sampling

Work samplingis a technique for conducting a large number of observations of the work activities of machines, processes or operators. Measurement with this method is the same as measuring work with downtime which is classified as direct work measurement because the implementation must be directly at the workplace. Broadly speaking methodwork samplingcan be used to measuredelay ratioof a number of machines, employees. Then can set performance levelof a person during his working time based on the times when this person works or does not work, especially for manual work, this work sampling method can be used to determine the standard time for a process or workoperation.
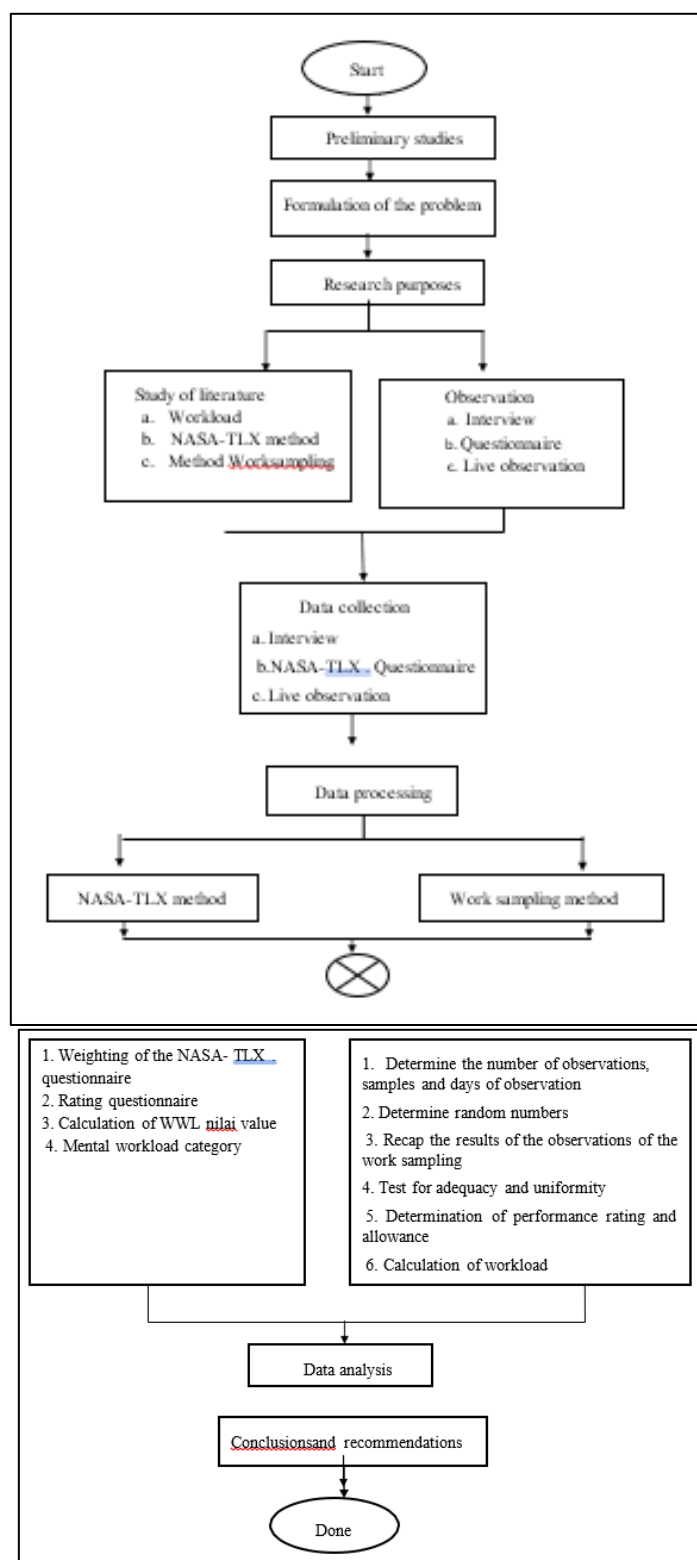
Research Methods

Figure 1. Flowchart

Result and Discussion
a. NASA-TLX method
Weighting of NASA TLX Questionnaire Results

Table 2. Questionnaire weighting data

Number	Name	Indicator						Total
		Mental Demand	Physical Demand	Temporal Demand	Performance	Effort	Frustration Level	
1	Gunawan	1	3	4	2	4	1	15
2	Segattulloh	3	3	4	1	2	2	15
3	Ariyadi	2	3	2	4	4	0	15
4	Parid	2	4	1	3	2	3	15

Rating

Table 3. Rating value

Number	Name	Indicator						Total
		Mental Demand	Physical Demand	Temporal Demand	Performance	Effort	Frustration Level	
1	Gunawan	70	70	80	90	80	70	460
2	Segattulloh	70	90	50	70	70	50	400
3	Ariyadi	60	90	70	50	70	80	420
4	Parid	70	80	70	70	60	50	400

Counting Products
Calculating the value of this product is obtained by multiplying the rating by the weightfactor for each descriptor.

Table 4. Calculating product value

Work Station	Name	Aspect	Weight	Rating	Rating x Weight	Total
Cutting	Gunawan	MD	1	70	70	1170
		PD	3	70	210	
		TD	4	80	320	
		OP	2	90	180	
		EF	4	80	320	
		FR	1	70	70	
Cutting	Segat	MD	3	70	210	990
		PD	3	90	270	
		TD	4	50	200	
		OP	1	70	70	
		EF	2	70	140	
		FR	2	50	100	
Cutting	Ariyadi	MD	2	60	120	1010
		PD	3	90	270	
		TD	2	70	140	
		OP	4	50	200	
		EF	4	70	280	
		FR	0	80	0	
		MD	2	70	140	

Cutting	Parid	PD	4	80	320	1010
		TD	1	70	70	
		OP	3	70	210	
		EF	2	60	120	
		FR	3	50	150	

WWL Average Score

Table 5. Average WWL

Number	Name	Average WWL
1	Gunawan	78
2	Segat	66
3	Ariyadi	67
4	Parid	67

Based on the table above, the mental workload category in sectioncuttingbelong to tall.
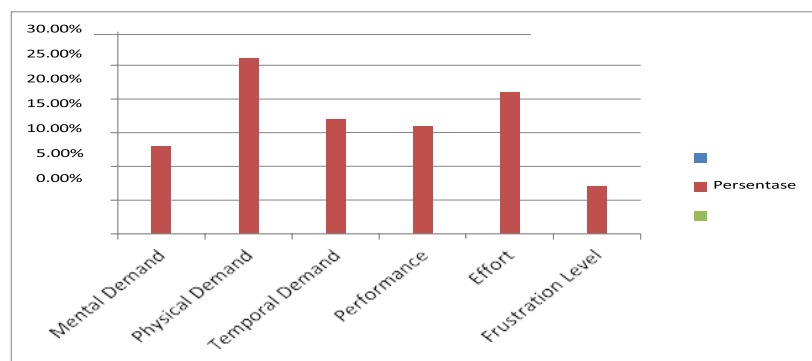

Figure 2. Percentage graph of each indicator

In the graphic above, the results of physical needs are 26% which states the highest physical need indicator, the high physical need is due to the many physical activities carried out by the operator from taking materials, drawing patterns, cutting patterns, and patterning bags. Then the level of effort of 21% is the effort expended mentally and physically required. Where the high physical needs and time affect in completing the work on the business so that the work is completed quickly and on time. Furthermore, this 17% time requirement is due to the time pressure that is felt when completing work activities. Indicator of the time needed to complete the target according to the working hours. Work performance of 16% where successin completing work to achieve the target. This mental need of 13% is due to the concentration of thinking at work, such as when carrying out activities of drawing patterns, cutting patterns, and patterning materials, so that mistakes do not occur when doing these activities and the lowest indicator of frustration level is 7%, that the level of frustration classified as still under control at the time of completing the work.

b. Work Sampling
   Uniformity Test and Data Sufficiency Test
Perform data uniformity test to determine whether the data is uniform and does not exceed the upper control limit (BKA) and lower control limit (BKB). For the level of confidence in this study of 95% where the researcher has confidence in the measurement results of 95% and for the level of accuracy of 5%, it means that the maximum deviation allowed in this study is 5%. On test This work sampling uniformity uses the percentage value of operator productivity for 5 days. Worker Name: Gunawan.
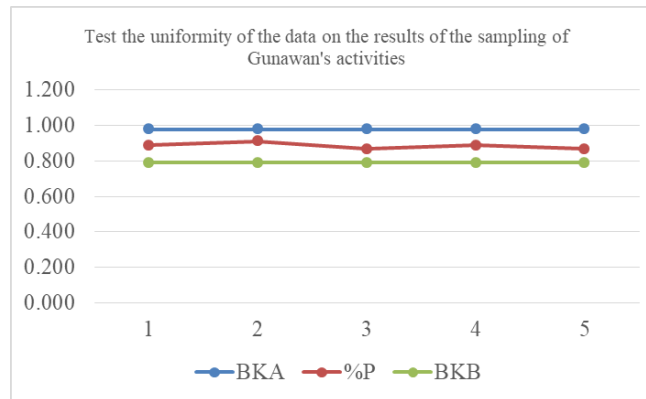
Figure 3. *Percentage value of operator productivity for 5 days worker Name: Gunawan*

Table 6. *Upper control limit (BKA) and lower control limit*

BKA	%P	BKB
0.978	0.889	0.791
0.978	0.911	0.791
0.978	0.867	0.791
0.978	0.889	0.791
0.978	0.867	0.791

After the data is uniform, then the data is tested for data adequacy, to determine the data to be used in this study. Perform data adequacy test If N' N, then the data is saidto be sufficient. Based on the calculations of the four operators that the data is declared sufficient and no additional data is needed. Calculation results N' N for operatorsGunawan 200.76 225, Segat 183.34 225, Ariyadi 209.53 225, Parid 218.40 225.

Determination of Productive Working Hours

Table 7. *Determination of productive working hours*

Nama Pekerja	Part	Productive Working Hours	Description
Gunawan	*Cutting*	141.44	Hours/Month
Segat	*Cutting*	142.88	Hours/Month
Ariyadi	*Cutting*	140.80	Hours/Month
Parid	*Cutting*	140.16	Hours/Month

Based on the calculation of the highest productive working hours in the cutting namely Segat with working hours of 142.88 hours/month, Gunawan with 141.44 hours/month, Ariyadi with 140.80 hours/ month, and Parid with 140.16 hours/month. From the results of these calculations due to the large amount of work from the process operator cutting.

Determination of the Amount of Adjustment and Allowance
Worker Name: Gunawan

Table 8. *Determination of the amount of adjustment and allowance*

Number	Work Element	Adjustment	Allowance %
1	*Deploying Material*	1.20	0.32
2	*Drawing Pattern*	1.26	0.26
3	*Cutting Fabric Pattern*	1.14	0.33

4	*Doing Rope Cutting*	1.24	0.35
5	*Doing PVC Cutting*	1.19	0.31
6	*Doing Spunbond Cuts*	1.16	0.30

Adjustment factor is a technique of adjusting the results of observations of the operator in completing the job. In this adjustment, the method used iswesting house. Westinghouseis a way of giving direction to scores or scores on 4 factors to determine fairness or unfairness in work, namely skills, effort, working conditions, and consistency factors. Allowance factors are given to activities in terms of personal needs, relieving fatigue, and unavoidable obstacles. The granting of slack intends to provide an opportunity for the operator to do the things that must be done so that the standard time obtained can be said to becomplete and representative working time data on the observed work system.

Conclusion

1. Based on the results of the calculation of subjective measurements using the NASA-TLX method The results of physical needs are 26% which states the highest physical needs indicators, the high physical needs are due to the many physical activities carried out by operators from taking materials, drawing patterns, cutting patterns, and patterning bags. Then the level of effort of 21% is the effort expended mentally and physically required. Where the high physical needs and time affect in completing the work on the business so that the work iscompleted quickly and on time. Furthermore, this 17% time requirement is due to the time pressure that is felt when completing work activities. Indicator of the time needed to completethe target according to the working hours. Work performance of 16% where success in completing work to achieve the target. This mental need of 13% is due to the concentration ofthinking at work, such as when carrying out activities of drawing patterns, cutting patterns, and patterning materials, so that mistakes do not occur when doing these activities and the lowest indicator of frustration level is 7%, that the level of frustration classified as still under control at the time of completing the work. As for the results of calculations with work sampling. The physical workload for the Gunawan operator was 128%, the Segat operator was 153%, the Ariyadi operator was 138%, and for the Parid operator 136%.

2. Suggestions for improvement that can be given are by adding a work chair in the cutting sothat operators are not tired in doing their activities and provide work instructions because work instructions are not written.

Reference

[1] Arasyandi, M., & Bakhtiar, A. (nd). Mental Workload Analysis Using the NASA TLX Method on Cargo Operators at PT. Dharma Bandar Mandala (PT. DBM). 1- 4.

[2] Indrawati, S., Prabaswari, AD, & Pradipta, T. (2018). The mental workload analysisof safety workers in an Indonesian oil mining industry.ICET4SD, 2.

[3] Sanria, P., & Hilman, M. (2021). EMPLOYEE WORKLOAD ANALYSIS USING WORK SAMPLING METHOD TO DETERMINE THE OPTIMAL NUMBER OF EMPLOYEES (Case Study: GMD Langensari Photo Studio).GALUH INDUSTRIAL JOURNAL, 34-39.

[4] Sutalaksana, IZ, Anggawisastra, R., & Tjakraatmadja, JH (2005).Work System Design Techniques.Bandung: ITB.

[5] Widiasih, W., & Nuha, H. (2019).Workload Analysis Using Work Sampling and NASA - TLX For Employee of private University in Surabaya.INDUSTRIAL ENGINEERING SCIENTIFIC JOURNAL. Vol.18(2), 136 -137.

[6] Widiastuti, R., Nurhayati, E., & Indah Sari, EN (2019). Analysis of Physical and Mental Workload of Cleaning Service Officers Using Work Sampling Methods and NASA - TLX (Case Study: UPT Lempuyangan Besar Station).Journal of Technoscientia Technology. Vol.12 N0.1, 58.

STRATEGY TO INCREASE THE COMPETITIVENESS OF PRODUCTION OF JAMKRINDO KCK JAKARTA PEOPLE'S BUSINESS CREDIT GUARANTEE (KUR) USING SWOT ANALYSIS AND QSPM METHODS

Silvia Aprilingga Kurniarti, Ni Made Sudri
Industrial Engineering, Institut Teknologi Indonesia, South Tangerang, Indonesia

Abstract.
The development of business in Indonesia in the field of services and products that are increasingly skyrocketing requires companies to be able to rack their brains to be able to survive and advance in the fierce competition. Based on data from the Ministry of Cooperatives and SMEs, the number of MSMEs in Indonesia reached 64.19 million units in 2021 and has contributed as much as 61.97% of GDP or IDR 8.6 trillion. The large number of MSMEs also indicates the importance of accessibility of people's business credit (KUR) products, Jamkrindo is present as one of the SOEs providing KUR guarantees. As of March 2022, Jamkrindo KCK Jakarta is appointed to also produce KUR Guarantees like other branches with a target of IDR 160M per month. Strategic planning can help companies determine strategies and make decisions. This research uses swot and QSPM methods by analyzing the internal and external conditions of the company through the IFAS-EFAS approach. Based on the results of the IFAS-EFAS matrix analysis, an IFAS score = 7.86 and EFAS = 7.16 is obtained so that the company's condition is in quadrant 1 which means it is in a favorable position because it has strength in seizing existing opportunities. Based on the SWOT analysis, four sets of alternative strategies were obtained. With QSPM Analysis, Jamkrindo KCK Jakarta can carry out the following SO strategies: improving service and distribution networks, improving the quality of Human Resources, continuing to improve and evaluate service quality and continuing to maintain and improve good relations with partners.

Keywords: strategy, People's Business Credit (KUR), IFAS-EFAS, SWOT, QSPM

Introduction

A business is an organization that provides goods or services aimed at making a profit. Business development in Indonesia in both services and products is getting more and more fierce along with the increase in rivals and skyrocketing demand. This requires companies to be able to rack their brains to be able to survive and advance in the fierce competition. The key to continue to advance and develop is to continue to innovate and adapt to follow various changes that exist, one of which is to have strategic planning. By having strategic planning, the company can find out the internal and external conditions of the company objectively. Jamkrindo (Indonesian Credit Guarantee) is part of the IFG (Indonesia Financial Group) which is engaged in credit guarantees and guarantees almost all loans made by state-owned banks, such as BRI, Mandiri, BNI, and BTN. One of Jamkrindo's products is the guarantee of People's Business Credit (KUR). KUR is a program from the government that provides credit financing for customers with a guarantee pattern for UMKMs in the field of productive and feasible business, but has limitations in fulfilling the requirements set by banks (bankable). KUR aims to boost the community's economy by helping to increase access to capital and other resources for UMKM actors. Jamkrindo Jakarta Special Branch Office which only handles KUR products starting in March 2022, this is an interesting new challenge where KCK Jakarta itself is targeted to guarantee a KUR of IDR 160M per month. To be able to achieve the target and compete with other branches and competitors, of course, it is necessary to have a good and mature strategy. Strategy can be understood as a science of planning and direction.

Table 1. *Production data of KUR PT. Jamkrindo KCK Jakata from March to May 2022*
Source: Results of recapitulation of KUR bisnis satu KCK Jakarta

Bank	Month		
	March	**April**	**May**
PT. BANK RAKYAT INDONESIA	63.485.500.000	90.329.500.000	54.621.000.000
PT. BANK RAKYAT INDONESIA CABANG JAKARTA	45.580.000.000	-	
PT. BANK NEGARA INDONESIA	21.006.956.342	22.515.792.218	29.405.332.019
PT. MANDIRI	80.323.374.072	78.334.000.000	64.113.236.279
PT. BTN	-	-	-
TOTAL	**210.395.830.414**	**191.179.292.218**	**148.139.568.298**

Literature Review
IFAS-EFAS Approach

Quoted from the journal Business Development Strategy in the Sawn Timber Industry. Through a SWOT Approach and IFAS-EFAS Analysis, IFAS or Internal Factor Analysis Summary is a summary of the identification of

internal factors to find out the strengths that companies can use in overcoming existing weaknesses by conducting identification procedures on various existing factors within the company's functional areas such as human resources, location, production, marketing, finance and management. Then it is further analyzed with the IFAS matrix. (Makkarennu, Atuti, & Ridwan, 2019) Here are some aspects that can be considered in analyzing the internal environment of a company: Human Resources (HR), Location, Production, Financial condition, Marketing and Management.

Meanwhile, EFAS stands for External Factor Analysis Summary which can be used to expand opportunities that can be utilized to overcome threats that may be dating in the future. These external factors are divided into two environments, namely the macroenvironment (including demographic factors, economic factors, natural factors and political factors) and the microenvironment (including the conditions of the company, competitors, customers, and substitution products) which are further analyzed using the EFAS matrix. To analyze the external environment can be seen from several aspects, including the following: Demographic factors, Economic factors, Natural factors, Political factors, Consumers, Competitors and Substitution products.

SWOT

Rangkuti (2016) explained that SWOT Analysis is a tool for identifying various factors to plan company strategies systematically. This analysis is based on reasoning with the aim of maximizing (strength) and opportunities (opportunities), which simultaneously also minimize weaknesses (weakness) and threats (threats).

Quadrannt I: This quadrant is the most profitable because companies have opportunities and strengths so that they can use opportunities well. Strategies that can be applied are strategies that support aggressive growth policies (Growth Strategy).

Quadrannt II: Although it encountered various threats, the company still has internal strength. The strategy that companies can use is to use existing forces to take advantage of opportunities with a diversification strategy (product/market).

Quadrannt III: The company has a great opportunity but is constrained by its internal weaknesses. In this condition, companies can focus on minimizing weaknesses / internal problems in order to seize opportunities in the market better.

Quadrant IV: This situation is very unfavorable to the company because the company has to face various threats and has internal weaknesses

	Opportunities (external, positive)	Threats (external, negative)
Strengths (internal, positive)	**Strength-Opportunity strategies** Which of the company's strengths can be used to maximize the opportunities you identified?	**Strength-Threats strategies** How can you use the company's strengths to minimize the threats you identified?
Weaknesses (internal, negative)	**Weakness-Opportunity strategies** What action(s) can you take to minimize the company's weaknesses using the opportunities you identified?	**Weakness-Threats strategies** How can you minimize the company's weaknesses to avoid the threats you identified?

Figure 1. Production data of KUR PT. Jamkrindo KCK Jakata From March to May 2022
Source: https://binged.it/3AyWSlV

QSPM

David (2009) said that Quantifiable Strategy Planning Matrix is one of the methods in determining the relative attractiveness of various alternative strategies. This method uses the results of the analysis from the previous stage which will later produce an alternative strategy of choice to run. The calculation of the QSPM matrix uses internal and external factors combined with alternative strategies that have been formulated. At this stage, weighting is carried out, determining the attractiveness value or Attractiveness Scores (AS), and Total Attractiveness Scores (TAS). The weights on internal and external factors are adjusted to the weights already present in the previous IFAS and EFAS matrices. The US value describes a number indicating the relative attractiveness of each strategy of a set of alternatives. The U.S. assessment provisions apply as follows: (Hany Setyorini, 2016).

1 = Unattractive

2 = Rather Interesting
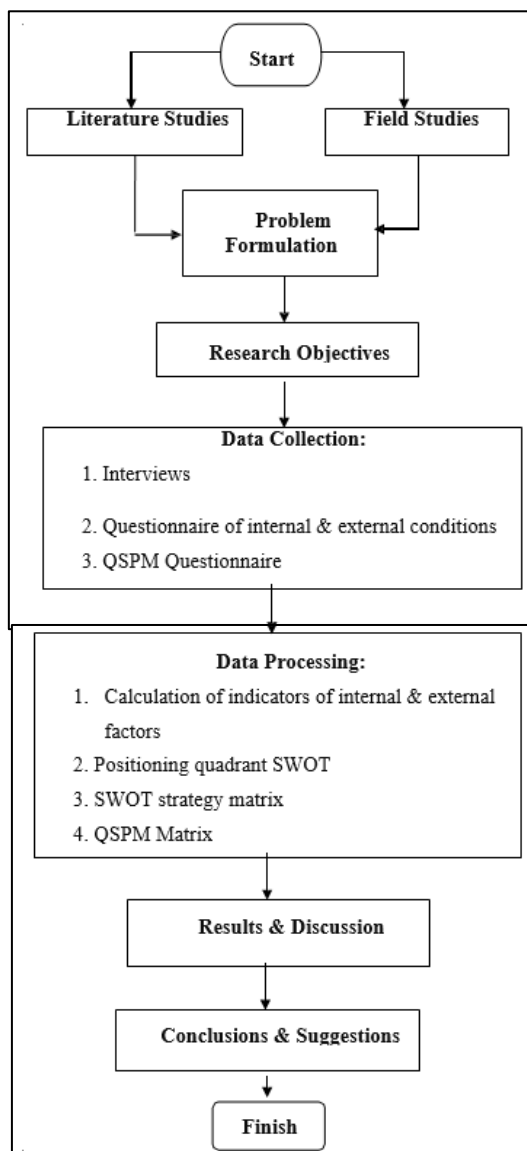3 = Quiet Interesting
4 = Very Interesting

Research Methode

Figure 2. *Research Methode*

Result & Discussion
IFAS-EFAS

After getting the Weight and Rating values of each indicator of internal factors and external factors, it is further multiplied to get the score as follows.

Score = Weight x Rating

Table 2. *IFAS Matrix*
Internal Factors

Strength	Weight	Rating	Score
Competent human resources	0.11	24.43	2.63
Strategic location of the company	0.12	21.43	2.66
Have a good relationship with partners	0.11	23.43	2.62
Healthy financial condition	0.12	20.43	2.37
Good service	0.11	23.43	2.60
			12.87
Weakness			
Rudimentary internal portal	0.12	10.14	1.17
Lack of team members	0.11	10.29	1.09
Lack of means of transportation for marketing activities	0.12	13.14	1.56
Computerized facilities are less supportive	0.09	13.29	1.19
	1.00		5.01

Table 3. *EFAS Matrix*
External Factors

Opportunities	Weight	Rating	Score
Received a direct appointment from the government in guaranteeing	0.18	22.43	3.94
Good Image	0.18	22.57	4.10
Increasing growth of UMKMs loans	0.17	22.43	3.80
			11.85
Threats			
The presence of competitors	0.16	9.29	1.44
Economic instability	0.16	10.29	1.60
Changes in business trends	0.16	10.14	1.64
	1.00		4.69

Positioning Quadrant **SWOT**

With the score obtained, the researcher can then find out where the company's position is which can be known based on the coordinates (x,y) in the quadrant. The X- axis as the internal factor and the Y-axis as the external factor. The coordinates obtained can be used as a reference for the formulation of alternative strategies used at a later stage. The following is the calculation of the coordinates of Jamkrindo KCK Jakarta:

X - axis = Total Strength Score – Total Weakness Score
    = 12.87 – 5.01
    = 7.86

Y - axis = Total Opportunity Score – Total Threat Score
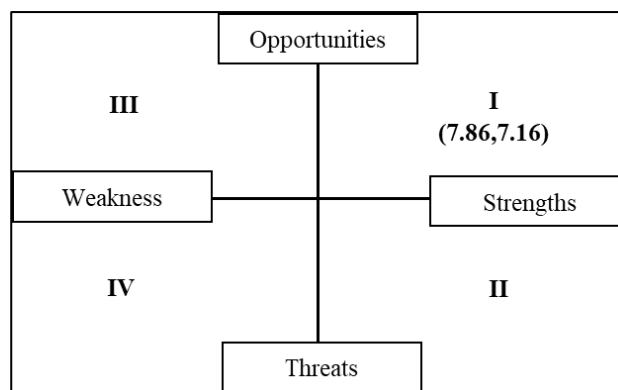   =11.85 – 4.69
    = 7.16

Figure 3. Diagram positioning quadrant SWOT Jamkrindo KCK Jakarta

Based on the Positioning Quadrant SWOT diagram depicted above, coordinates were obtained (7.86,7.16) so that Jamkrindo KCK Jakarta is in quadrant I. Being in quadrant I means that the company is in a strong condition and has the opportunity so that the strategy that can be carried out is an aggressive strategy.

SWOT Matrix

The SWOT matrix is used to formulate alternative strategies taking into account various internal and external factors that the company has. The SWOT matrix produces four sets of alternative strategies namely SO Strategy, WO Strategy, ST Strategy, and WT Strategy. This formulation was carried out by researchers with a literature review and direct interviews with the Head of Section and staff of Bagiain Bisnis 1. Here are the results of the SWOT matrix obtained.

Figure 4. Diagram positioning quadrant SWOT Jamkrindo KCK Jakarta

QSPM Matrix

After formulating what alternative strategies the company can do on the SWOT matrix, the next step is to determine the best alternative strategy by giving nilang to each strategy combined with its internal and external factors. At this stage, the weight of each indicator of internal and external factors from the results of previous calculations is used. Attractiveness Scores (AS) are the relative attractiveness values of each strategy on a single aternati cell. The Total Attractiveness Scores (TAS) are obtained by multiplying the Weight by the US value. The total value of TAS is then summed to produce the score levels of various sets of alternative strategies. The highest TAS score determines the best strategy to implement in a company. The TAS of the SO Strategy is 6.05, the TAS of the ST Strategy is 5.71, the TAS of the WO Strategy is 5.91, and the TAS of the WT Strategy is 5.28.

Tabel 4. *Diagram positioning quadrant SWOT Jamkrindo KCK Jakarta*

Internal & External Forces Table	Weight	Alternative Strat gies							
		SO Strategies		ST Strategies		WO Strategies		WT Strategies	
		AS	TAS	AS	TAS	AS	TAS	AS	TAS
STRENGTHS									
Competent human resources	0.11	3.43	0.37	2.71	0.29	3.00	0.32	2.86	0.31
Strategic location of the company	0.12	3.57	0.44	3.14	0.39	3.14	0.39	3.14	0.39
Have a good relationship with partners	0.11	3.14	0.35	2.71	0.30	3.00	0.33	3.00	0.33
Healthy financial condition	0.12	2.43	0.28	3.14	0.36	3.00	0.35	2.00	0.23
Good Services	0.11	3.29	0.36	2.43	0.27	3.57	0.40	2.86	0.32
WEAKNESS									
Rudimentary internal portal	0.12	3.14	0.36	2.86	0.33	3.29	0.38	3.57	0.41
Lack of team members	0.11	2.71	0.29	2.57	0.27	2.14	0.23	1.57	0.17
Lack of means of transportation for marketing activities	0.12	3.43	0.41	2.86	0.34	3.00	0.36	2.14	0.25
Computerized facilities are less supportive	0.09	4.00	0.36	3.71	0.33	3.14	0.28	2.86	0.26
OPPORTUNITIES									
Received a direct appointment from the government in guaranteeing KUR	0.18	2.86	0.50	2.86	0.50	3.29	0.58	2.14	0.38
Good Image	0.18	2.29	0.42	3.00	0.55	3.14	0.57	2.29	0.42
Increasing growth of UMKMs loans	0.17	3.57	0.61	3.00	0.51	2.86	0.48	3.00	0.51
THREATS									
The presence of competitors	0.16	2.71	0.42	2.57	0.40	3.00	0.47	3.29	0.51
Economic instability	0.16	2.71	0.42	2.43	0.38	2.57	0.40	2.43	0.38
Changes in business trends	0.16	2.86	0.46	3.00	0.49	2.29	0.37	2.57	0.42
TOTAL			**6.05**		**5.71**		**5.91**		**5.28**

Conclussion

Based on the SWOT analysis that has been carried out previously, four sets of alternative strategies were obtained which were divided into SO Strategy, WO Strategy, ST Strategy, and WT Strategy. Meanwhile, with the analysis of the QSPM method, it was found that Stretegi SO is the strategy with the highest TAS value and is the main strategy to be carried out first.

References

[1]   David, F.R., 2009, Strategic Management: Konsep. Jilid 1, ed. 12, Salemba Empat, Jakarta.
[2]   Hany Setyorini, M. E. (2016). Analisis Strategi Pemasaran Menggunakan Matriks SWOT dan QSPM (Studi Kasus: Restoran WS Soekarno Hatta Malang). Industria: Jurnal Teknologi dan Manajemen Agroindustri 5 (1), 46-53.
[3]   Makkarennu, Atuti, T., & Ridwan. (2019). Strategi Pengembangan Usaha Pada Industri Kayu Gergajian Melalui Pendekatan SWOT Dan IFAS-EFAS Analysis. *Jurnal Ilmu Teknol. Kayu Tropis Vol. 17 No. 1*, 90-100.
[4]   Rangkuti, F. (2016). *Teknik Membedah Kasus Bisnis ANALISIS SWOT (Cara Perhitungan Bobot, Rating, dan OCAI).* Jakarta: PT. Gramedia Pustaka Utama.

FINANCIAL RISK ANALYSIS OF BANK BNI PERSERO (TBK) USING ALTMAN Z SCORE

Reza Putra Tanwey[1], Mutiara Eka Puspita[1], Isni Andriana[2]
[1]Management Department, Institut Teknologi Indonesia, Indonesia
[2]Economy Faculty, Sriwijaya University, Indonesia

Abstract.

Financial health measurement is very important to be carried out, including PT Bank BNI Persero Tbk as a banking institution. One of the indicators of financial health is the measurement of the level of financial riskThe purpose of this research is to analysis the financial performance of PT. Bank BNI (persero) Tbk in 2017-2021, by using Altman z"-score method to see the financial risk possibility of the PT. Bank BNI itself. Data type used is the secondary data from annual report published. Based on the results of the analysis carried out on PT. Bank BNI (persero) Tbk data. From 2017 to 2021 using the modified z-score method, the z-score value obtained for 5 consecutive years is 9.595 for 2017, 8.331 for 2018, 8.744 for 2019, 8.111 for 2020, and 11.259 for 2021. It can be concluded that PT Bank

Keywords: *Altman Z Score, Financial Risk*

Introduction

In the current globalization era business competition is getting tighter. This competition demands the businesspeople to be able maximize company performance to be able to competition with another company. The company must be working really hard to make to make it to a new level and need to know and understand what the consumer wants. By knowing what the customer wants the company would be able to know how to move and what do the company need to do in the future. According to the law of Republic of Indonesia Number 10 of 1998 concerning banking, bank is entity that collects funds from the public in the form of deposits and distribute it to the community in the form of credit and other form in order to improve the people's standard of living.

Bank negara Indonesia (BNI) is one of the oldest bank in the history of Indonesia . this bank was founded in 5 July, 1946. The bank BNI has been able to be the income to Indonesia form it was founded until now, Superiority bank BNI compared to other banks has good service, the products offered are reliable, a bank that complies with regulations government, the application of standard interest rates, credit services and services the available money storage is very good and has many branch offices.

Bank Negara Indonesia or BNI (IDX: BBNI) is a state-owned bank institution, in this case a state-owned company, in Indonesia. In its organizational management structure, Bank Negara Indonesia (BNI), is led by a President Director currently held by Royke Tumilaar. Bank Negara Indonesia (BNI) is the oldest commercial bank in the history of the Republic of Indonesia. The bank was founded on July 5, 1946. Currently, BNI has 2,262 branch offices in Indonesia and 8 overseas. BNI also has a sharia banking unit, but since 2010 it has separated itself as BNI Syariah (now merged into Bank Syariah Indonesia).

Financial health measurement is very important to be carried out, including PT Bank BNI Persero Tbk as one of a state-owned banking institution. One of the indicators of financial health is the measurement of the level of financial risk. The purpose of this research is to analysis the financial performance of PT. Bank BNI (Persero) Tbk in 2017-2021, by using Altman z"-score method to see the financial risk possibility of the PT. Bank BNI itself. Data type used is the secondary data from annual report published

Body of paper

Altman Z-Score is one method to determine the level of financial health of a company that can be used to assess the success or failure of company management. That is a ratio model used to predict corporate bankruptcy (financial distress) and measure the financial health of a company. The Altman Z-Score model is developing over time, therefore the measurement of the use of this model is not fixed. Its use is not only devoted to manufacturing companies, but also to non-manufacturing companies, by looking at the company's condition at a macro level. Thus, the test can include an extended model of its application. In this analysis, the last modified Altman 1998 model will be used, where its application can be used for all types of companies in developing and developed countries. This model uses 4 ratios that have been modified from 5 ratios in the previous model.

Analysis financial ratios or financial statement analysis is a form of analysis to measure organizational performance based on data compared in writing in the financial statements on certain period. There is several types of analysis ratio, including:

1. Liquidity Ratio, this ratio is useful for measuring ability company to pay off its financial obligations that are soon due. Ratio Liquidity is divided into several types, including n: current ratio, quick ratio, and cash ratio.

2. Ratio Profitability or Profitability, the ratio used to measure how much the level of profit earned by the company. Profitability ratio consists of: Gross profit margin, net profit margin, return on assets, return on equity, and opera heart income ratio, earnings per share

3. Solvency Ratio or Leverage Ratio, the ratio shows how much the company's funding needs are spent with debt. This ratio consists of: Debt Ratio, Debt to Equity Ratio, Coverage Ratio, Fixed Charge Coverage Ratio, Debt Service Ratio.

4. Activity Ratio, the ratio used for measure how much the company's effectiveness in utilizing resources the funds. This ratio consists of: Tour inventory nove, receivable turnover, fixed asset turnover, to total asset turnover, average collection turnover, working capital turnover.

Altman Z-Score modified model with 4 (four) ratios are:

$$Z\text{-Score} = 6.5X1 + 3.26X2 + 6.72X3 + 1.05X4 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

where:

Z-Score : bankruptcy index
X1 : the ratio of working capital to total assets
X2 : the ratio of retained earnings to total assets
X3 : comparison between EBIT to total assets
X4 : the ratio of the book value of equity to the total book value of debt

The model is outlined in a theoretical framework that can be seen In the picture below
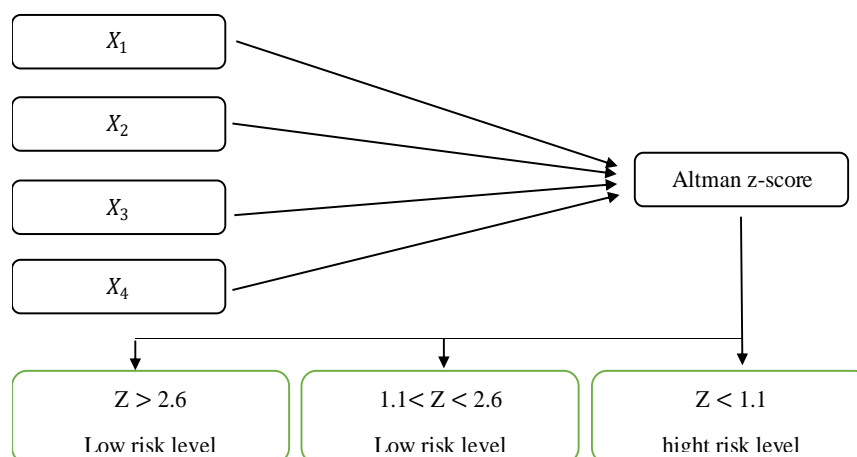

Figure 1. *Research Model*

From Figure 1 above, it can be explained that the Z-Score value is determined by 4 (four) variables (X1, X2, X3, X4), where the resulting Z-Score has 3 (three) risk interpretation classifications. Z-Score Score > interpret non-bankrupt companies. The value of 1.1 < Z-Score < 2.6 means that the company is in a gray area, that is, it cannot be determined whether the company is healthy or bankrupt. In this position, special attention is needed to prevent bankruptcy. If the handling is done incorrectly and too late, the company can go bankrupt. The value of Z-Score <1.1 interprets that there has been financial distress in the company.

In assessing the level of financial risk required financial statement data consisting of a financial balance sheet and income statement. After each data was obtained, then it was analyzed using the Z-Score method. The Z-Score model allows the company to determine the level of risk it has, whether it is in an area with a low risk level, in an area with a vulnerable position (grey area) or in an area with a high level of risk. The data used is quantitative data (numerical scale) in the form of secondary data (data from PT BANK BNI in published reports). Data obtained from:

1. financial balance sheet, which consists of current assets, total assets, current liabilities, total debt, retained earnings and total equity,

2. income statement, which consists of operating profit

By using the financial report data of PT. Bank BNI, which has been published and fully audited, can predict things related to the risk of company bankruptcy. Financial ratios are calculated to measure the level of financial health of the company using Z-Score analysis. The results of the calculation of the ratio of PT. Bank BNI based on the financial statements from 2017-2021 are as follows.

Table 1. *Accounts and data of PT Bank BNI Persero (Tbk)*
2017 to 2021

(in billions of rupiah)

Variable	Item	Formula	2021	2020	2019	2018	2017	Ket:
X1 = 6,56	Current asset	a	286868	220494	196236	188888	121062	X1 measures the proportion of working capital to total assets and liquidity
	Current liabilities	b	9033	9577	4417	1048	3816	
	Working capital (nett)	c = (a-b)	277835	210917	191819	187840	117246	
	Total asset	d	964838	822275	845605	808572	709330	
	WC / TA	e = (c/d)	0.287960259	0.256504211	0.22684232	0.23231079	0.16529119	
	Point	f = e X1	0.287960259	0.256504211	0.22684232	0.23231079	0.16529119	
X2 = 3,26	Retained earning	g	78250	69523	71407	60313	50798	X2 measures profitability historically so what is taken is retained earnings
	Total asset	d	964838	822275	845605	808572	709330	
	RE / TA	h = (g/d)	0.081101698	0.084549573	0.084444865	0.074591997	0.071614058	
	Point	i = h X2	0.162203396	0.169099146	0.16888973	0.149183994	0.143228117	
X3 = 6,72	Earning before Tax	j	148699	154602	286031	170647	369096	X3 measures the proportion of operating profit (EBIT) to total assets
	Intereset expense	k	11721	19021	21930	18692	16240	
	EBIT	l = (J+k)	148699	173623	307961	189339	385336	
	Total asset	d	964838	822275	918989	824788	709330	
	EBIT / TA	m = (l / d)	0.154118101	0.211149555	0.335108472	0.229560808	0.543239395	
	Point	n= m X3	0.462354302	0.633448664	1.005325417	0.688682425	1.629718185	
X4 = 1,05	Book Value of Equity	o	126520	112876	116898	103589	100903	X4 measure solvency
	Current liabilities	b	9033	13416	1480	1048	3816	
	Long term liabilities	p	39879	50606	62195	56017	48896	
	Book value of debt	q= (b+p)	48912	64022	63675	57065	52712	
	E / TD	r = (o/q)	2.586686294	1.763081441	1.835853946	1.81528082	1.914232053	
	Point	s = r X4	10.34674518	7.052325763	7.343415783	7.26112328	7.656928214	
TOTAL POINT			11.259263113	8.111377783	8.74447325	8.331300489	9.595165705	

The figure above shows the value of each account that will be used in the model to find the Z-Score value in a given year. This secondary data shows the value of working capital, retained earnings, debt, total equity, total debt and total assets of PT. Bank BNI Persero (Tbk) starting from 2017 to 2021. Almost all accounts have increased in value from year to year.

Conclusion

Based on the results of the analysis carried out on PT Bank BNI Persero (Tbk) data from 2017 to 2021 using the modified z-score method, it can be concluded that the z-score value obtained for 5 consecutive years is 9.595165705 for 2017, 8.331300489 for 2018, 8.74447325 for 2019, 8.111377783 for 2020, of 11.25926313 for 2021, every year the tendency for the acquisition value of the z-score to increase and decrease

Acknowledgment

References

[1] Darmawi, H. (2016). Manajemen Risiko. Edisi 2. Jakarta: PT. Bumi Aksara.

[2] Fahmi, I. (2016). Pengantar Manajemen Keuangan. Bandung: CV. Alfabeta.

[3] Hery. (2016). Analisis Laporan Keuangan Integrated and Comprehensive Edition. Jakarta: PT. Grasindo.

[4] Rivai, V. dan Veithzal, A. P. (2007). Bank and Financial Institution Management, Conventional & Sharia System. Jakarta: Rajagrafindo Persada.

[5] Harahap, Lily Rahmawati, Wulandari, Shara, Ellysc, dan Effendy, R.Y. 2020. Penggunaan Metode Altman Z-Score Dalam Analisis Risiko Keuangan PT. Bank Tabungan Pensiunan Nasional Syariah, Tbk. Jurnal Ilmu Manajemen, Volume 10, issue 1, Page 15 – 24.

[6] 2021. Annual Report PT Bank BNI Persero (Tbk). Access on 25 July 2022. https://www.bni.co.id/Portals/1/BNI/Perusahaan/HubunganInvestor/Docs/AR-BNI-TB-2021-IND-v2.pdf

[7] 2020. Annual Report PT Bank BNI Persero (Tbk). Access on 25 July 2022. https://www.bni.co.id/Portals/1/BNI/Perusahaan/HubunganInvestor/Docs/AR-BNI-TB-2020-Bahasa.pdf

[8] 2019. Annual Report PT Bank BNI Persero (Tbk). Access on 25 July 2022. https://www.bni.co.id/Portals/1/BNI/Perusahaan/HubunganInvestor/Docs/BNI_AR2019_BAHASA.pdf

[9] 2018. Annual Report PT. Bank BNI Persero (Tbk). Access on 25 July 2022. https://www.bni.co.id/Portals/1/BNI/Perusahaan/HubunganInvestor/Docs/AR_BBNI_2018_IND.pdf

[10] 2017. Annual Report PT. Bank BNI Persero (Tbk). Access on 25 July 2022. https://www.bni.co.id/Portals/1/BNI/Perusahaan/HubunganInvestor/Docs/bni-ar-2017-ind.pdf

ECONOMIC FEASIBILITY STUDY OF MgSO₄ FROM SALINE WATER WASTE

Sri Handayani, Serra Yunita, Fathan Affan Bambang Perdana, Muhammad Latif Firdaus, Ratnawati, Wahyudin

Department of Chemical Engineering, Institut Teknologi Indonesia, Jl. Raya Puspiptek Serpong
South Tangerang, Banten, Indonesia

Abstract.

This study aims to analyze the economic feasibility of $MgSO_4$ plant from saline water waste with a capacity of 20,000 tons/year. Saline water waste is obtained from processing iron ore using STAL (Step Temperature Acid Leach) technology with a waste TDS of 120,000 ppm. This $MgSO_4$ plant was built using 439,597.65 liters of saline water/hour which produces 2,577.89 kg/hour of $MgSO_4$ through 4 stages. These stages are filtration using a screen filter, then followed by ultrafiltration, then nanofiltration, evaporation, crystallization to obtain salt in the form of powder. From the calculation of the economic parameters using the fixed estimation method, the value and break event point of 38% for the first year and the Internal Rate of Return of 37.5% are an indication that this $MgSO_4$ plant is a feasible investment.

Keywords: *Magnesium Sulfat, Saline Water, Nanofiltrasi, Internal Rate of Return, Break Even Point*

Introduction

Nickel extraction from limonite ore using STAL (Step Temperature Acid Leach) technology produces a liquid waste called saline water waste which contains high salt and a TDS (Total Dissolved Solid) content of more than 120,000 ppm [1]. Meanwhile, in the Regulation of the Minister of the Environment of Indonesia No. 5 of 2014 concerning waste water quality standards for businesses and or activities that do not yet have a wastewater standard, one of the parameters is that soluble solids (Total Dissolved Solid / TDS) must be in the range of 2000 – 4000 ppm [2]. Therefore, it is still necessary to carry out a process to reduce the TDS content in the water to be discharged and also to utilize saline water waste to become a useful product.

There are currently no processing or manufacturing plants for magnesium sulfate ($MgSO_4$) in Indonesia. Meanwhile, the need for magnesium sulfate ($MgSO_4$) in Indonesia is quite high and only relies on imports from countries such as Russia, India, China, to the U.S.A, around 384,865 tons in 2021 [3]. Magnesium sulfate ($MgSO_4$) is one of the inorganic salts contained in saline water waste and can be used as the main ingredient or supporting material for plant fertilizers, animal feed supplements, drugs, textile dye mixtures. Due to the increasing demand for magnesium sulfate ($MgSO_4$), the potential to establish a magnesium sulfate ($MgSO_4$) processing plant is also quite large. The establishment of this factory is based on the market demand for magnesium sulfate ($MgSO_4$) which is quite large, utilizing saline water waste, increasing employment opportunities and reducing dependence on imports from other countries.

Theory
Market analysis

The development of $MgSO_4$ imports in Indonesia has decreased and increased from year to year. Until now, imported $MgSO_4$ products have met the needs in Indonesia. To meet domestic MgSO4 needs, Indonesia still relies on imports from countries such as Russia, India, China, to the U.S.A [5]. In 2021 the demand for magnesium sulfate is around 384,865 tons and will continue to increase every year [3]. So it can be estimated that the demand for magnesium sulfate in 2024 is around 500,000 tons/year.

Magnesium sulfate has many benefits, one of which is the main ingredient for making fertilizers. Therefore, the Fertilizer industry is one of the market objectives of this $MgSO_4$ factory, because data on $MgSO_4$ consumption in Indonesia is not yet available. To find out data on $MgSO_4$ consumption in Indonesia, secondary data is used, namely data from fertilizer production in Indonesia. To know the amount of fertilizer production can be seen in Figure 1.
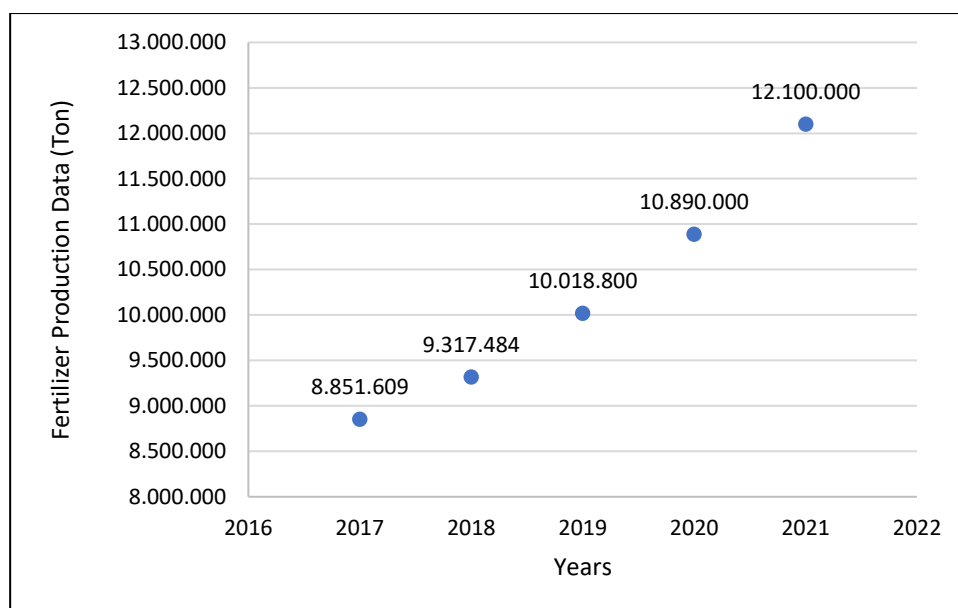
Figure 1. Fertilizer production data in Indonesia
Source: (Ministry of Industry of the Republic of Indonesia, 2021)

From Figure 1 it can be seen that fertilizer consumption in Indonesia continues to increase. However, this data is still used for all types of fertilizers. In general, the use of $MgSO_4$ in fertilizer is around 16%, so it is estimated that the need for $MgSO_4$ in 2021 [8] is around 1.936.000 tons/year.

Process Description
A. Raw Material
The raw material for saline water waste to be used still has a high TDS level and also solid particles that are still contained in the saline water waste. The components of saline water waste include: $Al_2(SO_4)_3$, $CoSO_4$, $Cr_2(SO_4)_3$, $CuSO_4$, $Fe_2(SO_4)_3$, $MgSO_4$, $MnSO_4$, $NiSO_4$, $ZnSO_4$, H_2O, and TSS (Total Suspend Solid) with a composition of 0.005% ; 0.005%; 0.005%; 0.005%; 0.01%; 10%; 1%; 0.005%; 0.005%; 78.96%; and 10 ppm respectively [1].

B. Pre-treatment
The complete process goes through several stages, with stages of pre-treatment, main process, product purification and final treatment, which can be seen in the block flow diagram, which can be seen in Figure 2.
The raw material pretreatment process uses a screen filter and an ultrafiltration device before entering the main process unit. The mass flow retained in the screen filter unit is assumed to be 40% of the total TSS contained in the saline water feed. This is because the TSS particle size contained in saline water is around 63-105 m (230-140mesh) [7] which is based on the size of iron ore produced by PT.HMI and operates at a temperature of 27°C with a pressure of 3 bar. While the Ultrafiltration Module unit functions to reduce the Silt Density Index of seawater from 30 SDI to < 5 SDI and removes seawater impurities in the form of dissolved solid particles that can increase.

C. Main Process
The main process in magnesium sulfate recovery lies in the nanofiltration unit which is then stored in the NF Feed Tank and flowed to the nanofiltration module at a temperature of 27°C and a pressure of 10-35 bar. The separation process using a nanofiltration system lasted for 60 minutes with a rejection of 87.4% with operating conditions of 27°C with a pressure of 10 bar [6].

D. Product Purification
The solution that has gone through the nanofiltration process is then stored in a concentrated tank and then fed to the triple effect evaporator unit with operating conditions of 62°C - 90°C and a pressure of 0.6-0.25 bar which functions to evaporate water with the help of steam flowing from the boiler. After going through the evaporator unit, the concentration is flowed to the crystallizer unit which aims to crystallize the $MgSO_4$ solution using steam as a heater. After going through the crystallizer unit with operating conditions of temperature 62°C and pressure of 0.04 atm. MgSO4 in the form of slurry is fed to a centrifuge unit to separate the crystals from the mother liquor with the assumption that the separation is 90% mother liquor and 10% $MgSO_4$ crystal.

E. Final Treatment

After purification of the main product, MgSO4, the final treatment is carried out before being marketed. The MgSO4 product that is being marketed is MgSO4 in the form of crystals with powder size. Then the product is MgSO4 and converted into powder with the help of a ball mill up to a size of 200 mesh and then the product will be stored in the silo.
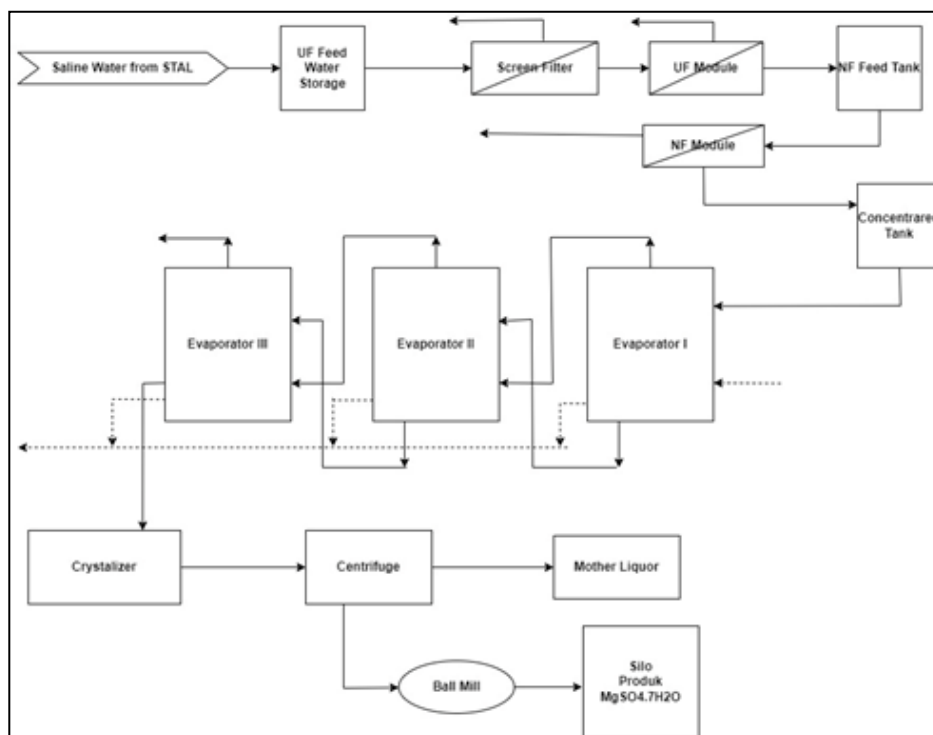

Figure 2. *MgSO4 Factory BFD*

Operating Unit Dimension

The design of operating unit dimensions begins with determining the operating capacity of each unit. By using the feed flow rate data that must be processed. The dimensions for the process unit are then designed according to the principles described by the literature [9 - 12].

The manufacture of Magnesium sulfate (MgSO4) is carried out in batches, and the process is completed within 8 hours. For units such as Screen Filters, cleaning needs to be carried out after each screen. Therefore, it is necessary to carry out a manual cleaning process. Therefore, the Screen Filter unit is installed in parallel so that the use of the screen filter tool can continue without waiting for the cleaning process to complete. With the units being carried out in parallel, the processing can be completed within 7-8 hours. The process dusration and unit specisications are shown in Table 1.

Table 1. *Tool specification data*

No.	Name	Code	Residence Time (hours)	Spesification	Total
1	Storage Tank	T-101	24	Dimension (PxT)= 3,35m x 7,15 m	1
2	Storage Tank	T-102	24	Dimension (PxT)= 3,05m x 6,89 m	1
3	Storage Tank	T-201	24	Dimension (PxT)= 1,69m x 3,72 m	1
4	Storage Tank	T-202	24	Dimension (PxT)= 3,2m x 6,98 m	1
5	Storage Tank	ML-401	24	Dimension (PxT)= 3,35m x 7,15 m	1
6	Screen Filter	F-101A F-101B	1	Dimension PxD= 0,42m x 0,05m	2
7	Ultrafiltrasi Module	UF-101	1	Dimension PxD= 2,3m x 0,225m	
8	Nanofiltrasi Module	NF-201	1	Dimension PxD= 1,01m x 0,2m	
9	Evaporator	EV-301	1	Dimension PxD= 2,8m x 1,9m	1
10	Crystalizer	CR-301	1	Dimension PxD= 2,98m x 1,67m	1

11	Centrifuge	CF-401	1	Dimension Diameter = 1,67m	1
12	Ball Mill	BM-401	1	Dimension PxD = 0,92 m x 0,61 m Daya = 7 Hp	1
13	Screw Conveyor	SC-401	1	Dimension LxD = 36,6m x 1,83m Daya = 2 Hp	2
14	Silo		1	Volume Dimension = 1.006.39 m^3 Tinggi = 4,14 m	1
15	Centrifugal Pump	P-101 P-102 P-201 P-203 P-301 P-302 P-304 P-305 P-401	1	BHP = 7,5 Hp BHP = 7,5 Hp BHP = 25 Hp BHP = 7,5 Hp BHP = 2 Hp BHP = 2 Hp BHP = 2 Hp BHP = 2 Hp BHP = 0,7 Hp	9
16	Vacum Pump	VP-301 VP-302 VP-303 VP-304	1	BHP = 0,5Hp BHP = 0,9 Hp BHP = 2,1 Hp BHP = 2,6 Hp	4

Economic Analysis

Economic analysis is one of the main factors for assessing the feasibility of a production process. The economic feasibility of a magnesium sulfate treatment plant from saline water waste can be determined after analyzing several factors such as production capacity, raw material costs, chemicals, utilities and equipment investment.

The economic analysis in this study is based on several assumptions:
- The production process lasts for 330 days/year. To carry out comprehensive maintenance, shutdowns have been carried out 35 days a year.
- The process used is a batch process.
- The physical construction of the factory will be carried out in early 2023 with a construction, investment, and installation period of one year so that the factory is expected to start operating in 2024.
- Working capital is calculated for 3 months.
- The working period of each unit is 10 years.
- The assumption of the dollar value against rupiah is 1 US$ is Rp. 15.000,-
- In 2023 with stable market conditions with a bank interest rate of 7.5% per annum.
- An increase in the price of raw materials and production output by 10% per year.
- Salvage Value is 10% of Direct Fixed Capital Investment (DFCI) without land price.

The approach to calculating the economic analysis used is a fixed estimation approach where the analysis is only based on process flow diagrams and rough calculations of the main unit dimensions. More detailed diagrams such as plot plans, piping diagrams, and instrumentation are not required in this method. In this method, the cost other than the investment for the unit is obtained by comparing it with the price of the main unit. Prices of production equipment and supporting equipment are calculated using data from reference manuals and several related online sites[13][14]. The steady-state estimation method has an accuracy range of +30% to -20%, so the results of this study may not accurately reflect the actual economic feasibility of magnesium sulfate production. However, the results of this study can be used as a reference to analyze the parts of the production process that need to be optimized.

A. Total Modal Investment (TCI)

Capital Investment or Total Capital Investment is the amount of capital invested to establish a factory until the factory is ready to operate. TCI consists of FCI (Fixed Capital Investment) and WCI (Working Capital Investment). FCI consists of equipment, installation, plumbing, instrumentation, electrical, building, utilities, storage, area development, additional building costs, contractor costs, and incidental costs. While WCI is the investment required to operate the factory for 3 months, during which all operating variables are adjusted until the factory is ready for production[15]. TCI calculation results are shown in Table 2.

Table 2. *Summary of TCI calculation results*

No.	Main and Support Equipment	A		Total Price (Rp)
Fixed Capital Investment				
DFCI				
1	Procurement of Equipment (Process Equipment and Utilities)	100%	A	58030830714
2	Instrumentation and control	39%	A	22632023978
3	Installation	13%	A	7544007993
4	Installed Piping	31%	A	17989557521
5	Electricity Installed	10%	A	5803083071
	Civil & Structural Cost			
6	Factory Building	29%	A	16828940907
7	Yard improvements	10%	A	5803083071
8	Service facilities	55%	A	31916956893
9	The Land Price (Land survey & cost)			37500000000
10	Land acquisition	6%	A	2250000000
	Total DFCI (A')			206298484149
	IFCI			
		B		
11	Engineering and Supervision	32%	A'	66015514927
12	Contractor and Construction Costs	34%	A'	70141484610
13	Trial Run Cost			208519273
	Unexpected IFCI	10%	A'	20629848414
	Total IFCI			156995367226
	Total FCI = DFCI + IFCI			363293851375
	Working Capital Investment			
14	Product Packaging and Distribution Costs	1%	Bahan baku	990000000
15	Quality Control Cost	1%	Bahan baku	990000000
16	Maintenance and Repair Costs	2%	FCI	7265877027
17	Employee Salary	3	x gaji /bulan	2498700000
	Subtotal WCI			9784377027
	Loan Interest during Construction	10%	DFCI	20629848414
	Total Capital Investment (TCI) = FCI + WCI + Loan Interest during Construction			**393708076818**

B. Total Product Cost (TPC)

Production costs are one of the determining factors for the selling price of a product. From this calculation, it can be estimated the profit that will be obtained from the sale. Total Product Cost (TPC) consists of 2 parts: production costs or costs needed to make a product and general costs or costs used to support factory operations. [15].

Production costs consist of direct cost, factory overhead, and fixed costs. Direct costs are costs that are used directly for factory operations including costs of raw materials, costs of supporting facilities, employee salaries, maintenance and repairs, royalties and patent costs, and laboratory costs. Meanwhile, factory overhead costs include hospital service and maintenance costs, general factory maintenance, security, rescue, and distribution costs. Fixed costs are costs that are fixed from year to year or do not change with changes in production capacity, including depreciation, taxes, and insurance costs. Finally, general expenses are costs used to support the operations of factory activities, including administrative costs, distribution and sales costs, research and development costs, and bank interest payments. The TPC for the Magnesium sulfate processing plant in the first year with a new production capacity of 80% is shown in Table 3.

Table 3. Summary of TPC calculation results

	Total Production Cost (TPC)			Biaya Tetap (Rp)	Biaya Variabel (Rp)
A	**Production Cost**				
1.	Direct Manufacturing Cost (DMC)				
a	Raw Material Cost				197835014904
b	Employee salary			5220145000	
c	Maintenance and Repair Costs (increase by 5% /year)	2%	DFCI	3791816486	
d	Patent Royalties and Fees	0,5%	TS		4663200000
e	Laboratory Fee	0,5%	BB		989175075
f	Product Packaging Fee	5%	BB		9891750745
g	Support Facility Fee			106278356	492474863819
h	Initial Cost			4453947104	
	Total Direct Manufacturing Cost (DMC)			13572186945	705854004543
	Factory Overhead Cost	20%	(b+c)	1802392297	
	Fixed Production Cost (FMC)				
2.	Depreciation			41483719541	
3	Land and Development Tax is estimated at 0.1% x (land + Building), increasing 10% /year			31136037	
a	Insurance fee (increase 10%) /year	0,5%	DFCI	947954122	
b	Total Fixed Production Cost (FMC)			42462809700	
B	**General Expenses**				
a	Administrative costs	5%	b	261007250	
b	Distribution and Sales Costs	10%	f		989175075
c	Bank interest				9500000000
	Total General Expenditure			261007250	10489175075
	Total Production Cost			58098396193	716343179618
	Total Production Cost			77441575811	

C. Internal Rate of Return (IRR) and Break Even Point (BEP)

Internal Rate of Return (IRR) is the loan interest rate (rate of interest) in percent at Net Cash Flow Present Value (NCFPV) = 0. within the technical life span of the machine/equipment. or a period that is expected to be sooner than the technical age. IRR analysis is carried out to assess the feasibility of establishing a factory. If the existing bank interest in the bank during the life of the factory is less than the IRR. then the establishment of the factory is feasible.

Table 4. Summary of IRR calculation results

	Net Cash Flow (Rp)	Interest $1/(1+1)^n$	Present Value
0	-393709076818	1	-393709076818
1	82051297212	0.701	57545551550
2	129690146565	0.492	63791036673
3	186569314932	0.345	64360459055
4	216595225391	0.242	52402752645
5	249294049962	0.170	42300299285
6	330130310504	0.119	39286490340
7	369876974510	0.083	30870341541
8	413533548611	0.059	24205897586
9	461491576736	0.41	18945258144
10	514181784854	0,29	14804022673
Total			**0**

Based on Table 4. the IRR value is 37.54% using the Goalseek method by changing the total NCFPV value to 0. The IRR value for the establishment of this factory is greater than the loan interest rate offered by Bank BNI as a reference for this factory.

The Break Even Point (BEP) or the break-even point is the percent of production capacity where the total cost incurred by the company is within 1 year. BEP is useful for controlling the company's operational activities. including controlling total production. total sales. and controlling finances for the current financial year. The table 5 shows the Break Even Point cost of the Magnesium Sulfate plant. The general formula for calculating BEP can be seen in

equation (1).

$$BEP = \frac{FC}{TC - VC} \times 100\%$$

(1)

Table 5. Summary of BEP calculation results

Year	Total Sales (Rp)	Total Fixed Cost (Rp)	Total Variabel Cost (Rp)	Total Cost (Rp)	BEP (%)
1	304000000000	111543019863	12366563446	123909583309	38
2	376200000000	113635179455	14418994777	128054084233	31
3	459800000000	113758043015	16640086408	130389129423	26
4	505780000000	115179876576	18304095048	133483971625	24
5	556358000000	116838553553	20134504553	136973058107	22
6	611993800000	87056956918	22147955009	109204911927	15
7	673193180000	89260592838	24362750509	113623343348	14
8	740512498000	91777101357	26799025560	118576126968	13
9	814563747800	94636979851	29478928117	124115907968	12
10	896020122580	124115907968	32426820928	156542728897	14

Conclusion

Research has been carried out to analyze the economic feasibility of producing magnesium sulfate from saline water waste. Through a fixed estimation approach, it is known that this production process is broadly economically feasible. With a production capacity of 20,000 tons/year, with an IRR value of 37.5% greater than the interest rate used, which is 7.5%. With a BEP value of in the first year of 38%.

References
[1]   PT. Hydro Metal Indonesia. (2020). PT. Hydro Metal Indonesia Profile. Retrieved 04 19, 2022, from https://hydrotechmetals.co.id/
[2]   Indonesia. Peraturan Menteri Lingkungan Hidup Republik Indonesia Nomor 4 Tahun 2014 tentang Baku Mutu Air Limbah Bagi Usaha dan atau Kegiatan yang Belum Memiliki Baku Air Limbah. Sekretariat Negara. Jakarta.
[3]   Badan Pusat Statistik (2021). Impor Magnesium Sulfat. Indonesia.[Online]. 21(3) Available: https://www.bps.go.id
[4]   Faizah, N., Indriyani, L., Juwari, & Renanto. (2018). Pra Desain Pabrik Pupuk MgSO₄.7H₂O dari Bittern. Jurnal Teknik ITS, 7(1), 1.
[5]   Prayugha, M., Afandi, A.R. (2020). Pra Rancangan Pabrik Magnesium Sulfat Heptahidrat dari Magnesium Karbonat dan Asam Sulfat dengan Kapasitas 70.000 ton/tahun. UII: Yogyakarta.
[6]   Shandong Haihua Co., L. (2019). China Patent No. CN 113929121A.
[7]   https://www.handalselaras.com/total-suspend-solid-tss/#:~:text=Total%20suspended%20%solid%20(TSS)%20atau,besar%20dari%20ukuran%20partikel%20koloid
[8]   https://bhinneka.com/pak-tani-pupuk-magnesium-sulfat-mgso4-1-kg-sku0013795632
[9]   Kern, D. Q. (1965). Process Heat Transfer. Japan
[10] Perry, R. H. (1999). Chemical Engineering Handbook. New York: Mc Graw Hill
[11] Brownell, L. E., & Young, E. H. (1959). Process Equipment Design. New York: John Wiley and Sons Inc
[12] Johns, M., & Fridjonsson, E. (2018). Magnesium Recovery from desalination Brine. CEED Semniar Proceedings, 50.
[13] https://www.alibaba.com
[14] https://www.matche.com
[15] https://text-id/123dok.com/document/wy3g7o0q-total-capital-investment-tci-total-production-cost-tpc.html

QUALITY IMPROVEMENT USING SIX SIGMA METHOD TO REDUCE DEFECTS OF OFFICE PARTITION PRODUCTS AT PT. INSPIRA MULTI KARYA

Alya Muthia Maharani, Made Sudri

Industrial Engineering, Institut Teknologi Indonesia, South Tangerang, Indonesia, 15314

Abstract.

Quality improvement carried out at PT. Inspira Multi Karya on partition products is still not effective, as evidenced by the presence of defective products such as scratches, dents, cracks, and edge defects. Based on these problems, the authors are interested in analyzing the quality improvement of Office Partitions products using the Six Sigma method and improving processes with the DMAIC approach (Define, Measure, Analyze, Improve, Control) to reduce the level of product defects, as well as with the help of analytical tools in the form of Pareto Diagrams. , Fishbone Diagram, FMEA after doing all the analysis, the results obtained are the factors that cause defects in office partition products at PT. Inspira Multi Karya namely Human, Environment, and Method. The results of the calculation of the value of Defects Per Million Opportunity (DPMO) are used to determine the level of defects per million opportunities. From the calculation results obtained a sigma value of 3.0502 with an average value of Defect Per Million Opportunity (DPMO) of 61405 per one million opportunity, Defect per Opportunity (DPO) or the possibility of the Office Partition product experiencing defects to meet the company standards of PT. Inspira Multi Karya of 0.061405. Proposed improvements that need to be made to reduce the level of defects in Office Partition products are Making good and appropriate SOPs, Cartons for packing must be given Styrofoam, Cutting materials according to size standard dimensions, Checking raw materials before processing, Employees must work carefully and focus , Conduct training for the operator concerned.

Keywords: Six Sigma, DMAIC, Pareto Charts, Fishbone Diagrams, Defects Per Million Opportunity, Quality Control

Introduction

Quality is very important for companies, in this case quality is the most important benchmark for consumers' views of the products/services that will be selected for use. According to Hendy Tanady (2015: 3) quality is an effort from producers to meet customer satisfaction by providing what is the need, and even the expectations of the customer, where these efforts are visible and measurable from the final product produced. In other words, quality is one of the guarantees that the company must provide and fulfill to customers. PT. Inspira Multi Karya is a company engaged in the manufacturing of office furniture and office partitions. Office Partition Products is one type of product produced at PT. Inspira Multi Karya, this is a desk partition product between employees, apart from being a barrier, the office partition also serves to provide privacy space for each staff so that they can work more optimally, designed with uniqueness and technology that will provide comfort in working. but the quality improvement carried out at PT. Inspira Multi Karya on partition products has not been effective, as evidenced by the presence of defective products such as scratches, dents, cracks, and edge defects.

Based on these problems, the authors are interested in analyzing the quality improvement of Office Partitions products using the Six Sigma method and improving processes with the DMAIC approach (Define, Measure, Analyze, Improve, Control) to reduce the level of product defects, as well as with the help of analytical tools in the form of Pareto Diagrams. , Fishbone Diagram, FMEA .Six Sigma is a strategy, science, and tool to achieve and support business success. Six Sigma focuses on increasing customer satisfaction, the success of Six Sigma depends on the ability to solve problems and quality programs, thus Six Sigma can be used as a measure of industrial system performance targets on how well a product transaction process between suppliers and customers is. the higher the sigma target achieved, the better the industrial system performance will be. This method is also very flexible to run a business easily. The drawback of this method is the need for perseverance in carrying out business strategies because in order to get a good product, special and regular monitoring must be carried out.

Literature Review

A. Quality

Quality is the totality of features and characteristics possessed by a product that is able to satisfy consumer needs. Quality in general means that the characteristics of a productor service are determined by the user or customer and obtained through process measurement and through continuous improvement. While the notion of quality in the context of the production process is the conformity of the specifications of the product design that has been determined by the company / manufacturer.

B. Six Sigma

Six Sigma is a comprehensive and flexible system for achieving, sustaining, and maximizing business success. Six Sigma is uniquely driven by a strong understanding ofcustomer needs, disciplined use of facts, data, and statistical analysis, and careful attention to managing, improving, and re-embedding business processes.

Table 1. *Simple Sigma Conversion Table*

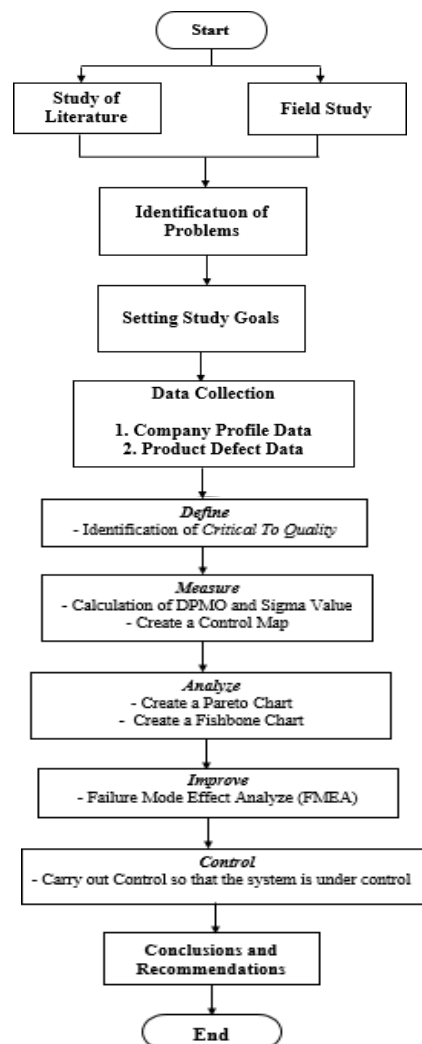| Yield = percentage of items without defect	Defect Per Million Opputinities	Sigma Level
30.9	690.000	1
69.2	308.000	2
93.3	66.800	3
99.4	6.210	4
99.98	320	5
999.997	3	6

Research Method

Figure 1. *Research Flow Chart*

Results And Disscusion

A. Define

In this define stage, the office partition product at PT. Inspira Multi Karya contains 4Critical to Quality (CTQ) which are determined based on the type of defect, namely scratches, dents, cracks, and edge defects. Of the 4 CTQs, there is 1 type of defect withthe highest percentage of defects, namely the type of scratches defect.
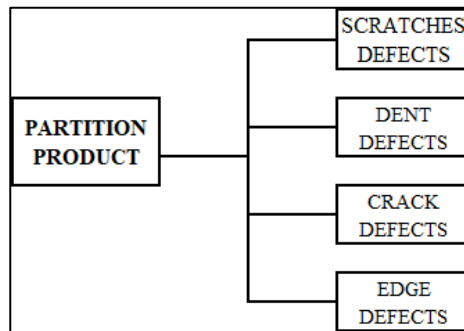
Figure 2. *Critical to quality on partition products*

B. Measure

Table 2. *DPMO value and sigma value*

Bulan	Jumlah Produksi	Jumlah Cacat	CTQ	DPU	TOP	DPO	DPMO	NILAI SIGMA
September	30	7	4	0.2333	120	0.0583	58333.3333	3.0689
	25	7	4	0.2800	100	0.0700	70000.0000	2.9758
	45	10	4	0.2222	180	0.0556	55555.5556	3.0932
	40	10	4	0.2500	160	0.0625	62500.0000	3.0341
Oktober	20	7	4	0.3500	80	0.0875	87500.0000	2.8563
	35	6	4	0.1714	140	0.0429	42857.1429	3.2185
	30	8	4	0.2667	120	0.0667	66666.6667	3.0011
	40	10	4	0.2500	160	0.0625	62500.0000	3.0341
November	50	13	4	0.2600	200	0.0650	65000.0000	3.0141
	25	6	4	0.2400	100	0.0600	60000.0000	3.0548
	30	5	4	0.1667	120	0.0417	41666.6667	3.2317
	35	9	4	0.2571	140	0.0643	64285.7143	3.0198
Jumlah	**405**	**98**		**2.94746**	**1620**	**0.7369**	**61405.4233**	**3.0502**

The results of the calculation of the value of Defects Per Million Opportunity (DPMO)are used to determine the level of defects per million opportunities. From the calculationresults obtained a sigma value of 3.0502 with an average value of Defect Per Million Opportunity (DPMO) of 61405 per one million opportunity, Defect per Opportunity (DPO) or the possibility of the Office Partition product experiencing defects to meet thecompany standards of PT. Inspira Multi Karya of 0.061405.

Table 3. *Calculation of P. control map*

| bulan	Total Input (Unit)	Good Product (Unit)	Cacat (Unit)	% Cacat (P)	$3\sigma = 3\sqrt{\dfrac{\bar{p}(1-\bar{p})}{n}}$	UCL (P bar + 3 STDV)	LCL (P bar - 3 STDV)	P bar
September	30	23	7	0.233	0.48809	0.73371	-0.24247	0.246
	25	18	7	0.280	0.48809	0.73371	-0.24247	0.246
	45	35	10	0.222	0.40837	0.65399	-0.16274	0.246
	40	30	10	0.250	0.40837	0.65399	-0.16274	0.246
Oktober	20	13	7	0.350	0.48809	0.73371	-0.24247	0.246
	35	29	6	0.171	0.52720	0.77282	-0.28158	0.246
	30	22	8	0.267	0.45657	0.70219	-0.21094	0.246
	40	30	10	0.250	0.40837	0.65399	-0.16274	0.246
November	50	37	13	0.260	0.35816	0.60378	-0.11254	0.246
	25	19	6	0.240	0.52720	0.77282	-0.28158	0.246
	30	25	5	0.167	0.57752	0.82314	-0.33189	0.246
	35	26	9	0.257	0.43046	0.67608	-0.18483	0.246
Total	**405**	**307**	**98**	**2.947**	**5.56646**			
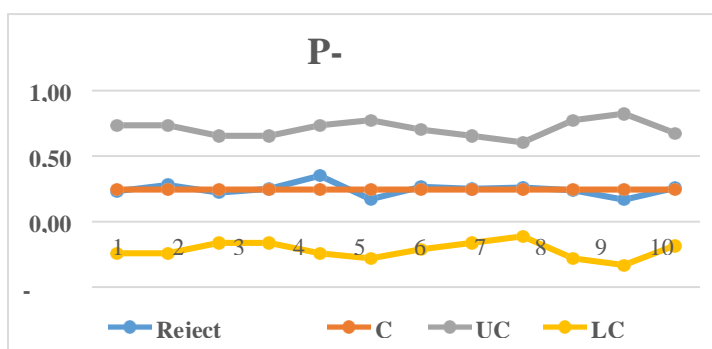
Figure 3. *Chart of P control map*

The graph above shows that the data generated on the P control chart does not pass through UCL and LCL. And the result is a control chart P whose data is still within the control limits.

C. Analyze

At this stage an analysis of the problems that occur in the Office Partition products atPT. Inspira Multi Karya, which previously did the calculations at the measure stage. At this stage, the biggest defects in Office Partition products will be known and the factors that cause these defects to occur.
This stage uses 2 tools, namely Pareto diagrams and fishbone diagrams. The Pareto diagram is used to determine the types of defects that most appear in Office Partition products so that the repairs that will be carried out focus on these types of defects. After knowing the type of defect that has the most number of defects, the next step is to use fishbone diagram tools (Fishbone Diagram) to find out the causes of the most common defects.
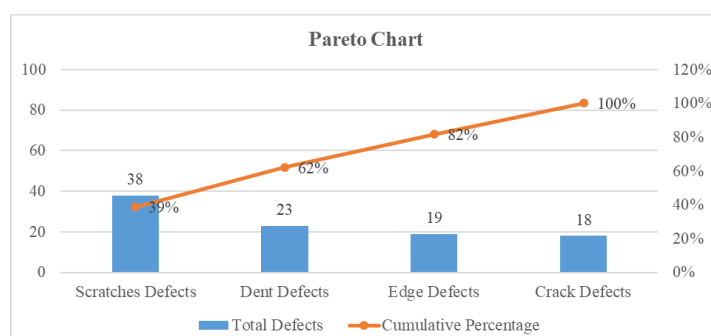

Figure 4. *Pareto chart of product defects*

The results obtained after finding the types of defects in office partition products on the Pareto diagram, the percentage of the highest types of defects reached 39%, namely scratches defects, 23% dent defects, 19% edge defects, 18% cracked defects.
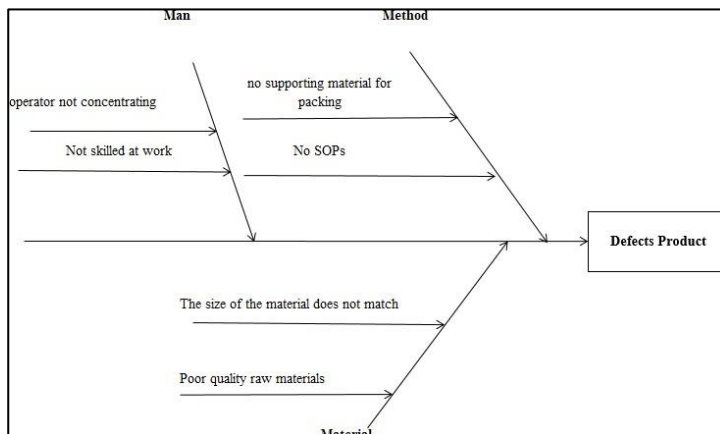

Figure 4. *Pareto chart of product defects*

Method

This factor is caused by the poor packing process and the absence of supporting materials for the packer, then the Standard Operation Procedure (SOP) or work instructions do not exist, resulting in irregular work procedures that must be carried out and ultimately causing the defect problem.

Material

This factor is caused by a discrepancy in the size of the material pieces that have beenstandardized, and also not checking the raw materials before processing, resulting in defects in the finished product.

Man

This factor is caused by the operator's lack of concentration so that in carrying out theirduties the operators are not focused, this also occurs because they are not experts in doingtheir work and there are mistakes that make the product defective.

D. Improve

The process carried out at this stage is to make various efforts to minimize various causes of product defects. The tools used at this stage are Failure Mode Effect Analysis (FMEA) and provide input on actions to reduce this with the Action planning for failuremodes tools.

Table 4. *Failure mode*

Modus of failure	Cause of failure	Effect of failure	Severity Rating	Occurance Rating	Detection Rating	Risk Priority Number	Ranking of RPN
Defects Product	No SOPs	Work is not according to the rules	6	5	5	150	1
	no supporting material for packing	Many products are damaged during shipping	5	6	4	120	2
	The size of the material does not match	Difficulty in assembling	5	4	3	60	4
	Poor quality raw materials	Product quality standards are decreasing	4	3	4	48	5
	operator not concentrating	Operators are not working optimally	5	4	4	80	3
	Not skilled at work	There were some errors at work	5	3	3	45	6

Failure Mode and Effects Analysis (FMEA) is useful for determining the priority of problems causing defects. Using FMEA by means of the highest Risk Priority Number (RPN) value obtained from the Severity (Severity), Occurance (Frequency) and Detectability (Detective Level) values indicate that the reason for the highest Risk PriorityNumber (RPN) value can be corrected to reduce defects. Calculate the RPN value by multiplying each of these factors S x O x D which is given a scale of 1 - 10 to get the RPN rating. based on the biggest problem seen from the results of the FMEA, the highestscore is the absence of SOP, so the author wants to make suggestions for improvements by designing the proposed Standard Operational Procedure (SOP).

Table 5. Action planning for failure modes

Expected product	Cause of failure	Effect of failure	Design Action	Design Validation
Partition products are not defective and are in accordance with company regulationsperusahaan	No SOPs	Work is not according to the rules	Suggest making SOP	Make a good and appropriate SOP
	no supporting material for packing	Many products are damaged during shipping	Need additional material to do packing	Cartons for packing must be styrofoam
	The size of the material does not match	Difficulty in assembling	Adjust the size of the pieces to fit the standard	Cut the material according to the standard dimensions of the size
	Poor quality raw materials	Product quality standards are decreasing	Pay attention to the quality of raw materials	Checking raw materials before processing
	operator not concentrating	Operators are not working optimally	Improve accuracy, focus, and skills	Employees must work carefully and focus
	Not skilled at work	There were some errors at work	Improve operator skills	Conducting training for the operator concerned

In the table, it is intended that the solutions specified can lead directly to the cause of failure. The determined solution is made effectively and realistically possible by considering several inputs from the company.

E . Control

1. Making SOPs and reviewing it better.
2. Checking on the Quality Control section, every Quality Control process must be carried out at every stage of the ongoing production process so that errors can be detected early.
3. Carry out periodic control or supervision of operators, raw materials and productionprocesses so that the products produced can have good quality.
4. The workers pay attention and carry out their duties according to the right rules.
5. Tidy up the production floor by properly arranging the finished goods, tools or products in place.
6. It is necessary to conduct regular training and evaluation of workers.
7. Create a work assistant team tasked with overseeing employee performance on the production process in order to reduce errors made by operators.

Conclusion
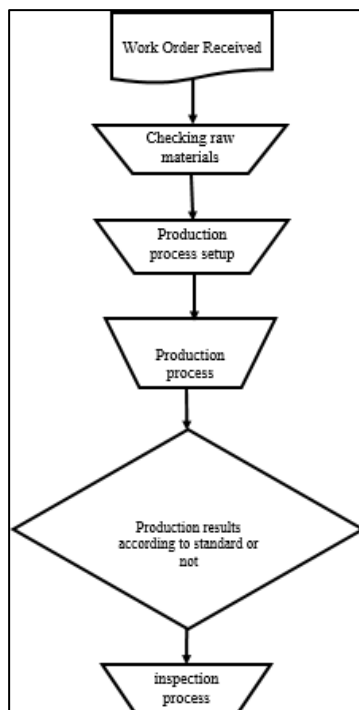*Standard Operation Procedure* (SOP) proposal

Figure 6. *Standard operation procedure (SOP)*

Production Department receives Work Order Document(SPK)
1. The SPK document that has been given will be signed, and the party who signed it must be responsible for the contents and information of the SPK document.
2. Prepare raw materials from the warehouse to be immediately processed into production.
3. After the material has been prepared, then theproduction process is carried out.
4. During the production process, only the main director, the head of the production division, the head of the production division and staff are allowed to enter the production area
5. If anyone with an interest wants to enter the productionarea, they must have a clear permit and reason.
6. Each operator works according to their responsibilities in terms of supervising the machine and its production process
7. Stages of the Production Process
8. The finished product will be inspected

Reference
[1] Aan Zainal Muttaqin, YA (2018). Failure Mode and Effect Analysis of Project X in Madiun City. Industrial Engineering, 81-82.
[2] Adetia Harpensa, AH (2015). Proposed Quality Improvement Using Six Sigma Method to Reduce Number of Defects of Terrazzo Tile Products at PT.UbinAlpen. Industrial Engineering, 3-9.
[3] Gaspersz, V. (2005). Integrated Six Sigma Implementation Guidelines with ISO9001:2000. Jakarta: PT. Main Library Gramedia.
[4] Gaspersz, V. (2005). Total Quality Management. Jakarta: PT. Library Gramedia.
[5] Safrizal, M. (2016). Quality Control with Six Sigma Method . JOURNAL OF MANAGEMENT AND FINANCE, 618-619.

UTILIZATION OF DURIAN PEEL WASTE AS BIOSORBENT FOR LEAD (PB) REMOVAL IN INDUSTRIAL WASTE

Ratnawati, Maika Putri, Mayang Andriyani, Yuli Nurul Maulida, Is Sulistyati Purwaningsih
Chemical Engineering Department, Institut Teknologi Indonesia

Abstract.
Lead (Pb) is one of the toxic and dangerous metals if it accumulates in the body. It comes from industrial waste. The adsorption is one of the efficient methods for handling the impact of water pollution caused by lead waste. This research utilizes durian peel as a raw material for making biosorbent for the removal of Pb in liquid waste. From its characteristics, durian peel can be used as a potential raw material in the manufacture of biosorbent due to the rich in cellulose content of 43.72% which can be utilized as raw material of activated carbon (AC) for eliminating industrial wastewater containing Pb metal. The durian peel waste was converted to AC by chemical activation. The adsorption process was carried out using variations in biosorbent concentration (1; 1.5; 2; 2.5 and 3 grams in 50 ml sample) and contact time with Pb concentration was measured every 15 min for 75 min using Atomic Absorption Spectrophotometry (AAS) equipment. Based on the Langmuir equation, the adsorption capacity and Langmuir coefficient were 43.860 mg/g and 0.318, respectively. The results of the Pb concentration analysis showed that the maximum elimination in Pb levels in industrial wastewater was obtained at the adsorbent amount of 3 grams with contact time for 60 minutes and resulting the adsorption efficiency of 99.48%.

Keywords: Durian Peel Waste, Activated Carbon, Biosorbent, Pb

Introduction

Pollution that generally destroys the environment usually comes from very dangerous wastes that have high toxicity. Highly toxic wastes are generally chemical wastes, either in the form of compounds, elements or ions. Usually chemical compounds that are very toxic to living organisms and humans are chemical compounds that have active ingredients from heavy metals. This toxic power will work as a barrier to the work of enzymes in the physiological process of a body's metabolism and if it accumulates in the body will cause chronic poisoning problems [1]. Some elements of heavy metals are dangerous metals such as Lead (Pb), Cadmium (Cd), Chrome (Cr), Cuprum (Cu), Iron (Fe) and Mercury (Hg), most of these metals have very high affinity for sulfur. These metals attack the sulfur bonds in the enzymes so that the enzymes don't work. Protein, carboxylic acid and amino groups are also attacked by heavy metals. For example, Cd, Cu, and Hg (II) ions are bound to the cell membranes causing inhibition of transport processes through the cell wall [1].

The industries that have the potential to produce waste containing lead (Pb) are related to machining work, metallurgy, metal plating, paint, leather, and mining industry. This heavy metal is toxic to animals, humans, plants and shows persistence. It is nondegradable in aquatic media [2]. Several methods that can be used to reduce the concentration of heavy metal ions especially Pb in wastewater include Photocatalysis [2], precipitation [3], ion exchange using resins [4], and adsorption [5] of pollutants by adsorbents in the form of synthetic resins and activated carbon [6-9].

So far, from the several existing methods, researchers are still trying to choose the most optimal method by studying various variations of the influential process in order to fulfill the quality standards for the disposal of wastewater. The method that is often used for the process of removing heavy metals from polluted environments is using the adsorption method. This method is effective and simple to remove heavy metals. The adsorbent can use durian or banana peel as a biosorbent for the Pb removal in liquid wastewater [6-9].

Durian is one of the most famous fruit crop commodities in Indonesia with a production of 1.350.000 tons in 2021 [10]. In general, Indonesian people only consume durian meat and some also process durian seeds into certain foods. As a result, it produces waste in the form of durian peel which will cause an unpleasant odor and if burned will cause air pollution. The durian peel contains about 47.2% of cellulose, 9.63% of hemicellulose, 9.89% of lignin and 4.2% of ash [11]. It has been extensively studied as a adsorbent of pollutants (heavy metals) and a fuel. The reduction of heavy metals can be done by forming cellulose complex bonds with heavy metals.

The manufacture of biosorbent from durian peel can be done by chemical activation method. Previous researcher has studied the use of durian peel as adsorbent with different conditions namely particle size, contact time and different application [8,9]. To the best of our knowledge, the application of sodium hydroxide (NaOH) and nitric acid (HNO_3) as chemical activating agents to convert durian peel into AC that will be used as an adsorbent in Pb removal with variation of adsorbent mass and contact time is still rarely studied. In this study, we conducted adsorption process for Pb removal from wa ste water with adsorbent mass of 1; 1.5; 2; 2.5 and 3 grams in 50 ml

sample and contact time for 15 to 75 minutes.

Methods

The stages of the process of making a biosorbent from durian peel for the absorption of Pb from the liquid waste of the industry include size reduction, drying, refining, chemical activation of biosorbent, sample testing and evaluation. The durian peel that has been prepared was cleaned, cut into small pieces so that the size became ± 1 cm. Then the durian peel was dried in the sun and used an oven to reduce the moisture content to close to 0%. Furthermore, the durian peel was mashed and sieved with a 60 mesh sieve, soaked in a 40% NaOH solution for 4 hours at a temperature of 60°C. The biosorbent is then filtered and washed. After being activated using an alkaline activator, the biosorbent was immersed in a 20% HNO_3 solution for 4 hours at a temperature of 80°C at a pH value of 2. The biosorbent which had been activated by an acid activator was then filtered (60 mesh) and washed again, and dried using an oven at 50°C. The next process was measuring the cellulose content using reflux method and surface area using Surface Area Analyzer (Nova Touch IF, 17017122201/1.04 type) of adsorbent.

Adsorption process was carried out by mixing 50 ml of liquid waste with a biosorben with a mass variation of 1; 1.5; 2; 2.5 and 3 grams and stirred using a shaker for a variation of time 15; 30; 45; 60 and 75 minutes. The results of stirring are then filtered and the filtrate is taken. After that, the concentration of Pb metal was tested using AAS (Shimadzu, AA-6300 type) so that the results of the absorption efficiency of the adsorbent on Pb metal and the Langmuir isotherm adsorption equation were obtained. The adsorption efficiency was calculated by the subtraction of initial concentration before process by final concentration after process divided by initial concentration multiplied by 100%. In this study, the initial concentration of Pb in the wastewater was 5.58 ppm.

Results and Discussion

The result analysis of the cellulose content of durian peel was 43.7%, with a surface area of 1.06 m^2/gram. Table 1, Figure 1 and Figure 2 show the % reduction in Pb concentration (adsorption efficiency, %) at various adsorbent mass, namely 1.0; 1.5; 2.0; 2.5; and 3 grams in 50 ml of wastewater with contact times of 15; 30; 45; 60; and 75 minutes. The larger the adsorbent mass and the longer the contact time up to 75 minutes, the greater the decrease in Pb concentration.

Table 1. *Effect of contact time and mass of durian peel adsorbent on the adsorption efficiency with an initial concentration of Pb 5.58 ppm*

Contact time (minutes)	Adsorbent mass (mg) in 50 ml sample	Concentration of Pb (ppm)			Adsorption efficiency of Pb (%)
		I	II	Average	
15	1	3.549	3.540	3.545	36.47
30		3.179	3.176	3.178	43.06
45		2.736	2.732	2.734	51.00
60		2.591	2.591	2.591	53.57
75		2.635	2.635	2.635	52.78
15	1,5	2.893	2.897	2.895	48.12
30		2.489	2.488	2.489	55.40
45		1.992	1.993	1.993	64.29
60		1.697	1.693	1.695	69.62
75		1.784	1.784	1.784	68.03
15	2	1.889	1.887	1,888	66.16
30		1.491	1.491	1,491	73.28
45		1.272	1.278	1,275	77.15
60		1.083	1.083	1,083	80.59
75		1.095	1.097	1,096	80.36
15	2,5	1.143	1.149	1.146	79.46
30		0.855	0.851	0.860	84.59

45		0.693	0.693	0.693	87.58
60		0.389	0.390	0.390	93.02
75		0.374	0.374	0.374	93.30
15		0.299	0.298	0.299	94.65
30		0.097	0.097	0.097	98.26
45	3	0.043	0.045	0.044	99.21
60		0.029	0.029	0.029	99.48
75		0.031	0.034	0.033	99.42
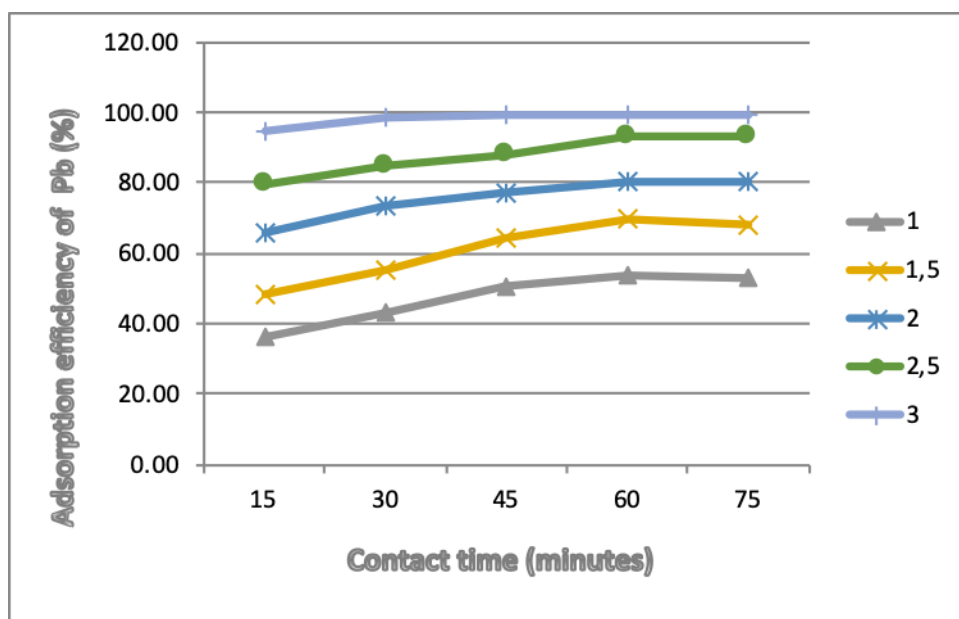
Figure 1. The effect of contact time vs % adsorption efficiency in variations adsorbent mass
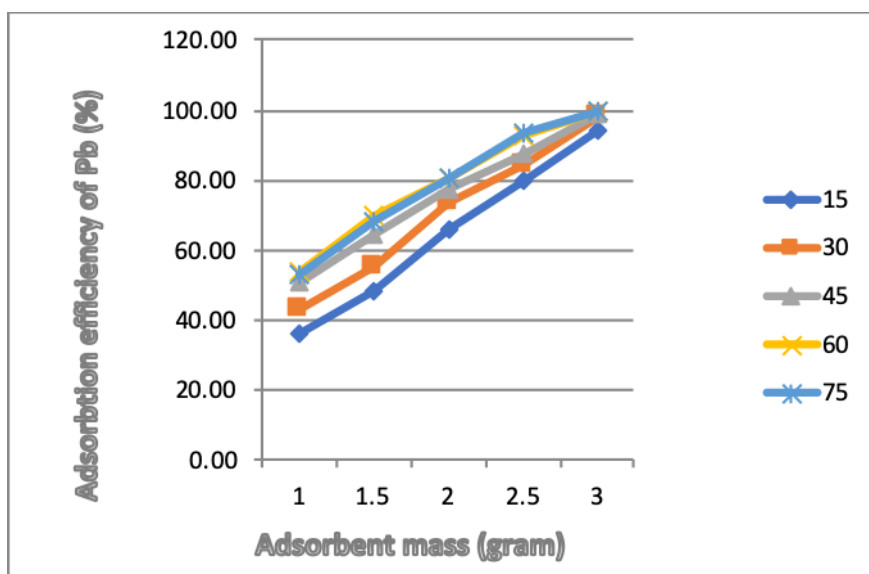

Figure 2. The effect of absorbent mass vs % efficiency in variation of contact time

Based on Table 1, Figure 1 and Figure 2, it can be seen that the best efficiency for the absorption of Pb metal was obtained at 3 grams of adsorbent with a contact time of 60 minutes with an adsorption efficiency of 99.48%. The adsorption capacity has increased because the longer the contact time, the more opportunities for adsorbent particles to contact with Pb metal bound in the pores of the adsorbent. Furthermore, the greater the adsorbent mass, the higher the % adsorption efficiency (the Pb concentration decreases). The same result was also conveyed by previous researchers which the longer the contact time, the greater the adsorption efficiency [12].

This shows that adsorption is a phenomenon which is closely related to the surface area where the interaction between liquid or gas molecules and solid molecules is involved. This interaction occurs due to the attraction of atoms or molecules that cover the surface of the adsorbent. However, at the contact time of 75 minutes, the adsorption efficiency did not increase significantly compare to 60 minutes (Figure 2) since the surface area of the adsorbent was saturated with Pb. In the use of 3 grams of adsorbent, the contact time from 15 and 75 minutes has little effect as indicated by the adsorption ability which is relatively slightly changed between 94.65-99.48%. The surface area is influenced by the size of the particles or pores, the shape of the pores, the arrangement of the pores in the particles and the number of adsorbents. The larger the surface area of the adsorbent, the greater the adsorption that occurs because the possibility of substances sticking to the surface of the adsorbent increases. According to the Regulation of the Minister of the Environment of Indonesia Number 5 of 2014 concerning the quality standard of clean water, the maximum Pb content for industry group 1 is 0.1 ppm. This condition was achieved with the use of 3 grams of adsorbent with a contact time of 30 minutes with a final Pb concentration of 0.094 ppm as shown in Table 1.

The adsorption process is influenced by several factors and has a specific adsorption isotherm pattern. The type of adsorbent, the type of substance being absorbed, the surface area of the adsorbent, the concentration of the adsorbed substance, and temperature are several factors that influence the adsorption process. With these factors, every adsorbent that absorbs a substance will have the different adsorption pattern. From the research data, it can be then developed in a calculation and plotting on the graph so that the Langmuir adsorption isotherm equation will be obtained which is used to study the adsorption ability of durian peel biosorbent on Pb metal.

Figure 3 shows the equation of the line in the Langmuir adsorption isotherm with C_e = the concentration of Pb in the solution after adsorption at equilibrium, X_m/m = the amount of adsorbate that is adsorbed into the adsorbent at equilibrium (mg/g).
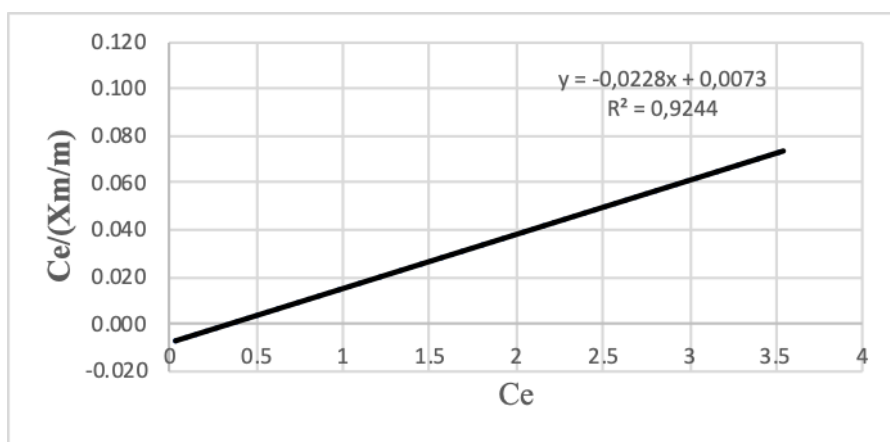

Figure 3. Langmuir isotherm adsorption equation

From Figure 3, it can be calculated that the adsorption capacity was 43.860 mg/g and the Langmuir constant of 0.318. The application of the adsorption isotherm model shows a linear relationship between the amount of substance adsorbed per gram of absorbent and the parameters of the Langmuir equation.

Conclusion

Durian peel can be used as a biosorbent so that it can reduce environmental pollution. The highest adsorption efficiency was obtained at the condition of using 3 grams of adsorbent and a contact time of 60 minutes with an efficiency of 99.48%. The adsorption capacity and the Langmuir constant were 43.860 mg Pb/g adsorbent and 0.318 respectively.

Acknowledgment

References

[1]   Said, N. I. (2010). Metoda Penghilangan Logam Berat (As, Cd, Cr, Ag, Cu, Pb, Ni dan Zn) Di Dalam Air Limbah Industri. *Jurnal Air Indonesia*, Vol. 6, No. 2, pp. 136-148.

[2]   Kumar, V., Wachoo, R. K., Toor, A.P. (2021). Photocatalytic Reduction and Crystallization Hybrid Systém for Removal and Recovery of Lead (Pb). *Industrial and Chemistry Research*, Vol 60, pp. 8901-8910.

[3]   Kavak, D. (2013) Removal of lead from aqueous solutions by precipitation: statistical analysis and modeling. *Desalination and Water Treatment,* Vol 51, pp. 1720-1726.

[4]   Lalmi, A., Bouhidel, K. E. (2018). Removal of lead from polluted waters using ion exchange resin with $Ca(NO_3)_2$ for elution. *Hydrometallurgy*, Vol 178, pp 287-293.

[5]   Waly, S.M., El-Wakil, A.M., El-Maaty, W.A.M., Awad F.S. (2021). Efficient removal of Pb(II) and Hg(II) ions from aqueous solution by amine and thiol modified activated carbon. *Journal of Chemical Society*, Vol 25, pp. 1-11.

[6]   Rizna R., Sajidah. (2017). Pemanfaatan Adsorben Alami (Biosorben) Untuk Mengurangi Kadar Timbal (Pb) Dalam Limbah Cair. *Prosiding Seminar Nasional Biotik 2017*, pp. 274-279

[7]   Purnama, P.E., Dewi, I. G. A. S. P., Ratnayati K. (2015). Kapasitas Adsorpsi Beberapa Jenis Kulit Pisang Teraktivasi NaOH Sebagai Adsorben Logam Timbal (Pb). *Jurnal Kimia 9*, Vol 2, pp.196-202.

[8]   Raditya, S. B., Hendiyanto, C. (2016). Pemanfaatan Kulit Durian Sebagai Adsorben Logam Berat Pb Pada Limbah Cair Elektroplating. *Jurnal Ilmiah Teknik Lingkungan,* Vol 8, No. 1, pp. 10-18.

[9]   Zarkasi, K., Moelyaningrum, A. D., Ningrum, P. T. (2018). Penggunaan Arang Aktif Kulit Durian (Durio Zibethinus Murr) Terhadap Tingkat Adsorpsi Kromium (Cr^{6+}) Pada Limbah Batik. *Efektor,* Vol 5, No. 2, pp. 67-73.

[10] Balai Pusat Statistik dengan link: https://dataindonesia.id/sektor-riil/detail/produksi-durian-di-indonesia-capai-rekor-pada-2021, access on September 4, 2022.

[11] Adunphatcharaphon, S., Petchkongkaew, A., et al. (2020). The Effectiveness of Durian Peel as a Multi-Mycotoxin Adsorbent. *Toxins*, Vol 12, No 108.

[12] Zikra, N. R., Chairul, Yenti, S. R. (2016). Adsorpsi Ion Logam Pb Dengan Menggunakan Karbon Aktif Kulit Durian Yang Teraktivasi. *Jom FTEKNIK,* Vol 3, No.1, pp. 1-8.