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Quality Improvement Of Fast Moving Parts Procurement With Multi-Attribute Failure Mode Analysis (MAFMA) in A Petro-Chemical Industry

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ABSTRACT

This paper addressed the problem of high waiting time in a petro-chemical industry in Indonesia. According to Pareto diagram, the procurement process at the industry showed that the number of fast moving item transactions was more than 70% or 19,836 item transactions with 2,524 fast moving material items. The activity of making Purchase Requisition (PR) until the issuance of Purchase Order (PO) for fast moving items required a cycle time of 71.2 days. The highest waste was waiting with a weight of 0.248 and a total of 17 waste items from 27 sub-activities. The average value of sigma for 6 years was 1.79. The application of lean six sigma and MAFMA found that the dominant causes of waste were unfulfilled specified demand and long delivery time. We proposed improvements by enhancing monitoring processes and submitting a contract agreement for the procurement of fast moving spare parts.

Keywords: procurement, lean, Six Sigma, MAFMA, Waste

ABSTRAK

Makalah ini membahas masalah waktu tunggu yang tinggi pada suatu industri petrokimia di Indonesia. Berdasarkan diagram Pareto, proses pengadaan di industri tersebut menunjukkan jumlah transaksi barang fast moving sebanyak lebih dari 70% atau sebanyak 19.836 transaksi dengan 2.524 barang kategori fast moving. Aktivitas pembuatan purchase requisition (PR) hingga penerbitan purchase order (PO) untuk barang fast moving memerlukan waktu siklus selama 71,2 hari. Sampah tertinggi menunggu dengan bobot 0,248 dan jumlah sampah sebanyak 17 item dari 27 sub kegiatan. Nilai rata-rata sigma selama 6 tahun adalah 1,79. Penerapan lean six sigma dan MAFMA menemukan penyebab dominan terjadinya waste adalah tidak terpenuhinya permintaan yang ditentukan dan waktu pengiriman yang lama. Perbaikan diusulkan dengan meningkatkan proses pengawasan dan mengajukan perjanjian kontrak pengadaan suku cadang fast moving.

Kata Kunci: procurement, lean, Six Sigma, MAFMA, Waste

1. Introduction

Quality is a feature and characteristic of a product or service that carries its ability to create value and customer satisfaction (Kotler & Keller, 2008). Quality management is a way to continuously improve performance at every level of operation or process, in every functional area of an organization, using available human and capital resources (Gasperz, 2005). Quality management includes all activities in all management functions that determine the quality policies, objectives and responsibilities and implement them through tools such as quality planning, quality control, quality assurance, and quality improvement as included in ISO 8042.

Meanwhile, procurement management activities are included in supply or supply chain management. According to Siahaya (2012), procurement management is a very strategic and systematic activity that contains the process of procuring goods and services starting from the origin of the goods to their destination based on quality, quantity, time, price, place and source to meet consumer needs. According to Pujawan and Er (2017), the provision of goods or services is classified in general, i.e., raw materials or production components, machines or equipment with long-term use, and machine spare parts, office stationery, or goods used for maintenance, repair, and operating supplies.

Good quality procurement is the ability of a product or service to meet customer needs into user needs and desires (Yamit, 2013) so that the procurement of goods or services takes place according to order, as needed and obtained at the appropriate (efficient) price. In procurement activities including procurement planning carried out by the procurement agency, it must determine procurement arrangements that will be carried out to achieve the stated program or project objectives (Khan, 2018), program or project needs for goods, works, and services are then identified and calculated based on the cost per units (Khan, 2018). Furthermore, the final stage in the procurement of goods and services needs to be evaluated. The main difference between procurement of goods & works and the selection of consultants lies in the input and quality of recommendations by intellectual services, and in the price of the goods and work required which can be measured in terms of physical input as a determining factor in awarding contracts that will result in quality intellectual recommendation services, or poor knowledge can lead to failure in the procurement process for these goods and services.

Failure Mode and Effect Analysis (FMEA) is an engineering technique used to determine, identify, and to eliminate known failures, problems, errors, and the like from a system, design, process, and or service before it reaches the consumer (Stamatis, 2003). From the definition, which refers more to quality, it understood that FMEA is a method used to identify and analyze a failure and its consequences to avoid that failure. Failures are grouped based on the impact they have on the success of a system's mission. In general, FMEA is defined as a technique that identifies three things, i.e., potential causes of failure of systems, designs, products, and processes during their life cycle, the effect of the failure, and the level of criticality of the effects of failure on system function, design, product, and process.

Lean Six Sigma is a tool used to describe the problems that occur and identify the causes of the problems (Ulfah et al., 2019). Multi Attribute Failure Mode Analysis (MAFMA) was used to determine the causes of problems prioritized for proposed improvements (Ulfah et al., 2019). A combination of FMEA and Fuzzy Analytical Hierarchy Process (AHP) was used to determine priority risk on the criteria of severity, occurrence, and detection as well as the addition of one criterion that considers economic aspects (Ilangkumaran, Periyasamy, & Gnanasekaran, 2014).

The concept of using the MAFMA method is based on Braglia (2000) which explained the use of MAFMA by combining the FMEA with the addition of one additional criterion that considered economic aspects or unexpected costs, i.e., expected cost with the expected cost analysis process using AHP. Braglia (2000) did not integrate AHP and fuzzy in his research so it was equipped with Hetharia (2009) who completed MAFMA research by integrating FMEA, AHP, and fuzzy methods.

The procurement process at a petro-chemical industry based on Pareto diagram data showed a very high number of fast-moving item transactions with more than 70% or 19,836 item transactions based on Purchase Requisition (PR) to Purchase Order (PO) transactions with 2,524 fast-moving materials. The activity of making PR until the issuance of PO for fast-moving items required a cycle time of 71.2 days. The standard time set by the industry in the procurement process for fast-moving items was 52 days, meaning that there was a time span that could cause waste and reduce the quality of procurement management so that the cycle time in the procurement process of existing goods can be maintained.

Evaluation of the procurement process was carried out by finding the causes of waste from the high level of cycle time spare parts in the fast-moving category using a combination of the lean six sigma method with MAFMA. The flow of identification of the causes of waste to the proposed improvement stage was compiled using the DMAIC concept in Six Sigma. The flow of the procurement process for spare parts, starting from making PR until the issuance of PO was described by the application of value stream mapping (VSM). Identification of causes used value stream analysis tools (VALSAT) to determine the causes of waste in the spare parts procurement process by generating non-value added activity values. The root causes of waste were identified using root cause analysis (RCA), and then, the most critical potential failures were identified using a combination of MAFMA with fuzzy AHP and FMEA by considering the effect of costs or economic aspects. Quality improvement was based on potential failure analysis in MAFMA by obtaining local priority, global priority and total priority values by comparing severity, occurrence, detectability, and expected cost by distributing questionnaires to experts directly involved in the company.

2. Metodologi

The problem identification stage explained the background of the problem and determined the reason for conducting the research. The selection of appropriate methods in the research was conducted. Identification of problems also describes the problems that occurred in the company currently.

The data collection was performed to identify and prioritize waste problems in the company through an online-questionnaire. The questionnaire was filled by 19 staffs in goods planning and purchasing. Data from the questionnaire was used to develop a Pareto diagram, map the process flow with value stream mapping, and identify waste that occurred with VALSAT. The most dominant waste was identified with MAFMA. The data processing process used the DMAIC concept in Six Sigma with the stages of define, measure, analyze, and improve. The methodology of the research is shown in Figure1.

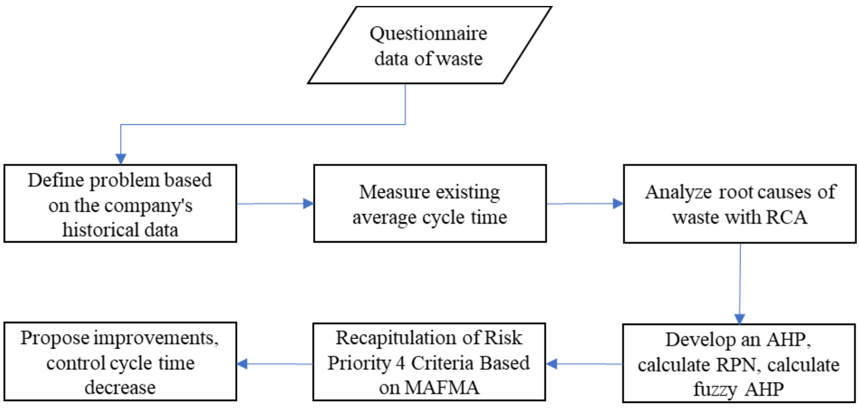

Figure 1. Methodology of the research

3. Hasil dan Diskusi

3.1 Define

The define stage defined the problem based on the company's historical data with a total number of 19,836 transactions from 2016-2021 with the fast moving spare parts category as the highest material category. The total amount of cycle time required in the procurement process of fast moving spare parts also has the highest total with more than 80% of the total cycle time in the procurement of spare parts. The total number of fast moving spare parts was 2,524 materials out of a total of 46,735 materials.

The flow of spare parts procurement process at the industry was illustrated by a value stream map by showing the flow of PR making process, the tender process, the bid evaluation process, the negotiation process, and the issuance of PO which showed the average cycle time required for 71.2 days and the average lead time was 45.5 days. The standard time set by the industry in the procurement process was 52 days while the lowest existing average cycle time with the highest number of transactions still took 71 days which showed a large difference, so it was necessary to measure whether there was waste in the procurement process flow using VALSAT described in the measure stage.

3.2 Measure

The measure stage took measurements based on problems in the define stage, i.e., the existing average cycle time which was still far from the specified standard. The use of VALSAT could identify waste by measuring seven wastes in the procurement process flow by distributing a questionnaire with the highest waste weight, i.e., waiting of 0.248, and identifying waste based on weight comparison and correlation between seven wastes and seven tools (Hines & Rich, 1997) with the selected tool, i.e., process activity map which had the highest comparison value of 4.795.

The results of the process activity map showed non value added (NVA) activities from 5 main processes and 27 sub processes of 45.5 days with the highest NVA value was in the negotiation process for 24.6 days. The process activity map also showed waste in each sub-process with the highest waste, i.e., waiting, as much as 17 activities. The measure stage also measured the sigma value from 2016 to 2021. The Critical to Quality (CTQ) value was determined based on the highest waste in VALSAT, i.e., waiting with a total of 5 CTQ. The average sigma value for 2016-2021 was 1.79, with a DPMO of 77,726.48.

3.3 Analyze

Based on measurements at the measure stage, a high average existing cycle time was found, which caused by waiting. The root causes that lead to waiting in the spare parts procurement process were identified by using RCA. The identification of the root causes of waste showed nine root causes, as seen in Table 1.

Table 1. Determination of Root Causes of Waste with RCA

Waste Type	WHY 1	WHY 2	WHY 3	WHY 4	WHY 5
Waiting	PR/PO processes often experience waiting times	The process of making PR/PO often encounters obstacles at several stages of the process	Procurement of goods often experiences delays in completing requests from users	Vendors are often unable to meet the demand given procurement of goods	The specifications of the required demand are difficult to meet by the vendor
					The price estimated by the procurement does not match the price offered by the vendor
					The delivery time proposed by the procurement cannot be fulfilled
			Users and procurement often experience delays in completing the evaluation	The offer provided by the vendor is not in accordance with the standards required by the user or procurement	The specifications offered do not match the request
					The price offered by the vendor is above the previous estimated price or previous PO
					The delivery time offered by the vendor is too long than the delivery time given by the procurement
			The negotiation process often delays	Negotiations between users and vendors take too long	User specification approval exceeds the validity confirmation limit given by the vendor
					Budgeting the price given by the user is below estimated price
					The delivery time given by the user is too fast compared to the validity confirmation limit

The most critical root causes of waste in order were identified using the MAFMA method to determine the most appropriate improvement proposal. The identification steps using MAFMA are as follows.

1. Develop an AHP hierarchy
   The development of the AHP hierarchy was based on the most influential waste, i.e., waiting, following the four main criteria in MAFMA and the root causes of waste previously identified with RCA (see Fig. 2).
2. Calculate the RPN value
   The RPN value in FMEA was obtained from distributing questionnaires based on 3 main criteria in FMEA, i.e., severity, occurrence, and detection. The highest RPN values were P3 and P6 of 512.
3. Calculate the value of Consistency Ratio (CR) AHP at level 1 and level 2
   Consistency test was carried out at each level in the hierarchy that has been prepared. Level 1 was to do a consistency test on 4 main criteria, i.e., severity, occurrence, detection and expected cost. CR level 1 value was 0.032, less than 0.1, meaning that the data was consistent. The CR value at level 2 or alternative level was 0.084 meaning that the data was considered consistent and the calculation was acceptable.

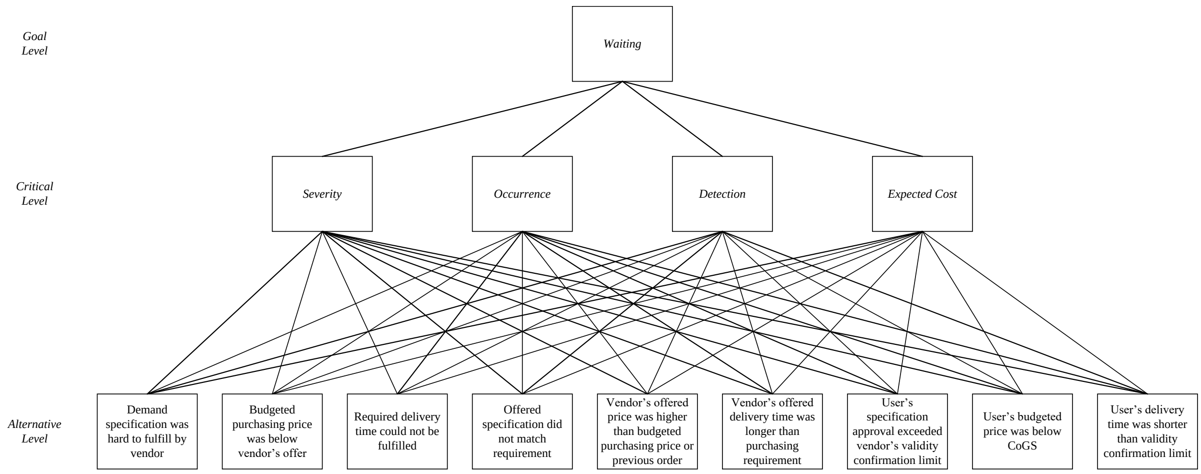

Figure 2. AHP Hierarchy Based on Waste Waiting

4. Calculate the value of the weight of the criteria with fuzzy-AHP
   Fuzzy AHP combined the hierarchy contained in AHP and fuzzy logic by converting the results of the pairwise comparison test on AHP or the so-called triangular fuzzy number. The results of the fuzzy AHP weight on severity was 0.290, the occurrence was 0.111, the detection was 0.171 and expected cost was 0.429.
5. Calculate local priority expected cost with fuzzy-AHP
   The value of local priority on the expected cost was obtained from filling out the AHP comparison questionnaire by experts in the procurement department and processed with pairwise comparison tests and the help of fuzzy logic.
6. Determine the value of local priority severity, occurrence, and detection
   Local priority severity, occurrence, and detection values were obtained based on the results of the questionnaire on each FMEA criterion divided by the total of each criterion.
7. Calculate the value of global priority four criteria
   Global priority was calculated from the multiplication between the weights of each criterion that has been calculated with fuzzy-AHP with local priority results for each criterion.
8. Calculate the value of the total priority 4 criteria
   The total priority value was used to determine the most dominant cause of potential waste with the results of the sum of global priorities in the four criteria of severity, occurrence, detection, and expected cost. Of the three potential causes of waste, the most dominant cause was proposed for improvements to the procurement process in the industry.

Based on the results of total priority on MAFMA, the highest total priority value was P2, with a total of 0.155. The three highest priority values were taken to support a better improvement proposal, i.e., P2, P1, and P8.

Table 2. Recapitulation of Risk Priority 4 Criteria Based on MAFMA

Code	Potential waste	Global priority Severity	Global priority Occurrence	Global priority detection	Global priority Expected Cost	Total Priority	Rank
P1	Specifications offered do not match the request	0.032	0.010	0.009	0.095	0.146	2
P2	The price offered by the vendor is above the previous estimated price or PO	0.032	0.008	0.009	0.105	0.155	1
P3	The delivery time offered by the vendor is longer than the delivery time given by the procurement	0.032	0.008	0.009	0.053	0.102	6
P4	Approval of technical specifications from the user exceeds the	0.032	0.014	0.026	0.017	0.089	7

Code	Potential waste	Global priority Severity	Global priority Occurrence	Global priority detection	Global priority Expected Cost	Total Priority	Rank
	validity confirmation limit from the vendor						
P5	The estimated price provided by the procurement does not match the price offered by the vendor	0.032	0.013	0.026	0.016	0.088	8
P6	The delivery time proposed by the procurement cannot be fulfilled	0.032	0.012	0.019	0.023	0.086	9
P7	Budgeted price given by the user is below the estimated price	0.032	0.016	0.026	0.040	0.115	4
P8	The delivery time given by the user is shorter than the validity confirmation limit	0.032	0.016	0.026	0.042	0.116	3
P9	The specifications of the required demand are difficult to meet by the vendor	0.032	0.012	0.019	0.038	0.102	5

3.4 Improve

Improvements were proposed according to the results of Analyze phase with RCA and MAFMA, i.e., by implementing contemporary procurement processes and entering into contract agreements. Contract agreements can cut cycle time because after fast-moving spare parts are submitted and become contract material, the procurement process only goes through two main processes, i.e., PR creation and PO issuance. According to Siahaya (2012), there are five types of contract agreements with terms and conditions in each agreement that must be fulfilled.

From the analyze phase, it is showed that the most dominant root cause of waste were required specifications were difficult to fulfill by the vendor, the specifications offered did not match the demand, and the delivery time offered by the vendor was longer than the delivery time given by the procurement staff.

Agreements in the spare part procurement process could cut cycle time because the flow of the goods procurement process starting from the tender process, the bid evaluation process, and the negotiation process only needs to be performed once at the beginning of the contract submission process. This could occur because a contract agreement is valid in the long term according to a certain time with predetermined item specifications. After entering into a contract agreement, the procurement department only needs to make a PR and then a PO is issued, and the vendors appointed as suppliers are vendors who have entered into agreements in accordance with the specified timeframe. The proposed goods procurement contract agreement must meet the specification requirements offered at a consistent price, and the vendor can ensure the delivery of goods according to needs and on time.

The contract type could be selected by conducting a focus group discussion with the goods procurement staff to decide which type of contract is most suitable to be implemented based on the results of the analyze phase using MAFMA. Determining the type of contract should consider the possibility of potential waste.

After submitting a proposed contract in November 2021 and conducting an evaluation and discussion with the directors of the industry, the proposed improvements can be realized as a price agreement contract submission by the goods procurement department. The contract submission process was carried out step-by-step from November 2021. Until this research was completed the contract submission process was still in the process of submitting 2,524 fast moving materials submitted as contract material by the procurement of goods that had become contract material and issued agreement numbers with around 334 new vendors material.

The time required for the submission of the contract until the vendor is selected and the contract number comes out was from 3 to 6 months according to the type of material and the process of negotiation and evaluation from the user and the procurement of goods. The control stage to see the overall improvement and reduction of cycle time could not be carried out yet because there was still a lot of material that has not yet become contract material. However, in order to see the improvement with the implementation of the contract agreement, data was collected for 334 materials that had become contract material or around 16% of the total material amount and it was found that the cycle time required from the process of making PR to issuance of PO on 334 materials before submitting a contract and after improvements can be reduced as shown in Table 3.

Table 3. Cycle Time before and After Repair on 334 Materials

Cycle time before improvement (2016-2021)	Cycle time after improvement (January – May 2022)
42 days	16.6 days

The sigma value in the material that has become a contract material increased from the average sigma from 2016-2021 of 1.79 sigma to 2.43 sigma. The process of implementing the contract agreement up to the research only reached 334 fast moving spare parts, which have become contract material from a total of 2,524 fast moving spare parts. This was because the process of submitting a contract agreement took 3 to 6 months. The contract submission process was only carried out once as long as the contract was valid with a predetermined period of procurement of goods around 2 to 3 years.

There were managerial implications from the implementation of MAFMA in the industry that being studied. First, there was the need for a clear understanding of the organization's goals and objectives from stakeholders from all relevant departments, so everyone could involve proactively in the MAFMA implementation. Second, there was the need to monitor and evaluate the results of MAFMA on an ongoing basis, especially monitoring the process of implementing the contract agreement for the remaining 2,190 spare parts. This might be in process for the next 6 months after this research completed. Finally, there was the need to provide training for the people who will be implementing improvements developed from MAFMA.

Additionally, after the improvements proposed in this study has been implemented successfully, a new round of MAFMA needs to be conducted to find new emerging problems and solutions. This cycle should be perpetually executed as parts of a continuous improvement.
3.5

4. Conclusion

Based on the calculations using value stream analysis tools, Non Value Added was accounted for 45.5 days, mostly came from waiting in the contract agreement cycle time for 42 days. MAFMA in the framework of FMEA was effective to reduce the contract agreement cycle time in the studied industry from 42 days to 16 days and to increase the sigma value from 1.79 to 2.43. The quality improvement process was carried out by identifying waste, looking for the root causes of waste and determining the most dominant root causes of waste. The results of the most dominant root cause with the MAFMA method occurred in the root causes of P1, P2, and P8. Suggestions for improvement were given by implementing contemporary procurement processes and entering into contractual agreements. The contract agreement selected based on the results of the focus group discussion was the price agreement.

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