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Increasing productivity of stamping press manufacturing using ahp and objective matrix methods

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Abstract

This study aims to understand the level of company productivity in a more structured way and provide suggestions to improve and increase productivity in the stamping press section in order to achieve the set production volume. The focus of this study is a company that produces automotive components, including car accessories and spare parts, especially in the Stamping Press Manufacturing section. Samples taken during the period July 2023 to June 2024 were from the stamping press production area. To determine the productivity index value, a productivity measurement method called Objective matrix was used, with an analysis of factors that influence productivity using the Analytical Hierarchy Process (AHP) method. The results of this study indicate that there is the most significant decrease in productivity at ratios 4 and 5. In addition, the analysis of ratio 5 revealed that the cause of the decrease in productivity is related to product quality, where the high defect rate occurs because the product is scratched due to damaged dies components that have not been replaced. Suggestions for improvement that can be submitted for ratio 5 are the installation of a digital counter equipped with an alarm system as a reminder to check, while for ratio 4, the influencing factors are high working hours and low production results caused by the lubrication process on the dies. The suggested improvement for ratio 4 is to reduce the lubrication frequency to every 20 strokes.

Keywords: analytical hierarchy process, objective matrix, performance, productivity, stamping press

1. Introduction

The companies are expected to always increase productivity, so that they can compete and survive in the current changes that are occurring in the industrial world today (Irwansyah et al., 2022). In general, the things that influence productivity are internal factors, where internal factors can usually be regulated by the company through criteria determined to evaluate performance in existing systems and to understand the productivity index for an activity (C. F. Putri, 2022). The automotive components industry is currently required to be efficient and have high productivity in order to produce goods that have the best competitiveness, both domestically and abroad (Kotimah & Aryanny, 2023). The automotive components industry is a company that focuses on the production of spare parts and accessories for four-wheeled or more vehicles (Dewayana, 2021). They offer vehicle accessories that have been distributed to various vendors who produce vehicles, especially those related to four wheels. The company is determined to continue to improve its expertise and always make improvements and improvements continuously in order to become the most useful and sought-after company in the global automotive industry (Syakhroni & Khoiriyah, 2022). One of the results that the company focuses on is the production of the stamping press section. The company has determined that this section has never reached the production target in the past 1 year. The following is the data on the production results of the stamping press from July 2023 to June 2024, which is shown in Figure 1.

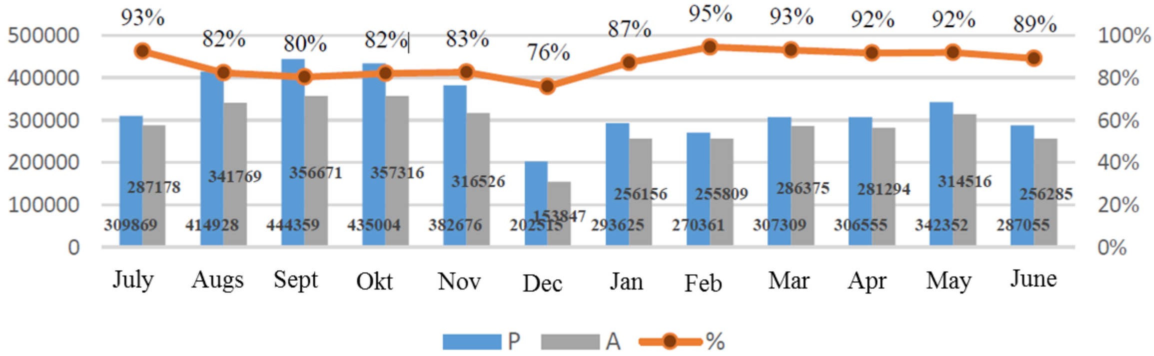

Figure 1. Graph of production achievement results for the period july 2023-june 2024

Figure 1 above shows the production results compared to the production plan in the stamping press section, with inconsistent results and an average of only reaching 80% each month. Unstable productivity fluctuations will affect customer assessments of the production capabilities of the stamping press factory. These production results are the main focus for the company, so it is necessary to take appropriate steps to increase productivity in order to reduce the decline that occurs (Akhmad Diantono, 2020). In an effort to improve and increase productivity, a systematic analysis is needed to understand changes in productivity and the factors that cause a decline in productivity, so that steps can be taken to improve and increase productivity. Productivity measurement is crucial because it can show whether the company is achieving productivity targets for the production process (Agung et al., 2024). This research aims to understand the needs of the company's related parties (Stakeholder Requirements) and improve and enhance the company's performance (Marchand & Girardin, 2020). Performance measurement can be a means to improve the company if the results obtained are not satisfactory (Haniyah, 2023). Companies can involve stakeholders in the performance measurement process. Stakeholder involvement plays a role in performance measurement activities that can support the achievement of company performance (Budiarti et al., 2019). Computer technology is crucial in carrying out business and market interactions in companies (Aulia et al., 2023). The research results determine the total and partial levels using the Objective Matrix model. This shows whether productivity figures vary and how significant improvements can be made by optimizing each aspect of productivity (Sayuti et al., 2021). One way to measure productivity that can solve this problem is the Objective Matrix (OMAX)(Indriani et al., 2024). This method combines various productivity criteria into one interconnected whole. In this way, this model is able to identify elements that influence lower productivity, it is hoped that this method can present a picture that becomes a certain reference in measuring (Fawzy, 2023). We can see to what extent the production process is effective in increasing output and how efficient the input sources are in increasing productivity (Sari & Nugraha, 2019). The use of the Analytical Hierarchy Process (AHP) method, which is a multi-criteria decision-making method in complex problems (Manik, 2023). This method was created by Prof. Thomas L. Saaty in the 1970s. AHP is an efficient method for making decisions in complex situations (Pebrianti et al., 2022). This method transforms a complex problem into a hierarchical structure that shows the relationships between goals, criteria, sub-criteria, and alternatives (Rodrigues et al., 2022). Therefore, it is necessary to analyze performance measurement involving company stakeholders. The existence of stakeholders has a function in the performance measurement process so that it can support the achievement of company performance (Nugroho, 2021).

2. Methodology

This research was conducted in the automotive industry sector, especially Stamping Press Manufacturing as a four-wheeled vehicle component company. In this study, productivity measurements were conducted using the Objective Matrix (OMAX) method to increase and improve productivity in the Stamping Press Manufacturing production section based on production achievement data. The research stages shown in Figure 2.

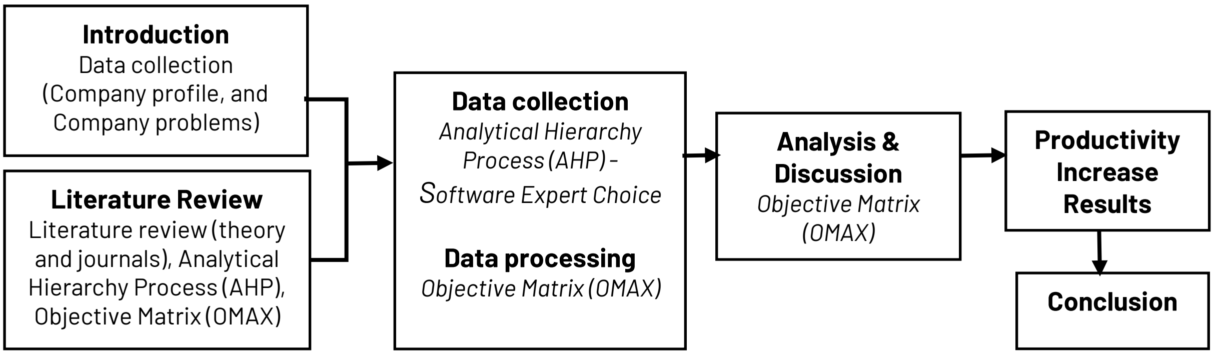

Figure 2. Research stages

In this data collection process, the techniques used are observation and interviews, so the tools used in this study are questionnaires and interview results. (Sari & Nugraha, 2019). The following is the observation and interview data which can be seen in Table 1.

Table 1. Observation and Interview Data

Variables	Indicator	Data Types	Data Source	Data Collection Technique
Production Plan	Product	Secondary	Production Planning	Observation and Interview
Production Achievements	Product	Secondary	Stamping Production	Observation and Interview
Production process	Process Stages	Primary	Stamping Production	Observation and Interview
Number of Man Hours	Working hours	Secondary	Stamping Production	Observation and Interview
Direct Labor Force	Operator	Secondary	Stamping Production	Observation and Interview

The discussion of productivity measurement in this study consists of several stages, namely:

a) In the first stage, a first-stage questionnaire was given to determine the intensity of the importance of the six productivity ratios that will be used for productivity measurement. Then a second-stage questionnaire was given to obtain the average value of the comparison between one ratio and another.
b) In the second stage, weighting was carried out on the six productivity ratios using the Analytical Hierarchy Process (AHP) method.
c) In the third stage, the necessary data is collected according to the ratio of the questionnaire results in the previous stage.
d) In the fourth stage, the productivity ratio is calculated and then the observation results are put into the ratio calculation table according to the time or observation period, namely July 2023 to June 2024.
e) In the fifth stage, the initial standard value calculation is carried out which is useful as a basic reference for the company's productivity value. Then the target value or company performance will be calculated. The lowest and highest values during the observation period will be displayed in a table for ease of calculating the target value.
f) In the sixth stage, the objective matrix table will be created and calculated.

This first stage questionnaire is used to determine the intensity of the importance of the productivity ratio. (Marshafina & Hanun, 2024). This questionnaire was given to 6 respondents consisting of 5 questionnaires given to the section heads at the functional level, and 1 questionnaire to the head of the stamping press manufacturing production section. Table 2 below is the importance of the productivity ratio, the score values based on the level of importance are as follows. The following can be seen in Table 2.

Table 2. Data collection techniques

Level of interest	Score
Not important	1
Less Important	2
Quite Important	3
Important	4
Very important	5

The determination of the ratio that will be used in measuring the company's productivity is based on the company's vision and mission, which will form a potential objective measurement that can influence the measurement of said productivity (Rodrigues et al., 2022). The objective potential of the measurement is to always exceed customer expectations in providing products and services. After giving the first stage questionnaire to the respondents, the results are averaged and then divided by the number of respondents (Marshafina & Hanun, 2024). After that, the ranking of the scores was given. The results of the first stage of the questionnaire can be seen in Table 3**.**

Table 3. Results of the first stage questionnaire

No	Criteria	Productivity Ratio	Respondent Results						Score	Rank
			1	2	3	4	5	6		
1	Efficiency	GSPH / GSPH Current	3	5	5	4	4	5	4.33	1
2	Efficiency	Total Products Produced / Number of Workers	5	3	3	4	3	3	3.50	2
3	Efficiency	Total Products Produced / Number of working hours used	4	4	2	3	3	3	3.17	4
4	Effectiveness	Product quantity is not good / Good product quantity	2	3	2	2	2	3	2.33	5
5	Effectiveness	Total products produced / Total Products Shipped	2	4	4	5	2	3	3.33	3
6	Inferential	Total Overtime Hours / Total normal working hours	1	2	1	1	1	1	1.17	6

Judging from the results of the distributed questionnaire, there is one indicator whose level of importance has the lowest average value and does not affect productivity, so the ratio of 6 of 1.17 is not the productivity ratio that will be measured in this discussion with the predetermined formula, which is shown in Table 4.

Table 4. Ratios used after questionnaire calculation

No	Category	Productivity Ratio
1	Ratio 1	GSPH / GSPH Current
2	Ratio 2	Total Products Produced / Number of Workers
3	Ratio 3	Total products produced / Total Products Shipped
5	Ratio 4	Total Products Produced / Number of working hours used
6	Ratio 5	Product quantity is not good / Good product quantity

In table 4 there are 5 ratios that will be used for calculating the questionnaire to stakeholders, where the determination of the ratio measurement formula has been determined based on productivity criteria such as efficiency, effectiveness, and inferential. Respondents are asked to give a value based on the scale table that has been provided. After the questionnaire from each respondent is filled in, a calculation is carried out to obtain the average result of the questionnaire.

3. Result and Discussion

Analytical Hierarchy Process (AHP) is a method for decision making that involves many criteria in a selection problem. This method combines qualitative and quantitative factors to prioritize, rank, and evaluate available alternatives. AHP Online Calculator (https://bpmsg.com/ahp/ahp-calc.php) is an online-based AHP system and is part of BPMG'S. This system can be accessed free of charge, allowing users to use this system anytime and anywhere. With the "My AHP" feature, users can re-access the AHP projects they have done so as not to lose the results of the weight calculations that have been done. AHP Online Calculator calculates the priority of the comparison matrix using the eigenvector method, calculates the Consistency Index and checks the consistency ratio with the ideal provision of <10%, and then produces a decision based on weight, where rank 1 indicates the highest weight value. Meanwhile, the Pairwise scale applied in the calculation of the AHP Online Calculator uses the average scale data that has been given to six respondents who are considered competent in providing the comparison scale. The following are the results of the AHP Calculator Online calculations which show the weighting that will contribute to the productivity index, which can be seen in Table 5.

Table 5. Productivity ratio weighting results

Category	Priority	Rank
Ratio 1	12.6%	3
Ratio 2	42.9%	1
Ratio 3	33.6%	2
Ratio 4	6.8%	4
Ratio 5	4.0%	5

Furthermore, a large weighting value will also provide a large contribution to the productivity index value, and vice versa, a small weighting value will provide a small contribution to the productivity index value. In this writing, the data taken is data that has relevance to the productivity measurement process using the objective matrix (OMAX) method. The data that has been successfully collected as a reference for the company's current measurement can be seen in Table 6.

Table 6. Current productivity measurement results

Month	Total Production Results	Total Shipping	Total Hours Used	Total Workforce	GSPH Current	Good Product	Not Good Product
July	87,178	247,380	12,897	53	319	247,020	360
August	341,769	315,620	12,408	55	320	315,538	82
September	356,671	312,523	12,838	56	338	312,371	152
October	357,316	340,419	12,126	54	321	339,764	655
November	316,526	311,406	12,602	60	308	311,014	392
December	153,847	155,578	12,039	63	292	154,891	687
January	256,156	255,200	10,191	53	321	254,384	816
February	255,809	245,747	14,336	52	306	245,451	296
March	286,375	271,539	10,925	53	306	271,116	423
April	281,294	351,396	13,394	63	303	350,416	980
May	314,516	342,655	13,682	63	297	341,384	1,271
June	256,285	251,429	12,168	64	269	251,077	352

The next process is to calculate the productivity ratio and then simulate the observation results into a ratio calculation table according to the time or observation period. The results of this ratio calculation show the company's productivity value in each ratio used. The productivity value in this ratio will be used in the steps of creating the objective matrix table. The following are the results of the productivity ratio calculation, which are shown in Table 7.

Table 7. Current productivity ratio calculation results

Month	Ratio 1 (%)	Ratio 2 (Pcs)	Ratio 3 (%)	Ratio 4 (Hour)	Ratio 5 (PPM)
July	91.14	5418.45	1.16	22	1457.37
August	91.43	6213.98	1.08	28	259.87
September	96.57	6369.13	1.14	28	486.60
October	91.71	6616.96	1.05	29	1927.81
November	88.00	5275.43	1.02	25	1260.39
December	83.43	2442.02	0.99	13	4435.38
January	91.77	4833.13	1.00	25	3207.75
February	87.47	4919.40	1.04	18	1205.94
March	87.47	5403.30	1.05	26	1560.22
April	86.60	4464.98	0.80	21	2796.68
May	84.97	4992.32	0.92	23	3723.08
June	76.79	4004.45	1.02	21	1401.96

Table 7 is the result of the calculation of the productivity ratio as a reference. This initial standard was made with the intention of being used as an initial reference for productivity in stamping press manufacturing production, where the calculation of this productivity is in April, May, June 2024, namely the achievement of the last 3 months. The following is the determination of the complete initial standard for each ratio, which is shown in Tables 8, 9, 10.

Table 8. Initial Standard Calculation of Ratios 1 and 2

Month	GSPH	GSPH Current	Performance (%)	Products produced	Total Workforce	Performance (pcs)
April	350	303	86.60	281,294	63	4464.98
May	350	297	84.97	314,516	63	4992.32
June	350	269	76.79	256,285	64	4004.45
Average			82.79			4487.25

Furthermore, the ratio value of 4487.25 is used as the initial value for score 3 in the Objective Matrix calculation table for each month for the second ratio.

Table 9. Initial Standard Calculation of Ratios 3 and 4

Month	Products produced	Product shipped	Performance (%)	Products produced	Working hours used	Performance (%)
April	281,294	351,396	0.80	281,294	13,394	21.00
May	314,516	342,655	0.92	314,516	13,682	22.99
June	256,285	251,429	1.02	256,285	12,168	21.06
Average			0.91			21.68

For the next performance value of 0.91 is used as the initial value for the score in the Objective Matrix calculation table for each month for ratio 3. For the next performance value of 21.68 is used as the initial value for score 3 in the Objective Matrix calculation table for each month for ratio 4.

Table 10. Initial standard calculation ratio 5

Month	Good product	Not Good Product	Performance (pcs)
April	350,416	980	2796.68
May	341,384	1,271	3723.08
June	251,077	352	1401.96
Average			2640.57

For the next performance value of 2640.57 is used as the initial value at score 3 in the Objective Matrix calculation table for each month for a ratio of 5. The company's productivity target is the value that the company wants to achieve and will be placed at score 10 in the Objective Matrix calculation table. Based on the company's provisions with the basis of customer considerations, the final target or target that the company wants to achieve is the target of improving and increasing productivity by 10%. The following are the results of the calculation of the highest and lowest values during the observation period, shown in Table 11.

Table 11. Highest and lowest values during observation

Ratio	Highest	Lowest
1	96.57	76.79
2	6616.96	2442.02
3	1.16	0.80
4	29.47	12.78
5	259.87	4435.38

Next, the target calculation is carried out using the highest value of each ratio during the observation period, which can be seen in Table 12.

Table 12. Highest and lowest values during observation

Target Determination	Calculation	Results	Initial standard value Average of 3 months observation	Target 10 %
Target Ratio 1	(96.57 x 0.1)+96.57	106.23	82.79	106.23
Target Ratio 2	(6616.96 x 0.1)+6616.96	7278.66	4487.25	7278.65
Target Ratio 3	(1.16 x 0.1)+1.16	1.28	0.91	1.28
Target Ratio 4	(29.47 x 0.1)+29.47	32.41	21.68	32.41
Target Ratio 5	(259.87 x 0.1)	25.99	2640.57	25.99

In the ratio of 5, the target value is inversely proportional, namely the smaller the value, the better. Furthermore, the initial standard value, the lowest value and the target value will be used in making the objective matrix table. After carrying out several steps in making the objectives matrix table as mentioned above, the company's productivity index value per month during the observation period is obtained. The productivity index value is the sum of the productivity values of all ratios used. The following are the results of the productivity index using the objective matrix, which can be seen in Table 13.

Table 13. Productivity index results using objective matrix

Month	Productivity Value					Total Nilai
	Ratio 1	Ratio 2	Ratio 3	Ratio 4	Ratio 5	Productivity
July	50.46	128.78	235.39	27.24	20.12	461.98
August	50.46	300.48	168.14	40.86	36.21	596.14
September	75.69	300.48	235.39	40.86	36.21	688.62
October	50.46	343.41	134.51	54.48	16.09	598.94
November	37.84	171.70	134.51	27.24	24.14	395.43
December	37.84	42.93	134.51	0.00	0.00	215.28
January	50.46	128.78	100.88	27.24	8.05	315.40
February	50.46	128.78	134.51	13.62	24.14	351.50

March	50.46	171.70	134.51	27.24	16.09	400.00
April	37.84	128.78	67.25	20.43	12.07	266.37
May	37.84	128.78	100.88	20.43	8.05	295.98
June	0.00	85.85	134.51	20.43	20.12	260.90

From the results of the data processing that has been carried out, it can be seen that the achievement of the productivity index value in the measurement period, while to find out the change in the productivity index value against the previous period with the following formula (1), and the results of the calculation of the productivity index value are shown in Table 14.

$$\text{Productivity Index} = \frac{(\text{Current Period Index} - \text{Previous Period Index})}{\text{Previous period index}} \quad \text{..........................(1)}$$

Table 14. Recapitulation of productivity index values

Year	Month	Overall Activity	Recapitulation of Productivity Index Values
2023	July	461.98	0.00%
	August	596.14	29.04%
	September	688.62	15.51%
	October	598.94	-13.02%
	November	395.43	-33.98%
	December	215.28	-45.56%
2024	January	315.40	0.00%
	February	351.50	29.04%
	March	400.00	15.51%
	April	266.37	-13.02%
	May	295.98	-33.98%
	June	260.90	-45.56%

In Table 14, which is a recapitulation of the productivity index from July 2023 to June 2024, it can be concluded that negative values indicate a significant decline in productivity values, so it is very necessary to take steps to improve. The steps taken for improvement should be carried out continuously or continuous improvement so that the level of productivity can continue to be increased continuously (K. N. R. Putri, 2021). The initial step in the improvement efforts undertaken is to find the main cause or factor that has the greatest influence on the increase or decrease in the productivity level. From the 5 productivity criteria that are calculated, 2 criteria will be taken that have the greatest influence in calculating the productivity level. By using a Pareto diagram, the ratios that have experienced the greatest decline can be identified. The productivity decline table for each ratio is calculated based on the Productivity index value formula, shown in Table 15.

Table 15. Decrease in productivity index value

Category	Rank	Total decrease in production	Percentage	Percentage
Ratio 5	1	-4.8	41.0%	41%
Ratio 4	2	-1.9	16.4%	57%
Ratio 1	3	-1.8	15.7%	73%
Ratio 2	4	-1.7	14.4%	87%
Ratio 3	5	-1.5	12.5%	100%
Total		-11.70		

Table 15 is the basis for determining priorities in handling improvements and becomes a continuous improvement activity. So to facilitate understanding of the highest problems, a Pareto diagram is made, which is shown in Figure 3.

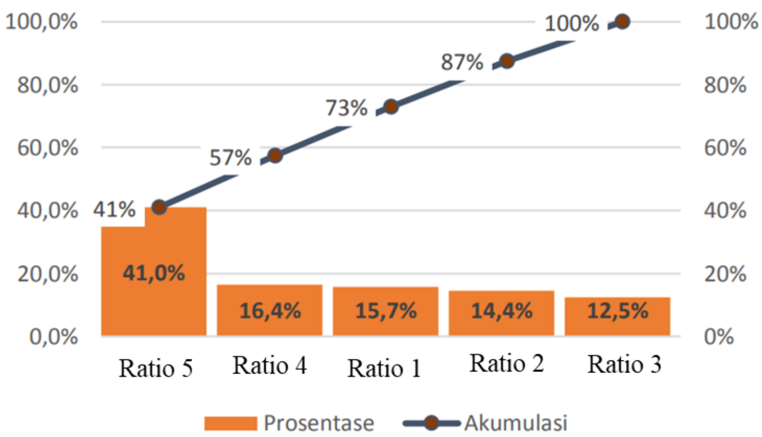

Figure 3. Accumulated rate of decline in productivity ratio

Based on Figure 3, the accumulation of the level of decline in the productivity ratio, productivity improvement steps will be carried out which will be focused on the two highest criteria, namely ratio 5 and ratio 4, so that it is necessary to evaluate the decline in productivity and make further improvements. The following are the priority criteria for the decline in productivity, which are shown in Table 16.

Table 16. Priority criteria for productivity decline

Category	Percentage	Total production decline
Ratio 5	41.0%	Total Products are not good against Total Products are good
Ratio 4	16.40%	Total products produced against working hours used

The following is a description of the root of the problem and proposed improvements, from the evaluation of the 2 priority criteria for productivity decline, which are shown in Table 17.

Table 17. Proposed productivity improvements at ratio 5 and ratio 4

Potential cause	Potential Root Cause	Company Condition	Suggested Improvements	Improvements Activities
High defect product type scratch	Lifetime Trimming knife and piercing punch are worn out and have not been replaced	Die component lifetime checks are not carried out consistently by die operators so that component use is not detected when it is no longer suitable for use.	The operator can exchange the blunt piercing punch trimming knife before the different product molding phase is processed. On the press machine, the piercing punch trimming knife has an average service life of up to 10,000 processes.	Installation of a digital counter capable of counting up to 10,000 times, this digital counter is connected to a press machine which is also connected to an Arduino Uno Microcontroller equipped with a warning alarm, this alarm will sound after the digital counter reaches 10,000 strokes and the program will stop the press production process.
High use of labor hours results in low product	Lubrication of each stroke during the production process	Some types of parts require lubrication during the process because the part is difficult to remove due to sticking to the die surface.	Reduces the lubrication process from every stroke to every 20 strokes.	To reduce the lubrication process, it can be done by maintaining the dies or repairing the dies that cause the product to stick. Reducing the use of lubricants can be done, only every 20 strokes the lubricant is given while ensuring that the lubricant used is of good.

4. Conclusion

In The results of this research analysis focus on efforts to increase productivity in stamping press manufacturing using the Analytical Hierarchy Process (AHP) and Objective Matrix (OMAX) methods, which then apply improvement steps to increase productivity. Productivity data measured by the company shows that production achievements in the stamping press manufacturing section for 12 months (July 2023-June 2024 period) averaged 80% of the monthly production plan. Productivity measurements are carried out systematically using the Objective Matrix (OMAX) method based on the level of importance determined through weighting using the Analytical Hierarchy Process (AHP), with a CR value of <10% which is considered appropriate, namely 4.3%. The weighting of each ratio based on the highest order shows ratio 2 with a value of 42.9%, ratio 3 with 33.6%, ratio 1 with 12.6%, ratio 4 with 6.8%, and ratio 5 with 4.0%. Furthermore, the productivity index is calculated through the Objective Matrix (OMAX) table to evaluate changes in the monthly productivity index. The two ratios that show the highest decline in productivity index based on the Pareto diagram are ratio 5 with a decline of 41.0%, which occurred in August 2023, and February, June, and November 2024. The second highest decline in productivity index value is in ratio 4 with a figure of 16.4% which occurred in October, November, December 2023, and January and April 2024. The results of the analysis of the decline in productivity in ratio 5 were caused by defective products, namely the type of scratch defect, where during the measurement period there were 1121 defective products, namely in the production results of part 5230h011 and part 65152. The first cause of the ratio 5 problem is the scratch type defective product, which appears because the trimming knife on the piercing punch is no longer suitable for use but has not been replaced. To overcome this, it is recommended to create an automation system that can count up to 10,000 strokes and is programmed to stop the press production process so that the trimming knife replacement activity can be carried out. The second cause analysis of the ratio 4 problem is the low output of products due to the high working hours used. This is caused by the lubrication given every stroke in the production process. The proposed improvement is to reduce the amount of lubrication, only giving lubricant every 20 strokes while ensuring the quality of the lubricant used is good.

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