ASM Sc. J., 19, 2024

https://doi.org/10.32802/asmscj.2023.1617

Application of Multi-Criteria Decision-Making in Leaf Spring Manufacturing's Performance

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Lean manufacturing is the optimal way of producing goods through the removal of waste and implementing flow, as opposed to batch processing. Many factories have transformed to align with the goal of lean manufacturing by minimising the resources of factories, such as less worker effort, less time and many more to lead to high efficiency towards good product quality and become highly responsive to customer demand. The condition of product and machinery, arrangement of inventory and equipment, the standard operation procedure of work and workers' safety awareness are the dominant elements in the leaf spring manufacturing process. Due to the crucial role that leaf springs play in the performance and safety of vehicles, it is crucial to eradicate any flaws in the designing and manufacturing processes. This study focuses on 5 core criteria, which are workers, time, safety, machines, and products that need to be enhanced. In the subgroup, each pair of sub-criteria will be compared regarding their importance with respect to each criterion. Analytical Hierarchy Process (AHP) is proposed to rank and aggregate the criteria based on their level of importance. The outcome of AHP showed that Safety (0.233) and Time (0.281) were the prominent criteria that need to be prioritised. Wear Personal Protective Equipment (PPE) (0.394), First Aid (0.324), Die and Pin (0.347), and Forklift Deliver (0.368) are the sub-criteria for safety and time. As a result, prompt and precise actions are needed to increase the quality and reliability of the product.

Keywords: Analytical hierarchy process; quality improvement; leaf spring manufacturing

I. INTRODUCTION

Small and medium enterprises (SMEs), including microenterprises, have played a pivotal role in Malaysia's economy since the late 1990s. According to the Department of Statistics, Malaysia (DOSM), on 27 July 2022, the contribution of Micro, Small & Medium Enterprises (MSMEs) to the overall Gross Domestic Product (GDP) decreased to 37.4% in 2021 compared to 38.1% recorded in 2020 (Mahidin, 2022). When the world economy slows down, it is difficult for SME owners to manage their capital spending. On the other hand, services, construction and manufacturing are the most contributed sectors in Malaysia to SME's GDP, which comprises more than 80 per cent (SME Corporation Malaysia, 2021).

Leaf springs are essential components in the automobile manufacturing sector, primarily used for vehicle suspension (Aized *et al.*, 2020). Crafted from spring steel, they flex under pressure and provide vital support between wheels, axles, and chassis, preventing axle damage and snapping (Couchman, 2015). Research showed that leaf springs can reduce vehicle weight by 10 to 20% (Ashwini & Mohan Rao, 2018). However, quality issues, such as shape changes, noises, and breakage, remain a challenge, often identified through customer feedback.

With increased competitive pressure, the potential exists for improved leaf spring quality in terms of durability and stiffness (Tyagi *et al.*, 2021). Manufacturing facilities require modern equipment for enhanced process control and efficiency (Aized *et al.*, 2020). External challenges include intense competition, and maintaining global quality standards, while internal hurdles encompass skilled labour

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scarcity, high costs, rejection rates, and subpar quality maintenance (Ngu *et al.*, 2020). Embracing lean manufacturing is essential for organisations seeking cost-cutting and competitiveness by optimising resources and reducing waste (Singh & Singh, 2020). Amid competition, inflation, pandemics, and economic challenges, it's crucial to identify key quality improvement areas in leaf spring manufacturing before prioritising criteria. The manufacturing process is intricate and shaped by multiple variables. Labour, machinery, safety, product, and time are the five most important elements influencing production quality.

A. Worker

Worker means standards for employee behaviour in the workplace. It also refers to the ability to take initiative for new things and be responsible for his or her own actions, which is demonstrated by their skill (Galaske *et al.*, 2017). A good worker will carry out their duties responsibly and demonstrate great productivity to the firm. In addition to enabling the firm to pay workers more, increased worker productivity will strengthen the company's competitive edge, increase profitability, and increase its chances of survival (Diwas, 2020). Undoubtedly, one of the factors that impact how well leaf springs are manufactured is the worker.

B. Safety

Safety relates to creating a favourable work environment, taking appropriate steps to safeguard employees from harm and raising self-defence awareness (Nahrgang *et al.*, 2011). Occupational safety is a major concern in manufacturing. It needs to progress together with the development of science and technology in the Fourth Industrial Revolution, plus these two cannot be isolated even if the previous preventive measurement are very effective (Badri *et al.*, 2018). The manufacturing industry has the largest number of workplace accidents compared to other industries in Malaysia, which is 17,577 cases (Pertubuhan Keselamatan Sosial, 2019). Accident-related disease and injury can cause lasting impairments or death, as well as financial costs to businesses and society (International Labour Organisation, 2014). Enhancing tolerance and acceptance of risks in the workplace might lead to future improvements in safety and profitability for the organisation (Reniers, 2017).

C. Machine

Machine indicates how the condition of machine parts can move and can do or help to do work that is needed (Chinniah, 2015). Leaf spring manufacturing machines run 24 hours every working day to keep mass production going continuously. A finding has shown that downtimes of machines are used as performance measures because they influence the availability of resources and the operational efficiency or product quality significantly (Haddad *et al.*, 2021). However, to ensure that there are no machine failures that impair output, a sustainable manufacturing facility should establish a comprehensive contingency plan. Kar (2016) used the Total Productive Maintenance (TPM) technique to implement Planned Maintenance (PM) in order to increase and maintain equipment availability and decrease production costs by reducing unplanned and unnecessary breakdowns brought on by a lack of a systematic approach in the bicycle tyre manufacturing industry.

Hence, machine is the backbone of manufacturing and is determined as one of the criteria to detect problems that affect the performance of manufacturing.

D. Product

Product refers to the management of product manufacturing during process and after finishing (Terzi *et al.*, 2007). A study demonstrated that qualification rate of product depends on ability of identification quality hidden dangers in the manufacturing process before product fails to meet the standard (Chen *et al.*, 2019). Quality management on a product is essential to produce good products. A high-quality product will increase customer satisfaction (Mittal & Gupta, 2021). Additionally, past research has shown that the most crucial factor in choosing a PVC (Polyvinyl Chloride) carpentry manufacturer is the product quality, which is shown by the results of multi-criteria decision-making methodologies (Nunić, 2019).

E. Time

Time indicates time-consuming in producing, delivering and finding tools (Dahmen & Constantinescu, 2018). Standard time has been applied in determining the amount of labour required, and predicting the execution of manufacturing tasks allows proper planning of production (Araújo *et al.*, 2017). Cycle time, lead time, just-in-time, set-up time, delivery time and processing time are considered vital elements to boost productivity in the manufacturing sector (Andrade *et al.*, 2015; Bhamu & Singh Sangwan, 2014). Ramachandran and Neelakrishnan (2017) pointed out that improving customer on-time delivery against the original promise date is crucial in the manufacturing industry. Thus, *time* is chosen as one of the criteria in this study.

F. Overview of MCDM

Multi criteria decision making (MCDM) is an effective tool designed to make useful decisions in situations where there are many criteria (factor). The goal of MCDM is to enhance the quality of decisions by increasing the efficiency, rationality and clarity of decision-making (Jayant & Sharma, 2018). MCDM can be carried out by using several methods such as AHP (Analytical Hierarchy Process), VIKOR (Vlsekriterijumsko Kompromisno Rongiranje), TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), COPRAS (Complex Proportional Assessment) and so on. Although different approaches can be applied to solve a problem with different outcomes, decision-making tools are useful and provide recommendations that do not entirely overrule their original choice as they assist them in revising their decisions (Ishizaka & Siraj, 2018).

MCDM has been widely used in various areas, such as evaluating the procurement process (Milyardi *et al.*, 2021), sustaining risk management in the manufacturing sector (Oduoza, 2020), evaluating and selecting the PVC carpentry manufacturer (Nunić, 2019), evaluating the service quality of employment (Ocampo *et al.*, 2019) and improving the sustainability in supply chains (Talib *et al.*, 2020). However, little research has been done on the use of MCDM in leaf spring production. Therefore, this study implements MCDM technique to analyse and prioritise the factors that affect the performance of leaf spring manufacturing's performance. AHP is carried out in this study due to its various advantages (Gavade, 2014). AHP has a preference for a certain academic field. Strategic planning, public policy, health care, resource allocation, demand estimation, system design, performance measurement, optimisation, benchmarking, and demand forecasting are some of those (Oğuztimur, 2011).

G. Overview of AHP

AHP is a powerful tool that is used to organise all critical aspects for managing decision-making behaviour qualitatively and quantitatively with different criteria (Saaty, 2008). The AHP method implements a rating method to represent the preference degree for each alternative and then rank the value of the preference degree for each alternative (Chai *et al.*, 2013). Complex decision-making in manufacturing will increase the number of constraints and decrease the flexibility of resources, which will make it more difficult to simplify the complexity of manufacturing to improve (Ma *et al.,* 2019). Therefore, a structural solution is required to simplify the complexity. Previous research claimed that AHP is suitable for making decisions about manufacturing, and it helps managers optimise their time and resources on the most promising reshoring alternatives (Ishizaka & Siraj, 2018). On the other hand, AHP acts as a navigation for practitioners who are trying to set some criteria and are attentive to advance difficulty and risk for choosing the best action plan when it comes to deploying strategic manufacturing objectives (Chiarini, 2019). Besides that, risk management is applied to AHP to recognise the key risk factors that threaten business performance like cost, time, quality and safety in the manufacturing sector (Oduoza, 2020). Typically, the AHP method was used to conduct research in small groups of 2 to 100 respondents (Şahin & Yurdugül, 2018).

H. Evaluation

The AHP model consists of three phases to perform the evaluation towards the criteria, which are problem structured, comparative judgments, and priority analysis (Longaray *et al.*, 2015). With these phases, the AHP model collects opinions from experienced people and experts through a questionnaire (Abu Ghazaleh & Zabadi, 2020).

Generally, the AHP algorithm consists of the following steps (Saaty, 1980; Karthikeyan *et al.*, 2016):

i. Define the decision problem: The first step is to clearly define the problem that you are trying to solve. This should include a clear definition of the alternatives and the criteria used to evaluate them.

ii. Develop a hierarchy: The next step is to create a hierarchical structure that breaks down the decision problem into smaller, more manageable parts. This should start with the overall problem at the top and then break it down into smaller sub-problems, with each sub-problem being further divided into even smaller sub-problems.

iii. Establish pairwise comparisons: For each sub-problem, pairwise comparisons of the alternatives to determine their relative importance will be performed. This is typically done using a pairwise comparison matrix, where each cell represents the relative importance of one alternative compared to another.

iv. Calculate priorities: The pairwise comparisons are then used to calculate the priorities of the alternatives. This is typically done using a mathematical algorithm, such as the eigenvector method, which considers the consistency of the pairwise comparisons.

v. Make the decision: The final step is to use the calculated priorities to make the decision. This typically involves selecting the alternative with the highest priority or a combination of alternatives that provide the best overall solution to the problem.

vi. Evaluate and refine the decision: Finally, it is important to evaluate and refine the decision as needed to ensure that it remains relevant and effective over time. This may involve re-calculating the priorities and making additional comparisons as the decision problem evolves.

II. MATERIALS AND METHOD

This section discusses the application of AHP in this study, including a flow chart of methodology, hierarchical framework, data collection and method of data analysis.

A. Methodology

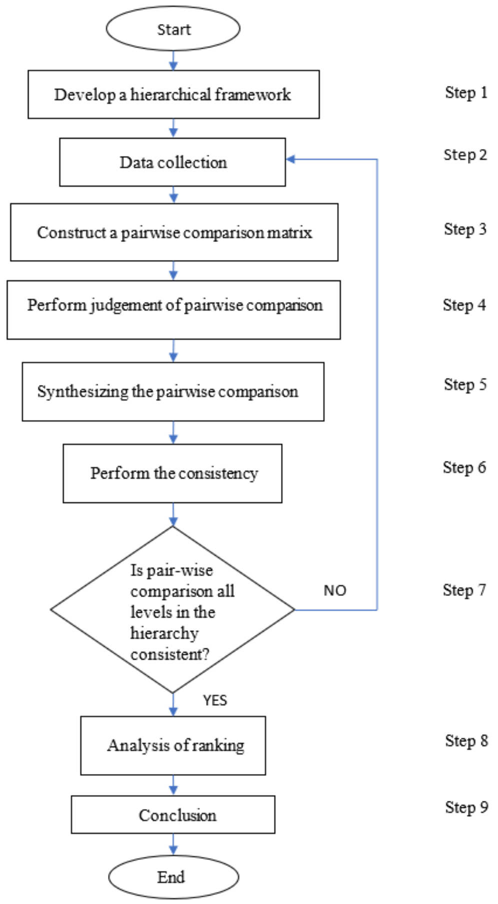

Figure 1. Research flow chart.

According to the flow chart in Figure 1, there are 9 steps are carried out to complete the process in this research. The steps are as follows:

Step 1. Develop a hierarchical framework pertaining to product quality evaluation.

Step 2. Create a questionnaire based on AHP hierarchical framework's requirement and collect data of opinions from experts in the factory.

Step 3. Construct a pairwise comparison for criteria (worker, safety, machine, product, time) and sub-criteria (attendance, follow SOP, skilled worker, no accident, sufficient first aid, wear PPE, cleanliness, regular inspection, no broken, no rejection, arrangement of product, waste management, progress of production, forklift deliver, die and pin) in matrix form.

Step 4. Judge each criterion by using scale of relative scale pairwise comparison as stated in Table 2.

Step 5. Synthesise the pairwise comparison by calculating the normalised matrix as shown in Figure 2.

Step 6. Perform degree of AHP consistency after synthesising pairwise comparison index. It required data from the consistency index (CI) and random index (RI) to calculate the degree of consistency. The formula of *CI* is calculated as follows:

$$CI = \frac{Avg\ of\ cons.\ measure - n}{n - 1} \tag{1}$$

where *Avg of cons. measure* is the multiplication of the row average and the row of the complete comparison matrix, and n is number of variables (Hong *et al.*, 2022; Hong *et al.*, 2023). As shown below, the consistency ratio's formula is:

$$CR = \frac{CI}{RI} \leq 0.1 \tag{2}$$

where *CR* is a consistency ratio, *CI* is a consistency index, and *RI* is a random index. The value of *RI* is determined by the number of variables listed in Table 1. For example, in the case of five variables, the value of the *RI* would be 1.12.

If $CR \leq 0.1$, then the judgment matrix is considered to meet the consistency test requirements. However, if $CR > 0.1$, then the judgment matrix is considered not to meet the consistency test standards and needs to be adjusted. In other words, revision of subjective judgement is needed (Saaty, 1980).

Table 1. Random index table.

N	2	3	4	5	6	7	8	9	10
RI	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.5

Step 7. If all levels of pairwise comparison in the hierarchy are consistent, then continue to step 8, inversely repeat step 2 to step 6 until all are consistent.

Step 8. Compute overall score of importance for each criterion and rank the criteria.

Step 9. Select the best criteria from the stated criteria based on ranking.

	A	B	C	D	E	F	G	H
2								
3		**CRITERIA**						
4			*WORKER*	*SAFETY*	*MACHINE*	*PRODUCT*	*TIME*	
5		*WORKER*	1	0.71	0.69	0.65	0.95	
6		*SAFETY*	1.41	1	1.47	2	0.65	
7		*MACHINE*	1.45	0.68	1	1.06	0.59	
8		*PRODUCT*	1.54	0.50	0.94	1	0.44	
9		*TIME*	1.05	1.54	1.69	2.27	1	
10		COLUMN SUM	6.45	4.43	5.80	6.98	3.63	
11								
12		**STEP 2 : DIVIDE BY COLUMN SUM AND ROW AVERAGE**						
13		**CRITERIA**						
14			*WORKER*	*SAFETY*	*MACHINE*	*PRODUCT*	*TIME*	*ROW AVERAGE*
15		*WORKER*	0.16	0.16	0.12	0.09	0.26	0.158
16		*SAFETY*	0.22	0.23	0.25	0.29	0.18	0.233
17		*MACHINE*	0.22	0.15	0.17	0.15	0.16	0.173
18		*PRODUCT*	0.24	0.11	0.16	0.14	0.12	0.156
19		*TIME*	0.16	0.35	0.29	0.33	0.28	0.281
20								
21		**PRODUCT OF MULTIPLICATION**			**SUM ALL PRODUCT**			
22		*WORKER*	0.810		5.1342			
23		*SAFETY*	1.203		5.1721			
24		*MACHINE*	0.891		5.1480			
25		*PRODUCT*	0.802		5.1480			
26		*TIME*	1.452		5.1714		AVERAGE	5.1547
27					25.7737		CI	0.0387
28							CI/RI	0.0345

Figure 2. Template of AHP analysis in Microsoft Excel.

B. Hierarchical Framework

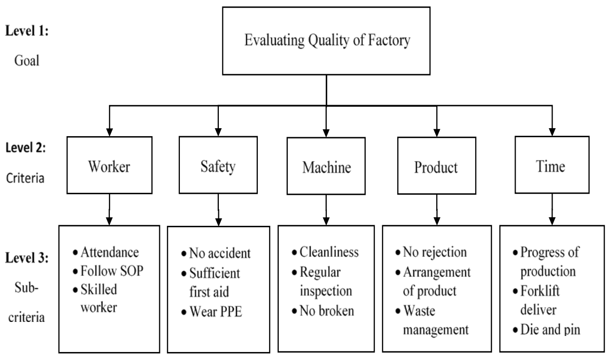

Figure 3. AHP hierarchical framework.

AHP hierarchical framework consisted of three levels shown in Figure 3. First level was the goal of this study which is the evaluation of the leaf spring quality. Second level comprised five criteria (worker, safety, machine, product and time) that would significantly affect to performance of leaf spring. The sub criteria were stated in level 3 (Russo & Camanho, 2015). The descriptions of each sub-criteria (according to the main criteria) are presented as follows:

Attendance is a crucial aspect that assesses an employee's commitment to regular work attendance, ensuring the continuity of manufacturing processes. Adherence to SOP (Standard Operating Procedures) is a validation of an employee's comprehensive understanding of the SOP and their ability to consistently implement it during their work. *Skilled worker* demonstrates proficiency in rapidly acquiring and effectively applying new production methods and acquired skills. *No accident* workplace signifies an environment where injuries and fatalities are absent. The utilisation of Personal Protective Equipment (PPE) serves as a critical gauge of an employee's awareness and ability to select and wear various PPE types that are suitable for their specific working conditions. *Sufficient first aid* refers to evaluating the readiness of first aid supplies, ensuring they are properly prepared and located in easily accessible areas.

Cleanliness serves as an indicator of an employee's commitment to maintaining machines and equipment after completing their work. *Regular inspection* involves the practice of conducting routine checks on machines before commencing the manufacturing process while *no broken* means the absence of machine breakdowns during manufacturing.

Besides that, no rejection represents the rate at which products meet the established quality standards after the manufacturing process (Chen *et al.,* 2019), whereas *arrangement of product* refers to the organised placement of products in specific spaces, which plays a pivotal role in determining process efficiency before they proceed to the next process station. *Waste management* indicates the proper disposal and cleaning of waste materials after completing manufacturing tasks at each process station.

Progress of production metric quantifies the average duration required to complete the construction of a finished product according to the established schedule, spanning from the initial process to the final process. *Forklift delivery* represents the time spent by forklifts during the loading process. *Die and pin* measures the setup time needed to change the die and pin on machines to facilitate various manufacturing processes.

C. Data Collection

Primary data was used in this study. The data collection adopted a questionnaire survey, which was distributed to experts who were working in the leaf spring factory.

AHP questionnaire is developed according to the goal, main criteria and sub-criteria of the hierarchical framework (Wadjdi *et al.*, 2018). The first part was the demographic section, followed by pairwise comparison ranging from 1 to 9. The ordinal scale indicated the intensity of importance of the criteria and sub-criteria. The indicators are shown in Table 2.

Table 2. Degree of importance.

Intensity of Importance	Definition
1	Equally importance
3	Moderately importance
5	Strongly importance
7	Very strongly importance
9	Extremely importance
2,4,6,8	Intermediate values

The scale value of 1 denoted equal weight for both criteria. When one criterion is somewhat more significant than the other, the scale value rises to 3. The scales rise in value based on the degree of importance, with a maximum value of 9 indicating that one criterion is seen to be extremely important in comparison to another. 2, 4, 6, and 8 are intermediate numbers that fall between the range of the odd numbers in terms of intensity.

D. Method of Data Analysis

AHP Priority Calculator – Business Performance Management Singapore (BPMSG) and Microsoft Excel software were used to run the analysis in this study.

Following the completion of the questionnaire from the respondents, the AHP Priority Calculator – BPMSG was used to input all the respondents' thoughts on the priority level of criteria and sub-criteria. The pairwise comparison matrix's derived results were then used to perform the analysis. The example of input data was showcased in Figure 4 and Figure 5.

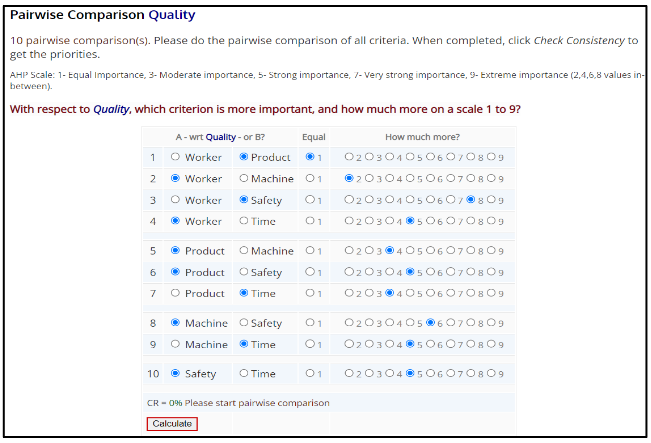

Figure 4. Pairwise comparison of criteria.

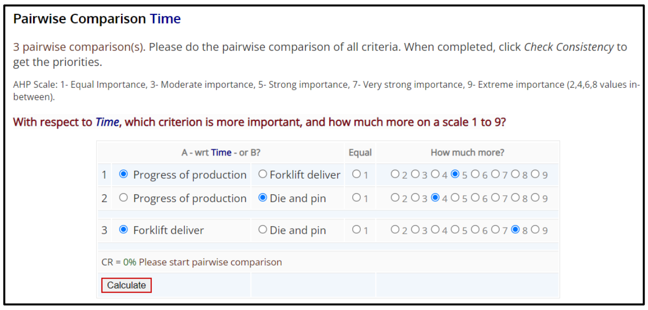

Figure 5. Pairwise comparison of sub-criteria.

Figure 5 illustrates one of the pairwise comparison tasks that respondents were required to complete. In addition to the "Time" sub-criteria, there were other criteria such as "Worker," "Safety," "Machine," and "Product" considered in the comparisons.

Microsoft Excel was used to synthesise pairwise comparison matrix by adding the values of each column of the pairwise comparison matrices, dividing each value in each column by the corresponding column sum, averaging values in each row of the normalised matrices, integrating the vectors of preferences for each criterion and lastly performed a degree of consistency.

III. RESULT AND DISCUSSION

A. Demographic

Table 3. Respondents by Department.

Department	Number of respondents	Percentage
Production	9	60%
Quality Assurance	6	40%

Table 4. Number of Respondents (by experience).

Number of working experiences	Number of respondents	Percentage
0 to 2	5	33.3%
3 to 5	5	33.3%
6 to 8	3	20%
More than 8	2	13.3%

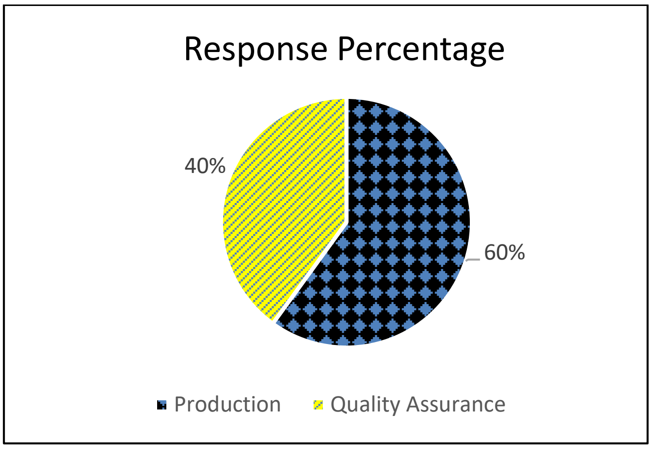

Figure 6. Experts by departments.

A total of 15 responses from experts were collected from the AHP questionnaire. The pie chart in Figure 6 and Table 3 shows the percentage of respondents by department. The figure showed that 60% of respondents were from the Production department while the remaining were from the Quality Assurance department.

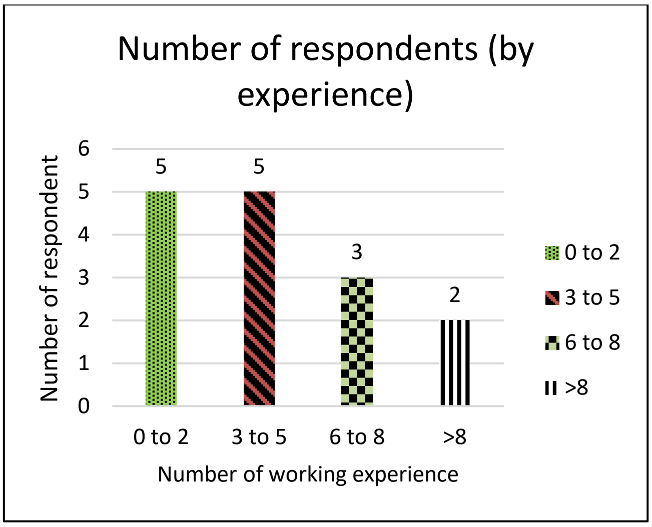

Figure 7. Number of respondents (by experience).

In Figure 7, respondents with 0 to 2 years and 3 to 5 years of work experience, respectively, made up the majority of respondents (66%). The remaining experts consisted of 3 professionals with 6 to 8 years of working experience and 2 professionals with more than 8 years. In this study, the Aggregation of Individual Judgment (AIJ) concept was implemented to describe the process of combining the preferences and judgments of multiple individuals into a single collective decision. A panel of experts convened to collect diverse viewpoints, aiming to inform a more informed decision-making process. (Forman & Peniwati, 1998).

B. Pairwise Comparison Analysis

Table 5. Normalised matrix of 5 main criteria with rank.

	Worker	Safety	Machine	Product	Time	Row average	Rank
Worker	0.16	0.16	0.12	0.09	0.26	0.158	5
Safety	0.22	0.23	0.25	0.29	0.18	0.233	2
Machine	0.22	0.15	0.17	0.15	0.16	0.173	3
Product	0.24	0.11	0.16	0.14	0.12	0.156	4
Time	0.16	0.35	0.29	0.33	0.28	0.281	1

Table 6. Consistency ratio of 5 main criteria's pairwise comparison matrix.

Consistency index, *CI*	Number of items compared, *n*	Random index, *RI*	Consistency ratio, *CR*
0.0387	5	1.12	0.0345

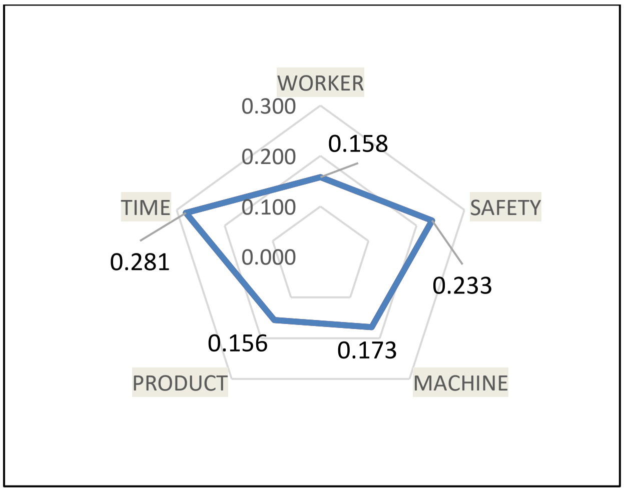

Figure 8. Relative weights of five main criteria.

Table 5 and Figure 8 demonstrated the priority result for the 5 main criteria. *Worker*, *Product*, *Machine*, *Time*, and *Safety* were the five primary criteria (factors). The results showed that *Time* (0.281) prevailed against other criteria, followed by Safety (0.233), *Machine* (0.173), *Product* (0.156), and *Worker* (0.158). Time and Safety recorded the highest importance by obtaining an interest value of more than 20%.

Based on Table 6, the consistency ratio was 0.0345 (< 0.10), indicating that the model was acceptable.

Table 7. Normalised matrix of Safety (sub-criteria).

	No accident	First aid	Wear PPE	Row average	Rank
No accident	0.28	0.30	0.26	0.282	3
First aid	0.30	0.33	0.35	0.324	2
Wear PPE	0.42	0.37	0.39	0.394	1

Table 8. Consistency ratio of Safety sub-criteria's pairwise comparison matrix.

Consistency index, *CI*	Number of items compared, *n*	Random index, *RI*	Consistency ratio, *CI/RI*
0.0022	3	0.58	0.0038

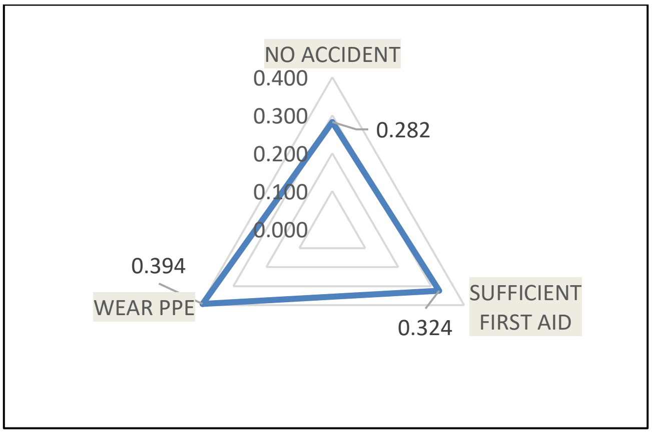

Figure 9. Relative weights of safety's sub-criteria.

The ranking of sub-criteria in safety was displayed in Table 7 and Figure 9. The results showed that Wear PPE ranked the highest (0.394), followed by First Aid (0.324), and No

Accident (0.282). Wear PPE and First Aid were identified as key factors of manufacturing performance that needed improvement. Wear PPE was chosen due to the low safety awareness among workers in the dangerous leaf spring manufacturing process. Although the manufacturer provided sufficient personal protective equipment to workers, they refused to use it while working. Encouraging employees to develop the habit of wearing PPE was deemed crucial.

First aid instruments were incomplete and out-of-date since they were not updated regularly. This will make it exceedingly difficult to obtain medical care in the event of an accident. Therefore, both elements need to be improved in order to ensure workplace safety and shield employees from disease and harm.

The inconsistency ratio was acceptable since the value of CR was 0.0038 ($\leq$ 0.1), which was shown in Table 8.

Table 9. Normalised matrix of *Time's* sub-criteria with rank.

	Progress of Production	Forklift Deliver	Die and Pin	Row average	Rank
Progress of Production	0.28	0.26	0.31	0.286	3
Forklift Deliver	0.40	0.36	0.34	0.368	1
Die and Pin	0.32	0.38	0.35	0.347	2

Table 10. Consistency ratio of *Time's* sub-criteria pairwise comparison matrix.

Consistency index, *CI*	Number of items compared, n	Random index, *RI*	Consistency ratio, *CI/RI*
0.0040	3	0.58	0.0069

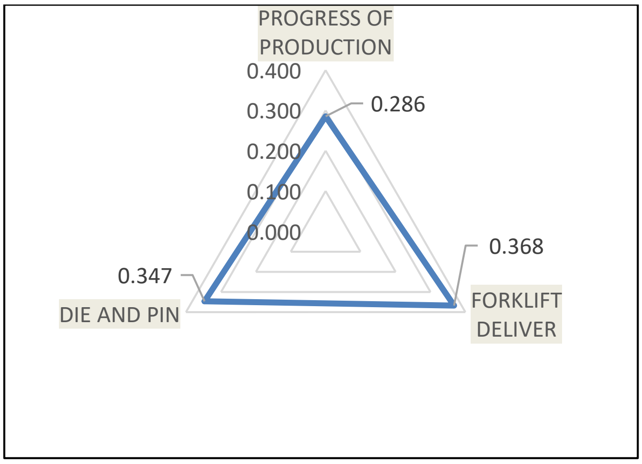

Figure 10. Relative weights of *Time*'s sub-criteria.

As shown in Table 9, *Forklift Deliver* was ranked first (0.368), followed by *Die and Pin* (0.347) and lastly *Progress of Production* (0.286). The result also showed a good consistency ratio of 0.0069, which was also less than 0.1 (refer to Table 10).

Forklift Delivery garnered attention due to its significance in transporting leaf springs between the 10 distinct process stations. Ensuring timely deliveries of leaf springs in-process was crucial to prevent idle process stations. The efficiency of the entire manufacturing cycle depended on delivery efficiency. Considering that obtaining the precise size and form of dies and pins required extra time, this factor was taken into account. Figure 11 depicted the challenges in locating the necessary die and pin, attributed to limited shelf space, uneven lighting, and gloomy conditions in the storage area.

Figure 11. Shelf for storing pin and die.

C. Recommendation

It is suggested that one of the relevant production divisions be given responsibility for managing emergency first aid to raise the standard of the leaf spring factory. First aid needs to be supplied in the case of an accident to reduce worker injuries. They may also upgrade first aid kits with new components, extra supplies, and other necessary items. Another suggestion is the imposition of sanctions, such as hefty penalties for employees who disregard safety precautions like wearing Personal Protective Equipment. In exchange for monitoring infractions, employees would be paid a commission. Thirdly, craftsmen should be located and consulted on designing a shelf with adequate light and space for staff to locate dies and pins.

Time constraints are a limitation of the study. It is essential to direct respondents when gathering data. Despite having written instructions, the questionnaire may take longer to complete than online data collection. The overall contribution of the study is a methodical, logical approach that provides information to understand workers' perceptions of the factory's quality level. Above all, knowing where to concentrate their efforts would help decision-makers enhance manufacturing quality.

IV. CONCLUSION

The AHP technique for this study evaluates and identifies quality problems in the leaf spring factory by ranking the satisfaction of criteria and sub-criteria. The degree of agreement among experts is assessed during the decision-making process, where a meeting is organised to review the pairwise comparison matrices and prioritise derived from the AHP process. The findings indicate that criteria safety and time in the leaf spring factory are lagging in the ranking based on satisfaction. Focusing on safety and time's sub-criteria, it shows that First Aid, Wear PPE, and Die and Pin require improvement by recommending actions such as delegating management of emergency first aid, implementing penalty mechanisms, and customising shelves for die and pin. This would help build up the factory's internal development and strive for the top-quality leaf spring factory.

V. ACKNOWLEDGEMENT

The authors would like to express their deepest appreciation to the School of Quantitative Sciences, Universiti Utara Malaysia for their continuous support and encouragement to ensure the completion of this study. In addition, the authors would also like to thank all of the respondents from the leaf spring firm for spending their time and giving cooperation in order to make this study feasible. Additionally, heartfelt thanks are extended to the journal editors and reviewers for their valuable feedback and constructive criticism, which significantly contributed to enhancing the quality of this research. This research did not receive any specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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