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Quality Improvement Project Selection Using Fuzzy AHP and TOPSIS to Support Lean Six Sigma at PT ABC

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ABSTRACT

This research aims to improve project quality at PT ABC by integrating the Fuzzy Analytical Hierarchy Process (F-AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) within the Lean Six Sigma framework. This method assesses and selects quality improvement projects by considering uncertainty and complexity in decision-making. The Fuzzy AHP approach is used to flexibly assign criteria weights, while TOPSIS is used to rank projects based on performance scores relative to the ideal solution. This research aims to select the most suitable Lean Six Sigma project using the MCDM fuzzy AHP and TOPSIS approaches at PT ABC. There are three alternative quality improvement projects and three assessment criteria. The data processing results using Fuzzy AHP and TOPSIS showed that the most influential criterion was the impact criterion, with a value of 0.665. Overall, the order of influencing criteria is cost (0.260) and time (0.075). Based on a review of all criteria, the project to increase the drive plate production line (A) capacity was ranked first with a value of 0.772. Second place is the project to increase capacity and consolidate rear axle assemblies A and B with a value of 0.5529. Finally, the third is the process innovation and integrated manufacturing project to strengthen the business with a value of 0.4053.

I. Introduction

This acceleration of technology makes the demands on companies even greater, including orders expected to be fulfilled quickly, with quality, and providing various types according to the preferences of customers [1]. The development of the industrial era that is so competitive makes the existence of every company to be able to produce quality products in the most efficient way possible [2] The automotive industry is no exception, where quality is determined through customer satisfaction with the products and after-sales services offered [3]. With increasing global competitiveness, the automotive industry is looking for new ways to increase productivity and revenue. This has created the need for modern managerial strategies such as "Lean manufacturing," "Six Sigma," and "Total Quality Management [4].

Lean manufacturing (LM) removes waste from the process, while Six Sigma focuses on identifying and reducing variation [5]. Researchers use these two approaches to achieve zero waste and zero defects [3]. There are seven original basic wastes defined by the LM philosophy, which include transportation, inventory, movement, waiting, overproduction, overprocessing, and defects [6]. Six Sigma significantly impacts decision-making (DM) when conducting improvement projects. Six Sigma significantly impacts decision-making (DM) when conducting improvement projects. One

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of the important metrics of Six Sigma in performance evaluation studies and quality management is Rolled Throughput yield (RTY) [7].

The application of lean Six Sigma also continues to be carried out at PT ABC, which is engaged in the automotive industry; they always strive to meet the increasing market demand by increasing product capability with high precision products and also with the latest technological equipment and providing the best services and solutions to customers to answer the challenges of the growing automotive industry. One of PT ABC's efforts in improving product capability is through continuous quality improvement projects as part of implementing Lean Six Sigma. The selection of this quality improvement project has several criteria, which makes it one of the Multi-Criteria Decision Making (MCDM) problems.

The MCDCM approach can handle the complexity of multiple criteria with trade-offs such as financial, performance, managerial, productivity, and waste-related criteria, thus making proper decision-making more complicated without a systematic methodology. This MCDM approach has several methods proven in previous research to help decision-making. For example, [8] proposed an approach with Fuzzy Stochastic Revised Ordered Weighted Averaging (FSROWA) in a case study of project selection among 12 water resources development projects. [9] demonstrated the suitability of a hybrid fuzzy-AHP-TOPSIS model for relocation decisions and resilient results. They contributed to practice by providing a general relocation decision support model capable of simultaneously handling and evaluating multiple relocation alternatives. [10] proposed an improved lean manufacturing approach to improve the sustainability performance of manufacturing processes using fuzzy evaluation based on distance from average solution (EDAS) and fuzzy technique for order preference based on similarity to ideal solution (TOPSIS) to rank a set of kaizen events according to their ability to improve sustainability indicators. [11] also used the AHP approach to choose what production projects to prioritize by adding the context of sustainability in determining the criteria.

From this explanation, it is clear that the MCDM technique has proven to be able to solve various multi-criteria problems in various industries. Therefore, in this research, to solve the problem of lean Six Sigma project selection, the research uses the fuzzy MCDM approach of AHP and TOPSIS. The method selection approach is carried out to complement the shortcomings of the two methods. Fuzzy-AHP has the advantage of being able to cover the shortcomings of the AHP method where in the AHP method, there is still much subjectivity from the selection of criteria provided, so using the fuzzy-AHP method will reduce the level of subjectivity because the uncertainty will be represented by a numerical scale sequence [12]. The TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method has advantages as an approach to handling complex systems related to making the most preferred choice among several alternatives and provides a comparison of the options considered [13]

II. Research Method

The methods used in this research are Fuzzy AHP and TOPSIS, which can be described in the stages of this research. This research has three stages of research, namely the initial stage of research, where at this stage there is a process of identifying existing problems, determining the topic of the problem to be discussed, there is a literature study, and determining the title and state of the art of this research. Then, the research limitations are also determined at this stage due to time and cost constraints. The next stage is the research implementation stage; at this stage, the criteria and sub-criteria are determined to determine the AHP hierarchy. These criteria and sub-criteria are determined based on in-depth discussions with competent and experienced industry experts and ergonomic experts.

Furthermore, data processing steps using Fuzzy AHP and TOPSIS are carried out at this stage. This stage ends after obtaining the ranking value of the LSS solution. The final stage of this research is to discuss and analyze the results of the ranking of solutions for LSS, provide recommendations for solutions for the application of selected alternatives, and compile conclusions and suggestions from this research and research opportunities that need to be developed in the future. The research stages can be seen in Figure 1.

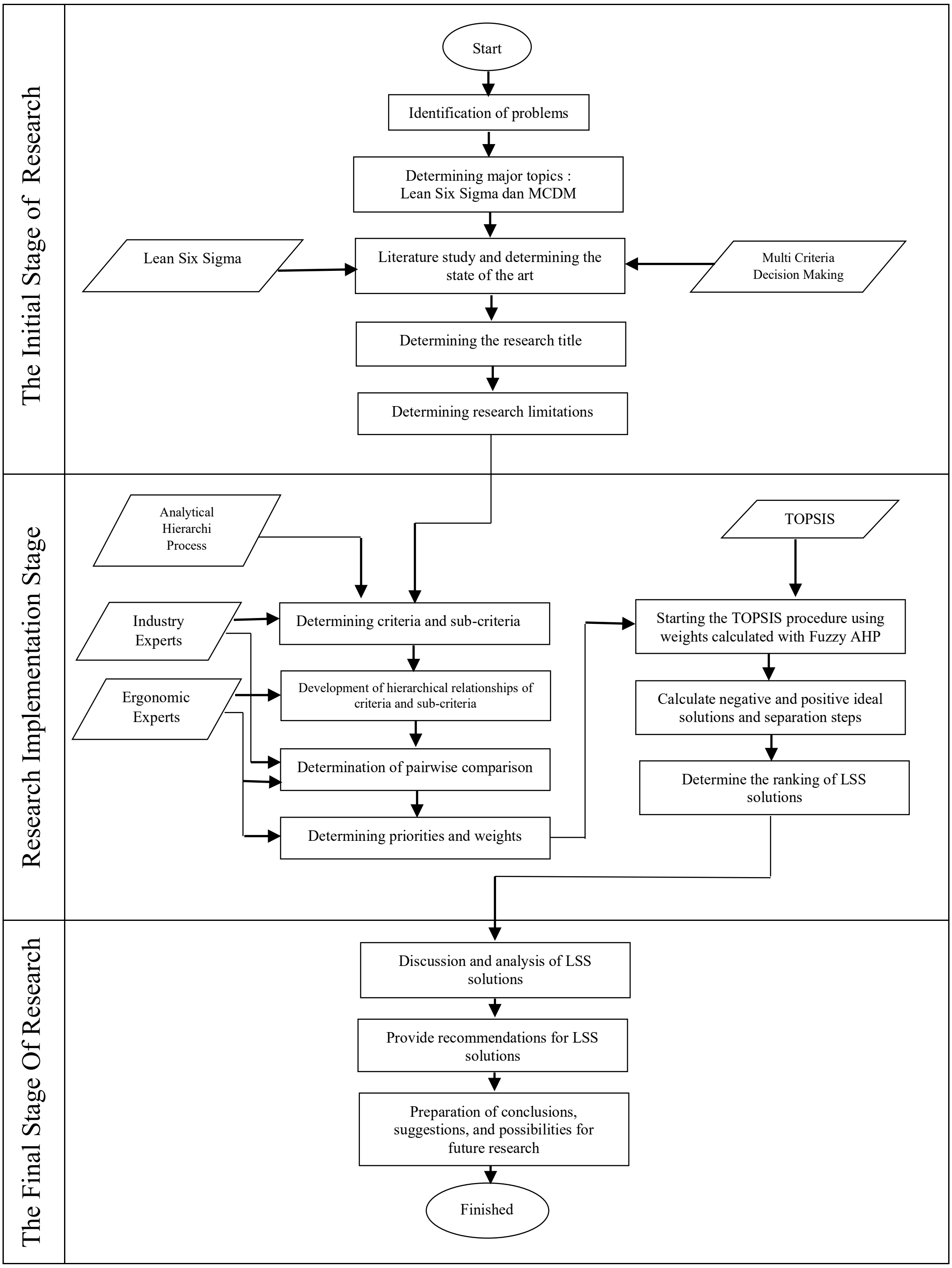

Fig. 1. Stages Of The Research

III. Result and Discussion

A. Determination of Quality Improvement Projects

There are 3 quality improvement projects at PT ABC as for these projects are:

Project A = Capacity Increase of Drive Plate Production Line.

Project B = Capacity Increase and Consolidation of Rear Axle Assembly A and B.

Project C = Process Innovation and Integrated Manufacturing to Strengthen Business.

The selected project will be determined based on the criteria and sub-criteria that have been set. Table 1 shows the data for each project's initial performance.

Table. 1. The Initial Performance Matrix

Project	Cost (Rp)	Time (Month)	Impact (Rp)
A	117,254,902	12	744,615,512
B	37,284,000	7	5,533,899,520
C	4,328,002,000	12	10,402,131,987

B. Fuzzy AHP Hierarchy

As shown in Figure 2, a hierarchical structure is arranged to facilitate a more detailed understanding of the problem. This hierarchical structure is arranged in two levels, where level 1 is the selection of lean six sigma project criteria and level 2 is the determination of alternatives. In the alternative section, the TOPSIS method will be used.

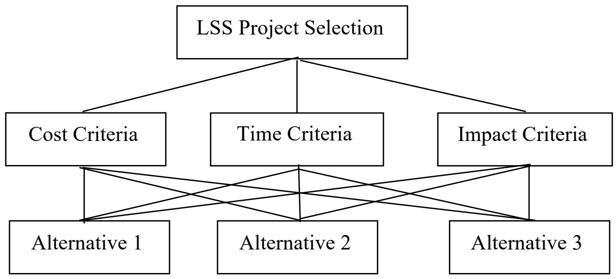

Fig. 2. Fuzzy-AHP Hierarcy

After obtaining the hierarchical structure of the problem, the weighting of each criterion is carried out with fuzzy AHP calculation with the aim of obtaining the weight of each criterion against the requirements with the assumption that there is no dependency relationship between the criteria. Then, the data will be entered into a pairwise comparison matrix to find the weight of the criteria in the selection of lean Six Sigma projects. The pairwise matrix is obtained by converting the linguistic scale obtained from the previous stage into a Triangular Fuzzy Number (TFN) scale. The pairwise matrix is shown in Table 2 below.

Table 2. Pairwise Matrix Between Criteria

	Cost			Time			Impact	
Cost	1.00	1.00	1.00	2.83	3.87	4.90	0.25	0.33
Time	0.20	0.26	0.35	1.00	1.00	1.00	0.12	0.13
Impact	2.00	3.00	4.00	7.35	7.94	8.49	1.00	1.00

After the pairwise comparison is carried out, the geomean value is calculated, and the fuzzy weight is calculated by summing the vectors and comparing the reciprocal sum for each criterion. The vector is obtained from the increasing order of the inverse value of the total geomean fuzzy number (L, M, U). After getting the fuzzy weight, the defuzzification process is carried out so that the crisp value or non-fuzzy weight of each criterion is obtained. Next, normalization is carried out so that the total of all weights = 1. Normalization is done by dividing the crisp value by the total crisp value so that the final weight of the criteria in Table 3 is obtained.

Table 3. Weight and Ranking of Criteria

Criteria	Weight	Ranking
Time	0.075	3
Cost	0.260	2
Impact	0.665	1

The next stage, the final step, is to check the consistency of the experts' assessments. In fuzzy form, the Saaty (2005) approach to determining the level of inconsistency cannot be applied but instead uses two consistency ratios, namely CRm (mean consistency) and CRg (lower and upper limit consistency). By using the eigenvalue and eigenvector, the Consistency Index is calculated. The CI value is then divided by Random Indices so that CRm = 0.017 and CRg = 0.04 are obtained. According to Saaty (2005), a consistency ratio of less than 0.1 indicates that the weighting results are consistent. Thus, the criteria weighting at the fuzzy AHP stage can be considered consistent.

C. TOPSIS calculation

After obtaining the criteria weights from the assessment using fuzzy AHP to select quality improvement projects, the next step is determining the ranking of alternative quality improvement projects using TOPSIS. The TOPSIS method is carried out by searching for positive ideal solutions and harmful ideal solutions for each criterion. The closeness of the positive and negative ideal solutions of the project alternative can be illustrated in Figure 3 below. The higher the bar chart, the closer it is to the positive ideal solution.

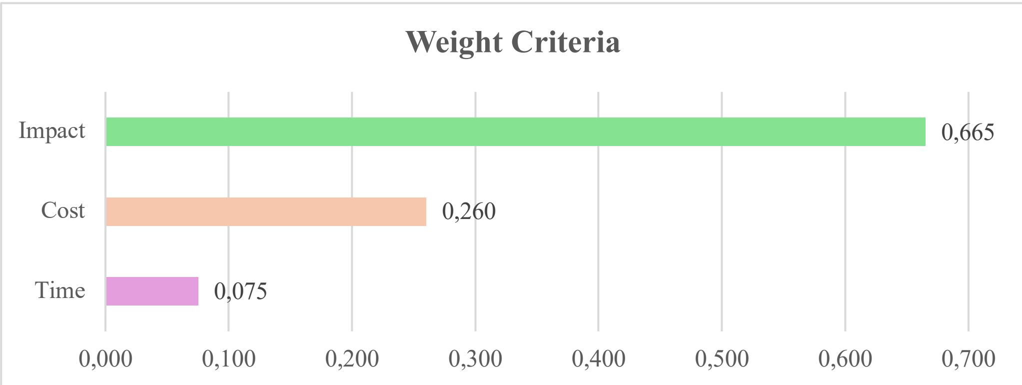

Fig. 3. Relative Proximity of LSS Project Alternatives

Based on the graph above, the average relative closeness of the three alternative LSS projects is 0.5767, which means that only Project A gets a score above the average and has the highest score. Therefore, Project A is the most feasible project to be selected and implemented at PT IGP.

The weight of the impact criteria in question is the result of fuzzy AHP, whereas these criteria include several sub-criteria, such as the benefits of reducing production time, increasing production quantities, reducing waste, and so on. So, the assessment of TOPSIS can be further reduced to several sub-criteria. Reducing some of the impact sub-criteria will make the project performance assessment even more accurate.

As input to the company, the research team suggested creating sub-criteria with defined unit definitions and including them as one of the prerequisites that must be written in the quality improvement project proposal. These sub-criteria must be filled in nominally so that the performance matrix used will be more detailed.

The research and analysis carried out can help companies select LSS projects not based on mere subjectivity but also on consistency of subjectivity in terms of criteria weighting and on making decisions based on the performance of the alternative LSS projects offered. In science, this research contributes to the application of MCDM Fuzzy AHP and TOPSIS for LSS project selection in the automotive components industry.

IV. Conclusion

The conclusion that can be drawn from the results of this research is that the implementation of Lean Six Sigma at PT Inti Ganda Perdana is quite good if you look at the project. Multi-criteria assessment and ranking system of sports team formation based on objectively measured values of criteria set. Expert Systems with Applications, 41, 6106–6113. quality, which is carried out periodically every year. Based on the implementation of Fuzzy AHP and TOPSIS, the most influential criterion is the impact criterion, with a value of 0.665. Overall, the order of influencing criteria is cost (0.260) and time (0.075). The experts selected in this research are those with over ten years of experience working at PT IGP and at least five years of involvement in selecting quality improvement projects. Based on a review of all criteria, the project to increase the drive plate production line (A) capacity was ranked first with a value of 0.772. The second place is the project to increase capacity and consolidate rear axle assemblies A and B, with a value of 0.5529. Finally, the third is the process innovation and integrated manufacturing project to strengthen business, with a value of 0.4053.

References

[1] D. Seth dan D. Tripathi, “A Critical Study of TQM and TPM Approaches on Business Performance of Indian Manufacturing Industry,” *Total Quality Management & Business Excellence,* vol. 17, no. 7, pp. 811-824. doi.org/10.1080/14783360600595203, 2006.

[2] R. Z. Tsaqif, S. Ali dan M. Marbun, “Ripple Mill Machine Damage Analysis Using the FMEA Method at the PT Argo Sinergi Nusantara Palm Oil Factory,” *Jurnal Inovasi Teknologi dan Rekayasa ,* vol. 9, no. 1, pp. 8-14, 2024.

[3] L. M. Sanches Jr, M. S. Filho dan G. F. Batalha, “Automotive body-in-white dimensional stability through pre-control application in the subassembly process,” *Journal of Achievements in Materials and Manufacturing Engineering,* vol. 31, no. 2, pp. 705-711, 2008.

[4] V. Shukla, V. Swarnakar dan A. R. Singh, “Prioritization of Lean Six Sigma Project Selection Criteria Using Best Worst Method,” *Materialstoday : Proceedings,* vol. 47, no. 17, pp. 5749-5754. doi.org/10.1016/j.matpr.2021.04.038, 2021.

[5] S. Vinodh dan V. Swarnakar, “Lean Six Sigma Project Selection Using Hybrid Approach Based on Fuzzy DEMATEL–ANP–TOPSIS,” *International Journal of Lean Six Sigma,* vol. 6, no. 4, pp. 313-338. DOI 10.1108/IJLSS-12-2014-0041, 2015.

[6] M. B. Kumar, R. Parameshwaran, J. Antony dan E. Cudney, “ Framework for Lean Implementation Through Fuzzy AHP-COPRAS Integrated Approach,” *IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT,* vol. 70, no. 11, pp. 3836-3848, 2023.

[7] R. Sindhwani, O. S. Vaidya, J. Antony dan A. Shokri, “Evaluating Performance of Projects Using Six Sigma Approach,” *IEEE TRANSACTIONS ONENGINEERINGMANAGEMENT,* vol. 70, no. 10, pp. 3539-3552, 2023.

[8] M. Zarghami dan F. Szidarovszky, “Revising the OWA Operator for Multi Criteria Decision Making Problems Under Uncertainty,” *European Journal of Operational Research,* vol. 198, no. 1, pp. 259-265. Doi:10.1016/j.ejor.2008.09.014, 2009.

[9] M. Sequeira, A. Adlemo dan P. Hilletofth, " A Hybrid Fuzzy-AHP-TOPSIS Model for Evaluation of Manufacturing Relocation Decisions," *Operations Management Researc,* vol. 16, pp. 164-191. Doi: 10.1007/s12063-022-00284-6, 2023.

[10] H. Auoag dan M. Soltani, " Improvement of Lean Manufacturing Approach Based on MCDM Techniques for Sustainable Manufacturing," *International Journal of Manufacturing Research,* vol. 18, no. 1, pp. 50-74. DOI: 10.1504/IJMR.2023.10040708, 2023.

[11] D. Rahmayanti, Y. Meuthia, J. Albin dan A. Hafizh, "An Integrated AHP-TOPSIS Framework For Determination of Leading Industrial Sectors," *Jurnal Sistem dan Manajemen Industri,* vol. 5, no. 2, pp. 115-124, 2021.

[12] M. Fajri, R. R. M. Putri dan L. Muflikhah, "Implementasi Metode Fuzzy Analytic Hierarchy Process (F-AHP) Dalam Penentuan Peminatan di MAN 2 Kota Serang," *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer,* vol. 2, no. 5, pp. 2109-2117, 2018.

[13] A. T. Gumus, " Evaluation of Hazardous Waste Transportation Firms by Using a Two Step Fuzzy-AHP and TOPSIS Methodology," *Expert Systems with Applications,* vol. 36, pp. 4067-4074, 2009.