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Decision Making for Welding Robot Selection in Suzuki Manufacturing Plant with Analytic Hierarchy Process Method

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Abstract

This research discusses the selection of welding robots in the PT Suzuki Indomobil Motor Manufacturing Plant. The existing situation is that PT SIM still uses manual welding, often resulting in product defects and inconsistent quality. To solve this problem and improve production quality, Suzuki is considering modernizing its welding line by replacing manual labor with a robot automation system. By using the Analytic Hierarchy Process (AHP) as a method for decision-making, this research evaluates alternatives based on multiple criteria such as financial aspects, operational efficiency, synchronization, and organizational readiness. A hierarchical model for criteria and sub-criteria is developed based on stakeholder interviews and a literature review. Pairwise comparison determines each weight of criteria, sub-criteria, and alternatives. Also, the consistency ratio (CR) was calculated to ascertain the reliability of the judgments. The other options, such as Yaskawa, Fanuc, and Nachi Fujikoshi, were evaluated against the criteria using AHP (Analytic Hierarchy Process) in Microsoft Excel. The results for the weight of each criterion are Financial Aspect (22.9%), Operational Aspect (41.7%), Process Synchronization and Improvement (24.3%), and Organizational Readiness (11.1%). Yaskawa welding robot was the best alternative with the highest priority (54.97%), Fanuc (38.81%), and Nachi Fujikoshi (6.22%). AHP was an effective multicriteria decision-making method for industrial applications in this study. It explores the challenges and solutions specific to PT Suzuki Indomobil Motor while improving manufacturing efficiency and quality. Recommendations include providing comprehensive employee training programs so that the workforce affected by the change from manual to robot can still contribute to the company.

Keywords: welding robots, analytic hierarchy process, decision-making, automation

INTRODUCTION

Cars are one of the vehicles chosen by Indonesian society as a vehicle to travel in daily activities. We will probably need a car to drive near or far, but this is still safer than using a motorbike. As one of the most popular car users in the world, it was very clear why many manufacturers from around the globe built factories here to fulfill Indonesia's substantial domestic market. PT Suzuki Indomobil Motor is one of the various products that have been manufactured correctly ills before. Car production also plays an economic role in Indonesia. Different car manufacturing factories in Indonesia meet domestic market demand and export to various countries worldwide. This shows that Indonesia can compete with the global market, which means that car production from Indonesia is recognized for its quality by other countries. In the last 5 years, Indonesia has experienced rapid growth in the number of car users. (Campilho & Silva, 2023; Kah et al., 2015).

According to the Association of Indonesian Automotive Industries (Gaikindo.or.id, 2024) Reports that car sales in Indonesia have surpassed one million units annually and are on the rise, alongside development and consumer buying capacity; however, in 2020, they experienced a downturn attributed to the COVID-19 outbreak. Suzuki is a Japanese car manufacturing company that has an assembly plant in Indonesia. One of the PT SIM factories has been operating since 1974. Some of the equipment used to produce cars is still manual and does not use robots, especially on the welding production line that uses manual human labor (Zhang et al., 2023). Although this method has been used for factory operations for years, several problems have been faced, primarily related to the level of human error that can cause production defects. (Torres et al., 2021). As a result, defects often occur during production, especially in the welding section, resulting in losses for the company because repairs are needed on the defective car body parts. (Nkosi et al., 2020; Torres et al., 2021). To solve this problem and improve production quality, Suzuki is considering modernizing its welding line by replacing manual labor with a robot automation system. This improvement is expected to reduce human error rates, improve welding quality, and increase production capacity. (Palčič & Prester, 2024; Tahapary & Saptadi, 2022).

On the other hand, moving from a manual system to a robotic automation system is a mature decision. Suzuki has to consider many factors, such as finance, operations, adaptability to existing production systems, and organization. Therefore, the use of the Analytic Hierarchy Process by (Saaty & Vargas, 2012) The method is relevant in the decision-making process to determine the optimal welding robot selection for Suzuki. Suzuki can analyze various available robot technology alternatives based on predetermined criteria with AHP, such as finance aspect, operational, process improvement, and organizational readiness. (Chakraborty et al., 2023). This method allows the company to make more measured and data-based decisions so that the selection of the right robot for the welding production line can be carried out optimally and support the company's production. (Weidemann et al., 2023).

In the modern industrial era, welding robots are increasingly common in factories, including Suzuki factories. Choosing the right welding robot is an important strategic decision because it can affect product quality, production efficiency, and operational costs. The AHP (Analytic Hierarchy Process) method is a structured and systematic decision-making method. AHP allows decision-makers to break down complex problems into simpler hierarchies, consider various criteria and alternatives, and evaluate and compare options based on decision-maker preferences (Bu et al., 2024). While according to Chuenmee et al., (2025) Current inspection methods, reliant on random checks after cars leave the Body-in-White (BIW), often lead to significant time losses, emphasizing the necessity for enhanced quality assessment. This study uses data analysis and machine learning techniques to transition from random checks to 100 percent inspection. This approach improves quality control by predicting weld quality levels before car body completion.

The novelty of this research lies in its application of the AHP method to the specific context of welding robot selection at PT SIM. While previous studies have explored the use of AHP in various manufacturing settings, limited research has focused on its application in the

Indonesian automotive industry, particularly concerning the transition from manual to robotic welding. This study contributes to the academic literature on multi-criteria decision-making and provides practical insights for PT SIM and other manufacturers facing similar challenges.

The urgency of this research is underscored by the increasing need for Indonesian manufacturers to enhance competitiveness in the global market. As consumer expectations for quality and efficiency rise, companies must adopt advanced technologies to meet these demands. Delaying the adoption of robotic welding could result in lost market opportunities, reduced profitability, and decreased customer satisfaction.

The primary objective of this research is to identify the most suitable welding robot for PT SIM using the AHP method, considering multiple evaluation criteria such as financial aspects, operational efficiency, process synchronization, and organizational readiness. By doing so, this study aims to support PT SIM in making an informed, data-driven decision that aligns with its strategic goals. The benefits of this research are twofold. For PT SIM, the findings will facilitate the selection of a welding robot that optimizes production quality and efficiency while minimizing costs and operational risks. For the broader academic and industrial community, this study offers a replicable framework for applying AHP in complex decision-making scenarios within the manufacturing sector.

RESEARCH METHODOLOGY

In this research on decision-making for welding robot selection using the Analytic Hierarchy Process (AHP) method, the research design will guide how data is collected and analyzed and give a conclusion to ensure that the welding robot selected is the best alternative for PT Suzuki Indomobil Motor. The research design will be primarily quantitative, focusing on collecting and analyzing the data from given questionnaires to evaluate the many criteria and sub-criteria in selecting a welding robot. (Keshvarparast et al., 2024). In addition to quantitative research, this study will use qualitative methods to validate the established criteria and sub-criteria through stakeholder interviews. The AHP technique requires a structured approach in which several criteria are weighted based on their value, and alternatives are compared against these criteria. (Mardani et al., 2015).

The first step is to identify the business issue. The issue is that the current manual welding production causes high defects in the PT Suzuki Indomobil Motor products. Laborers who do manual welding often make mistakes and produce products that don't meet the expected quality standards. This problem makes it hard for companies to improve the quality and speed of their operations. The second step is the research objective. The third step is data collection, which will be used to analyze with AHP. In this step, data is collected through two main methods: an interview and a questionnaire. The interviews and questionnaires are given to managers involved in the company's welding process. The information obtained from these sources covers essential criteria when selecting a welding robot. The fourth step is solving the problem using the AHP model development based on the requirements and data collected.

This stage of the Analytical Hierarchy Process (AHP) method. From this method, there are some stages which are:

a. Identify the Criteria and Sub-Criteria: Find the main criteria and sub-criteria that PT Suzuki Indomobil Motor should use to choose a welding robot. The most important criteria are financial aspects, operational aspects, process synchronization and improvements, and organizational readiness. There will be sub-criteria for each criterion to clarify the evaluation parameters.
b. Structure of the Decision Criteria Hierarchy: Create a decision hierarchy with the primary goal (choosing the best welding robot) at the top, the criteria and sub-criteria below it, and the alternatives like robots from Yaskawa, Fanuc, and Nachi Fujikoshi.
c. Pairwise Comparison: Each criterion and sub-criterion is compared with two others to determine their importance. This comparison will give each measure a weight, showing its importance in the AHP.
d. Results Analysis and Alternative Selection: Once the weights for the criteria are known, different welding robot alternatives are considered using these weights. The alternative with the highest weight will be the optimal solution for PT Suzuki.

The last step is the conclusion and implementation plan. After selecting the best welding robot, an implementation plan will be drawn to replace the manual welding process with a robot. The final recommendations for alternatives are provided based on the results of the AHP evaluation and chosen alternatives, which explain the reasons for selecting the welding robot.

Data Analysis Method

Data analysis is an essential phase in the research process. This chapter explains how the data collected through questionnaires and interviews are analyzed to support the selection of welding robots at PT Suzuki Indomobil Motor. After the questionnaires are collected, the data analysis method used in this study is the Analytic Hierarchy Process (AHP); comparisons between each criterion and sub-criteria and alternatives that respondents have given will be arranged in a comparison matrix. Each comparison will provide a preference weight, which will later be used to calculate the consistency ratio and determine the final priority weight of each criterion and sub-criteria.

1. Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making tool that helps in structuring complex decisions and calculating a ranking of alternatives based on various criteria and sub-criteria. Some steps are using AHP:

Table 1. Pairwise comparison rating scale

Intensity of Importance	Definition	Description
1	Equal Importance	Both elements are equally essential or preferred.
3	Moderate Importance	One element is moderately more essential or preferred than the other.
5	Strong Importance	One element is enormously more essential or preferred than the other.
7	Very Strong Importance	One element is very strongly more important or preferred than the other.
9	Extreme Importance	One element is hugely more essential or preferred than the other, with the highest degree of certainty.
2,4,6,8	Intermediate Values	When compromise is needed between two

Source: (Saaty & Vargas, 2012)

RESULTS AND DISCUSSION

Analysis

a. Defining the Criteria and Sub-Criteria

Creating the criteria and sub-criteria is the first step of the AHP Process. This breaks down the decision-making determinants into their important bite-size and statistically relevant pieces. This hierarchy will serve as the basis for systematic evaluation using the Analytic Hierarchy Process (AHP) method. It offers the framework for making objective comparisons, prioritizing alternatives, and choosing the selected options. Having clear criteria and sub-criteria ensures that decisions are comprehensive by helping all relevant aspects guide the decision-making process within an organized framework. This helps minimize biases when comparing robot alternatives because criteria give us a foundation for objective decision-making. This enables decision-makers to evaluate options based on objective, well-defined criteria instead of subjective impressions. Data collection of criteria by guiding the design and content of questionnaires and interviews to solicit structured inputs from stakeholders. That label on the info can be helpful to ensure that all the information gathered is directly transferrable and valuable in making a decision, which in turn increases the accuracy of the analysis.

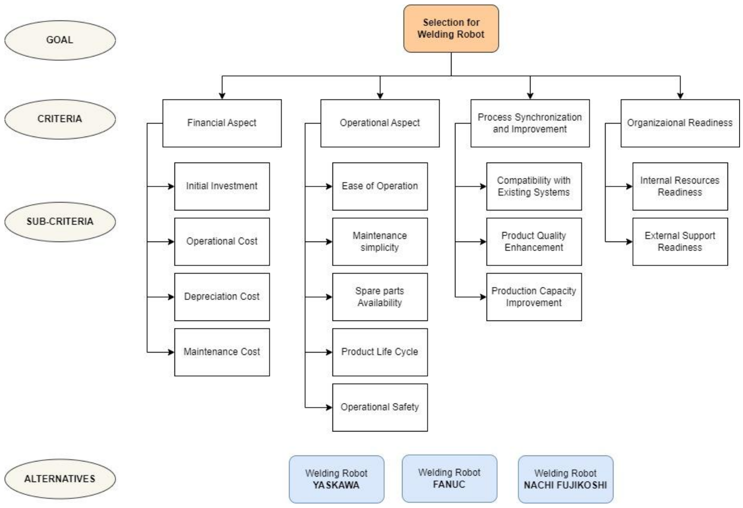

Figure 1. Hierarchical Model of Selection for Welding Robot

Based on Figure 1, the hierarchical model shown in the diagram provides a structured representation of the decision-making process for selecting the optimal welding robot. The criteria are divided into four: Financial Aspect, Operational Aspect, Process Synchronization and Improvement, and Organizational Readiness. These criteria are further broken down into specific sub-criteria. The Financial Aspect is a criterion that reflects the company's emphasis on cost-effectiveness, with sub-criteria like Initial Investment, Operational Cost, Depreciation Cost, and Maintenance Cost providing a detailed view of financial feasibility. The Operational Aspect emphasizes the usability and maintainability of the welding robots, with sub-criteria like Ease of Operation, Maintenance Simplicity, Spare Parts Availability, Product Life Cycle, and Operational Safety. The Process Synchronization and Improvement criteria focus on enhancing production quality and capacity, highlighting the importance of selecting robot compatibility with existing systems. Organizational Readiness ensures that the company's internal and external capabilities are prepared to support the new robot system. The three alternatives are Yaskawa, Fanuc, and Nachi Fujikoshi.

1. Description of Criteria and Sub-Criteria

Table 2. Description of Criteria

Criteria	Description
Financial Aspect	This criterion evaluates the economic feasibility of each welding robot. Financial is an important criterion; they directly impact the return on investment.
Operational Aspect	This criterion is considered how well the welding robot performs within the production environment. Operational aspects are needed to measure the robot to operate optimally without much interference and ensure smooth and efficient production.

Criteria	Description
Process Synchronization and Improvement	This criterion is how well the welding robot aligns with existing production systems and its potential to enhance process quality and efficiency.
Organizational Readiness	This criteria evaluates the company's preparedness to adopt and support the welding robot in terms of both internal resources and external support. This includes assessing whether the company has the necessary skills, infrastructure, and support services to operate and maintain the robot effectively.

Source: Data processed

Table 2. Description of Sub-Criteria

Sub-Criteria	Description
Initial Investment	This is the upfront cost of purchasing the robot, which includes the robot unit itself, installation, or adjustments during installation.
Operational Cost	This is the expense cost of operating the welding robot, including power consumption and consumables such as welding wire.
Deprecation cost	The robot's value is reduced over its operational lifespan.
Maintenance Cost	The cost of the expenses related to regular service and repairs to ensure the robot is always ready for production.
Ease of Operation	This is how user-friendly the robot is for operators. A robot that is easier to operate requires less training and is less prone to operational errors. It also refers to the simplicity and efficiency with which manufacturing processes or equipment can be operated.
Maintenance Simplicity	This evaluates how easy it is to maintain the robot. Robots that are simpler to maintain may reduce downtime, as repairs and routine maintenance can be conducted quickly and with minimal disruption to production.
Spare Parts Availability	The accessibility and availability of replacement parts for the robot. If robot parts are always available and do not require an indent, this will help to reduce production downtime.
Product Life Cycle	This refers to the expected lifespan of the robot before it becomes obsolete or needs replacement. Robots with a longer product life cycle are more sustainable investments for the company.
Operational Safety	The robot’s safety features include protective barriers, emergency stop functions, and sensors to prevent malfunction. Robots with better safety features reduce workers’ risks of accidents and injuries.
Compatibility with Existing Systems	Evaluate how easily the robot can be integrated with the current production equipment, software, and workflows. Compatibility reduces the need for modifications and makes installation and implementation smoother.
Product Quality Enhancement	Robots can improve the quality of the product's welding process, resulting in more consistent and precise welds. High-quality welds are crucial for maintaining product standards and reducing defect rates.
Production Capacity Improvement	The potential for the robot to increase production speed or output. A robot enhancing capacity enables the company to meet higher demand or improve production efficiency.
Internal Resources Readiness (IRR)	The availability and expertise of the workforce to operate and maintain the robot.

Sub-Criteria	Description
External Support Readiness (ESR)	External support from the robot supplier is available, including technical assistance, training, and after-sales services. Strong external support ensures the company can access expert help if technical issues arise, improving the robot's long-term operability.

Source: Data processed

2. The Weighted Calculation for the Criteria and Sub-Criteria

The criteria and sub-criteria calculations in this research were performed using Microsoft Excel. Microsoft Excel can manage pairwise comparisons, determine priority weights, and calculate consistency. By Microsoft using Excel, the author manually input the pairwise comparison matrices, normalized them, and computed eigenvalues and consistency ratios to ensure the reliability of the AHP. Respondents were managers who entered their values for scored pairwise comparisons according to their level of experience and expertise. The collected inputs were arranged into several comparison matrices in Excel, and the output of the analysis process provided numerical weights for each criterion and sub-criterion. These weights represent the relative significance of each aspect of the decision-making process.

Using Excel for AHP calculations ensures a transparent and replicable process, as the formulas and steps are explicitly visible, providing a comprehensive and accurate method for determining the weighted priorities. The following section includes an example of the questionnaire and pairwise comparison matrix used in this analysis.

a. Analysis calculation of main criteria

After the criteria and sub-criteria are determined, respondents fill out the questionnaire. After that, the author calculates the importance of each criterion in selecting the most suitable welding robot for PT Suzuki Indomobil Motor. This section focuses on estimating the weights assigned to each main criterion.

Table 3. Results of the Calculation of the Criteria Weights

Criteria	Financial Aspect	Operational Aspect	Process Synchronization and Improvement	Organizational Readiness	Weight	cr
Financial Aspect	1.00	0.67	0.88	1.81	0.23	0.91 %
Operational Aspect	1.50	1.00	1.73	4.53	0.42	
Process Synchronization and Improvement	1.14	0.58	1.00	2.06	0.24	
Organizational Readiness	0.55	0.22	0.49	1.00	0.11	

Source: Data processed

Table 3 presents the results of weighting he main criteria based on input from respondents Mr.Ag, Mr.To, Mr.Pu, Mr.Ro, and Mr. Ma, who calculated group results representing each criterion's consolidated weights. The Consolidated Priorities table displays the relative priority of each criterion based on the group's aggregated input, with a very low Consistency Ratio (CR) of **0.91%.** This low CR value shows the high consistency of participant decisions, which means the decision is stable and not substantially impacted by the inconsistency of each pair comparison. The Consolidated Decision Matrix indicates how all criteria compare against each other in terms of importance.

The operational Aspect is the most significant criterion in the group result, with a weight of **0.42**, indicating that respondents prioritize how effectively the robot functions within the production environment. In a production setting, a welding robot must perform its tasks reliably and fit seamlessly into production operations. The second criterion is the financial aspect, with a group weight of **0.23**. Focusing on the economic aspect is important because of the cost incurred. Justifying the investment means that the initial investment, operating costs, and maintenance must still fit within the budget at PT Suzuki Indomobil Motor. Respondents prefer optimizing the resources required to use a robot, emphasizing that the selected robot should be cheap enough to not lead to excessive long-term costs while delivering enough value.

Process Synchronization and Improvement, with a group weight of **0.24**. This criterion highlights the need for the welding robot to be compatible with the existing production processes. By prioritizing this factor, respondents convey that the robot's contribution to the quality and efficiency of production is essential. Adopting a welding robot that seamlessly integrates into the existing workflows and enhances process outputs will likely lead to reduced defect rates, improved consistency, and enhanced product quality.

Organizational Readiness receives a group weight of **0.11**, making it the least prioritized criterion overall. This criterion is essential for assessing the company's preparedness to operate and support the new technology or system; its lower weight suggests that respondents believe PT Suzuki Indomobil Motor is already well-positioned to manage the integration of a welding robot.

b. Analysis calculation of Sub-Criteria

After determining the importance of the main criteria, this section analyzes the specific factors within each requirements to provide a more granular perspective on what influences the decision-making process in selecting the most suitable welding robot for PT Suzuki Indomobil Motor.

1) Sub-criteria of Financial Aspect

Table 4. Results of the calculation of the sub-criteria financial aspect

Criteria	Initial Investment	Operational Cost	Deprecation cost	Maintenance Cost	Weight	cr
Initial Investment	1.00	0.58	1.46	2.27	0.25	1.88%
Operational Cost	1.73	1.00	2.99	4.95	0.48	
Deprecation Cost	0.69	0.33	1.00	0.88	0.14	
Maintenance Cost	0.44	0.20	1.14	1.00	0.12	

Source: Data processed

Based on Table 4, Operational Cost is the most important financial aspect sub-criteria, weighing **0.48**. This means that one of the respondents' primary concerns was the low operational costs of the welding robot. The second sub-criteria is Initial Investment ranks, with a weight of **0.25**. This reflects the importance of the initial cost of acquiring and installing the welding robot. It determines the feasibility of the robot acquisition. This shows that respondents are concerned with the initial cost. The third-highest weighted sub-criteria is Depreciation Cost, with **0.14**. This weight signals concern regarding how the robot's value decreases over time. Such cost impacts long-term financial planning and affects the value of the robot as an asset, especially if the plan is for the use of the robot without updates and upgrades. Maintenance Cost gets the lowest weight in the group, with a result of 0.12, suggesting it is the least critical financial sub-criteria according to the participants. The group result implies that these costs are manageable or expected to be relatively low compared to other expenses. The matrix has a good consistency of pairwise comparison as the Consistency Ratio (CR) is **1.88%,** which is less than 10%. A small CR value confirms the reliability of the prioritization process, which validates the consistency of the AHP method.

2) Sub-criteria of Operational Aspect

Table 5. Results of the Calculation of the Sub-Criteria Operational Aspec

Criteria	Ease of Operation	Maintenance Simplicity	Spare Parts Availability	Product Life Cycle	Operational safety	Normalized Weight	cr
Ease of Operation	1.00	0.72	0.44	1.16	0.22	0.10	1.86%
Maintenance Simplicity	1.38	1.00	0.53	2.06	0.22	0.13	
Spare Parts Availability	2.30	1.90	1.00	1.53	0.36	0.19	
Product Life Cycle	0.86	0.48	0.65	1.00	0.22	0.09	

Operational safety	4.58	4.60	2.79	4.60	1.00	0.49

Source: Data processed

Based on Table 5, the most crucial sub-criteria is Operational Safety, with a weight of **0.49**. The significant weight of this remains high as it indicates a strong focus on the safety of the operation of a welding robotic. Selection criteria that prioritize operational safety indicate that participants consider the protection of workers and preventing accidents in the selection process. The second is Spare Parts Availability, which weighs **0.19**. Suppose the spare parts are always ready without indenting. In that case, that means keeping downtime to a minimum when the robot malfunctions or breaks down, as delays in obtaining replacement parts can throw production schedules off track.

The third is Maintenance Simplicity, which ranked third with a weight of **0.13**. Maintenance simplicity reinforces how the respondents would prefer a robot that is easy to maintain, minimizes idle time, and allows seamless production operations. Less complex maintenance that can be performed faster means lower maintenance costs over time, making it vital to keep production from being stopped. The fourth is Ease of Operation, with a weight of **0.10**. A user-friendly welding robot can help reduce the time and resources spent on training and decrease the chances of user error. The last is the Product Life Cycle, which is weighted at 0.09, becoming the lowest sub-criteria. This criterion indicates a concern for the robot's longevity and durability, as a longer product life cycle means fewer replacements and upgrades are needed. The matrix has a good consistency of pairwise comparison as the Consistency Ratio (CR) is **1.86%**, which is less than 10%. A small CR value confirms the reliability of the prioritization process, which validates the consistency of the AHP method.

3) Sub-Criteria of Process Synchronization and Improvement

Table 6. Results of the calculation of the sub-criteria Process Synchronization and Improvement

Criteria		**Product Quality Enhancement**	**Production Capacity Improvement**	**Normalized Weight**	**cr**
Compatibility with Existing Systems	1.00	0.13	0.31	0.08	2.95%
Product Quality Enhancement	7.52	1.00	4.12	0.71	
Production Capacity Improvement	3.17	0.24	1.00	0.21	

Source: Data processed

Based on Figure 6, Product Quality Enhancement is the most critical sub-criteria, weighing **0.71**. This strong priority shows participants' high expectations of the welding robot's ability to improve product quality. The second most crucial sub-criteria is the Improvement of Production Capacity, which weighs **0.21**. This weight suggests a strong interest in using the robot to increase the speed or efficiency of production. Improving production capacity means that respondents seek a solution that improves quality while optimizing throughput to meet demand. A robot that can enhance production efficiency without compromising quality is essential to increase operations and maximize productivity. (Guo et al., 2021).

The last important sub-criteria is Compatibility with Existing Systems, which weighs **0.08**. This may mean that PT Suzuki Indomobil Motor is confident in integrating systems. The matrix has a good consistency of pairwise comparison as the Consistency Ratio (CR) is **2.95%**, which is less than 10%. A small CR value confirms the reliability of the prioritization process, which validates the consistency of the AHP method.

4) Sub-Criteria of Organizational Readiness

Table 7. Results of the calculation of the sub-criteria Process Synchronization and Improvement

Criteria	Internal Resources Readiness	External Support Readiness	Normalized Weight	Cr
Internal Resources Readiness	1.00	18.33	0.95	0.00%
External Support Readiness	0.05	1.00	0.05	

Source: Data processed

Based on Figure 7, Internal Resources Readiness is the most important, with a weight of 0.95; the high weight shows that the readiness of internal resources owned by PT Suzuki Indomobil Motor is essential in welding robots. Internal resources cover the staff or operator's existing skills, knowledge, technical capabilities, and the organization infrastructure for the new robot. External Support Readiness has a much lower weight of 0.05, indicating that participants see external support, such as supplier assistance, technical support, and maintenance services, as less crucial than internal resources. While external support remains a factor, it is perceived as supplementary rather than essential. This may suggest confidence in the organization’s ability to independently manage the welding robot or an assumption that external support can be arranged if needed but is not the primary focus.

After we calculate the sub-criteria weight value of each criterion, the global weight indicates the relative importance of each sub-criteria in the context of the overall decision hierarchy. The global weight value is calculated based on the local weight of the sub-criteria against the main criteria, which is then multiplied by the weight of the requirements.

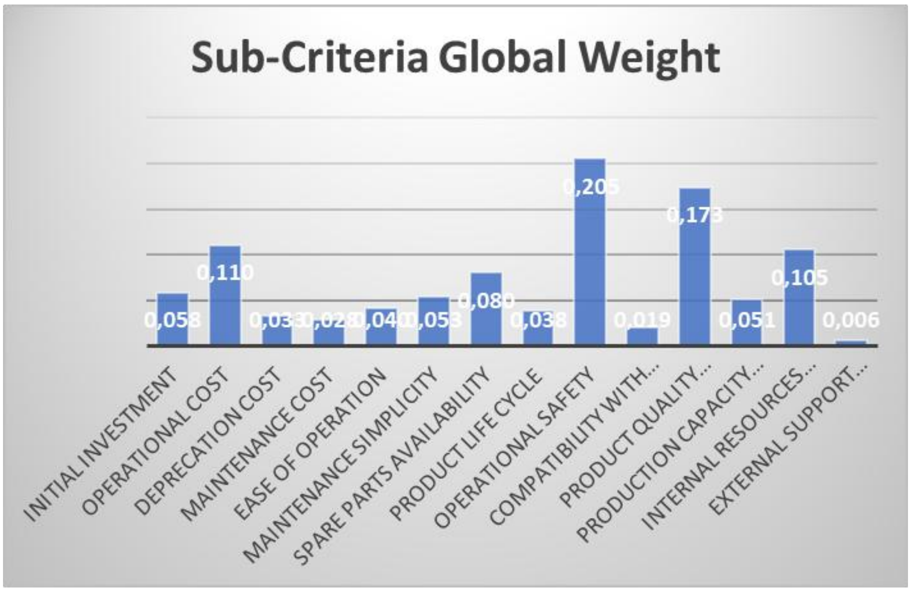

Figure 2. Sub-Criteria Global Weight

Figure 8 shows that operational safety has the highest global weight, **0.205**. This indicates that operational safety is the most critical factor in the robot welding selection. The company prioritizes this factor to ensure that robot operations can be carried out safely, reduce the risk of work accidents, and increase the efficiency of the production process. The second sub-criteria with a high global weight is Product Quality Enhancement at **0.173**, indicating the importance of product quality. The purpose of PT SIM is to use robots to improve welding quality and ensure the quality of the products made. Operational Cost, with a weight of 0.110, is the next priority, indicating that operational cost efficiency remains one of the main focuses in welding robot selection.

On the other hand, several sub-criteria, such as Depreciation Cost (0.033) and External Support Readiness (0.006), have low global weights. This shows that although important, these factors do not have as much influence as other sub-criteria in the context of robot welding selection decisions.

3. Analysis Calculation of Alternative

After analyzing the main criteria and sub-criteria, the next step is to explore the alternatives. The analysis calculation of other options in this research focuses on evaluating the three welding robot alternatives, Yaskawa, Fanuc, and Nachi Fujikoshi, using the weights from the Analytic Hierarchy Process (AHP) (Bhattacharya et al., 2005). This step integrates the priority weights of criteria and sub-criteria to calculate the overall ranking of the alternatives, allowing for the identification of the best options for welding robots for PT Suzuki Indomobil Motor.

Criteria	Local Weight	Sub-criteria	Local weight	Global Weight	Yaskawa	Fanuc	NachiFujikoshi
Financial Aspect	**0.229**	Initial Investment	0.252	0.058	0.539	0.405	0.056
		Operational Cost	0.483	0.110	0.627	0.330	0.043
		Deprecation cost	0.144	0.033	0.303	0.484	0.213
		Maintenance Cost	0.121	0.028	0.729	0.150	0.121
Operational Aspect	**0.417**	Ease of Operation	0.097	0.040	0.490	0.446	0.064
		Maintenance Simplicity	0.128	0.053	0.729	0.150	0.121
		Spare Parts Availability	0.191	0.080	0.548	0.354	0.098
		Product Life Cycle	0.091	0.038	0.260	0.692	0.048
		Operational Safety	0.492	0.205	0.573	0.366	0.061
Process Synchronization and Improvement	**0.243**	Compatibility with Existing Systems	0.079	0.019	0.564	0.397	0.038
		Product Quality Enhancement	0.713	0.173	0.346	0.613	0.040
		Production Capacity Improvement	0.208	0.051	0.636	0.332	0.032
Organizational Readiness	**0.111**	Internal Resources Readiness	0.948	0.105	0.768	0.202	0.030
		External Support Readiness	0.052	0.006	0.899	0.070	0.031
					54.97%	**38.81%**	**6.22%**

Figure 3. Consolidated Priorities Results of AHP

Based on figure 9 highlights the selection of the best welding robot alternatives. The weight of the global alternative combined with the weight of each criterion and sub-criteria clearly states which robot is the best fit for PT Suzuki Indomobil Motor. Yaskawa is the best alternative, according to the matrix, with a weight of **54.97%**. This means Yaskawa has the highest alignment with the criteria and sub-criteria. The second alternative is Fanuc, with a weight of **38.81%**. The last is Nachi Fujikoshi, with only a 6.22% weight, the previous position for other options. This means that it is not well aligned with the criteria and sub-criteria.

Business Solution

This sub-chapter describes the analysis of the business solution recommendation based on the Analytic Hierarchy Process (AHP) results for selecting welding robots at PT Suzuki Indomobil Motor.

1. Overview of AHP Results

The AHP analysis identified three potential welding robot alternatives: Yaskawa, Fanuc, and Nachi Fujikoshi. Based on the first research question, “What are the key criteria for selecting welding robots in PT Suzuki Indomobil Motor?” is answered by identifying and validating criteria such as financial aspects, operational aspects, process synchronization and improvement, and organizational readiness. Each criterion was broken down into some sub-criteria. The second research question, "How do we select welding robots in PT Suzuki Indomobil Motor using AHP?" is addressed by developing an AHP framework. After determining the criteria and sub-criteria, the next step is calculating each criterion's weights, comparing the alternatives, and ensuring that each result is consistent. The final research question, "What is the best alternative welding robot for PT Suzuki Indomobil Motor?" will be discussed below.

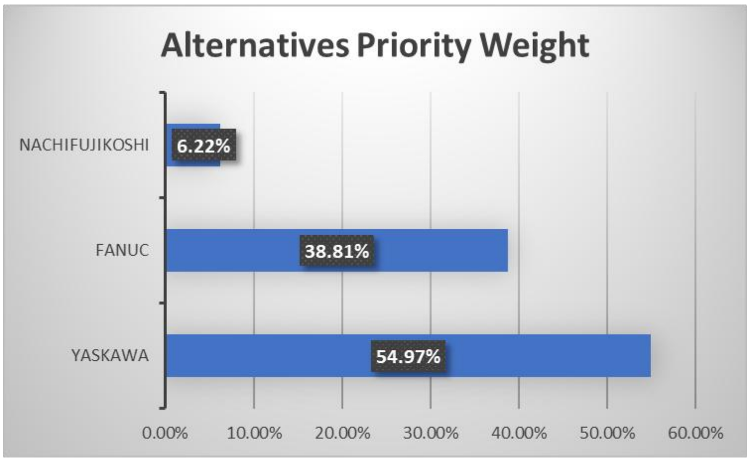

Figure 4. Alternatives Chosen Based on the result of AHP

Based on Figure 10, the consolidated result from the AHP analysis, represented in the bar chart, shows that Yaskawa is the highest-rated alternative, with an overall score of 54.97%, followed by Fanuc at 38.81%, and Nachi Fujikoshi at 6.22%. This means PT Suzuki Indomobil Motor can choose Yaskawa as the welding robot.

2. Implementation of Chosen Welding Robot

PT Suzuki Indomobil Motor can transition from manual to automated welding operations. Yaskawa has a high priority score in the AHP analysis. Robot welding will eliminate the mistakes or errors with manual operations, reduce production downtime caused by errors, and improve the overall quality and efficiency of the production line. The successful adoption of welding robots requires preparing the organization for this transition. A comprehensive training program should equip employees with the skills to operate and maintain the welding robots effectively. Ensuring the workforce is prepared will minimize resistance to change and guarantee a seamless integration process. Therefore, it is necessary to anticipate the implementation of robot welding.

a. Anticipation of Implementation

The change from manual to robot welding is a significant and challenging job. Therefore, a good project plan for implementation is needed. Preparing a comprehensive project plan that includes visibility study, procurement, installation, testing, and commissioning of the welding robots will give this implementation a high percentage of success. PT SIM must also create a complete training program for employees to operate, monitor, and maintain the robots. Training programs will allow them to quickly adapt to the robot technology while developing their technical skills, making the transition easier. The welding robots may also require modifications to the existing infrastructure. PT SIM needs to study the existing configuration of the production line and provide changes that will enable the robots to perform optimally.

Successful robot implementation requires collaboration between the engineering, maintenance, production, and vendor teams (Villani et al., 2018).

b. Risks That May Faced in the Implementation

The use of welding robots also gives potential risks to PT Suzuki Indomobil Motor. A significant challenge is resistance from employees due to fear of job loss. To counter this, PT SIM must mention that automation is about improving productivity and creating new opportunities for high-skill labor, not replacing jobs. Communication, transparency, and education about the purpose of automation and its advantages are essential to facilitate employees' acceptance of automation. The other risk relates to technical difficulties and risks when integrating the robots within existing production systems. During setup, PT SIM must consult with the Yaskawa technical support team and the vendors working on this project. (Kanth et al., 2018). Next are operational risks, like unplanned downtime resulting from either robot malfunction or a delay in maintenance. To prevent this, setting up a preventive maintenance plan and ensuring that spare parts are always available will be essential to ensure that production will continue.

Conclusion

Based on the analysis of the analytic hierarchy process (AHP), the welding robot selection is the best solution for the quality problem in the PT Suzuki Indomobil Motor product. The company has faced challenges with high defect rates in its welding process due to human errors in manual operations. Robot automation to address these concerns has emerged as a solution to improve production quality and decrease defects. The analysis considered multiple criteria: Financial Aspect, Operational Aspect, Process Synchronization and Improvement, and Organizational Readiness. Each criterion is essential in determining whether the selected solution would be practical and feasible. This main criterion was also divided into several sub-criteria, for example, initial investment, operational cost, ease of maintenance, and compatibility with the existing systems. Based on the results of the AHP analysis, Yaskawa is the most suitable alternative and has the highest priority score of 54.97%. This means Yaskawa can address the company's operational issues, improve welding quality, and reduce defect rates. Fanuc, with a score of 38.81%, is the second-best option, showing strong performance in specific areas. Last is Nachi Fujikoshi, with a score of 6.22%.

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