Determining The Type of Maintenance by Using Multi-Attribute Utility Theory Case Study: Small and Medium Enterprises Printing in Jabodetabek

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Abstract
Printing industry is one of business that categorized in production sector which required support utility ie photocopy machine and printer in well condition. Maintenance activities are generally considered as supporting activities in the production process. However, this activity is very important because it contributes directly to the smooth running of the production process and productivity. The purpose of this paper is to guide the use of decision-making techniques in selecting some important criterion in the most trending of maintenance strategy for Small and Medium Enterprises (SMEs) organizations of Printing Industry. Multi-Attribute Utility Theory (MAUT) are used for the selection of some important criterion in the most trending of maintenance strategy for Small and Medium Enterprises (SMEs) of Printing Industry in Jabodetabek Indonesia. The practical implication shows that for 30 respondents they have a minimum performance indicator allocating a budget for maintenance of 15-25% of net profit. The processing of the survey results shows that from a cost perspective, breakdown maintenance has proven to be more effective than PM. By changing the type of maintenance from PM to BM, Small and Medium Enterprises (SMEs) Printing in Jabodetabek can save maintenance costs by 22%.

Keywords: Maintenance Strategy, Survey, Multi Attribute Utility Theory, Small Medium Enterprise Printing Industry

1. Introduction
Maintenance is Usually becoming a cost center in operational system of Industrial (Al-Najjar, 2007). It can be absorbed 30 % of operational budget while it should be treated as profit-generating center of operational (Al-Najjar, 2007). Maintenance organization has to be designed by considering important determinants including the maintenance capacity and the person that was responsible for maintenance (Rahayu Agustina Puji et al., 2019). Therefore, in Organization not just how to running the organization, but also needed maintenance strategy that contain all of process of the maintenance, from the beginning till the end.

Many strategies or method of maintaining operational system to find the best result based of cost effect, operational condition, flexibility of those method, and acceptable of those strategy or method. Many popular strategy / methods of maintenance success applied to industry such us TPM, Vibration Based Maintenance, Reliability Centered Maintenance etc (Al-Najjar & Alsyouf, 2003).

Maintenance role in maintaining the quality of the essential element contribute in the manufacturing process such as production / operation and quality on the economics basis for achieving competitiveness advantage (Al-Najjar, 2007). The optimum Maintenance strategy meet when they raised expectation of reliability and availability (Al Meanazel et al., 2020). The performance of every company is related to the performance level of its maintenance function. Nevertheless, maintenance performance is characterized by a high level of complexity due to its multi-criteria nature. As a result, to improve the overall maintenance performance with the least cost and effort, it will be necessary to identify and select the maintenance's key success factors. (Naji & Mousrij, 2018).

The object of this paper is printing industry that have photocopy machine and print on their asset. we make a questionnaire that contain various question about maintenance of their assets and the tendency to choose several types of work, and spread that questionnaire to 30 responden in JABODETABEK.

This research focuses on finding some the type of maintenance in printing industry in JABODETABEK by using Multi-Attribute Utility Theory (MAUT). Limitation of the research carried out maintenance strategy in 30 respondents from small and Medium Enterprises (SMEs) in JABODETABEK and only with Multi Attribute Utility Theory. The results of this study can help printing industry to find out about type of maintenance that can be used in there.

2. Literature Review

2.1. Multi Criteria Decision Making

Multi Criteria Decision Making (MCDM) consist of a finite set of alternatives aiming which a decision maker has to select or rank, a finite set of criteria weighted according to their importance (Al-Najjar & Alsyouf, 2003). Benítez (2019) said that the process of multiple-criteria decision-making (MCDM) may comprise the solution of the problem referred as how to derive weights or rankings of importance for a set of alternatives/criteria according to their effect on the objective of the decision taken.

There are several methods used for decision making such as simple additive weighting (SAW), multiplicative exponential weighting (MEW), technique for order preference by similarity to ideal solution (TOPSIS), the analytical hierarchy process (AHP), etc (Al-Najjar & Alsyouf, 2003). It is necessary to use a multi criteria decision making method. The most popular decision-making methods are the analytical networking process ANP and the analytical hierarchy process AHP (Naji & Mousrij, 2018). The multi-criteria decision-making models are a useful tool for the maintenance planning of constructed structures and infrastructures (Benítez, Pablo et al.,2019).

2.2. Multi-Attribute Utility Theory (MAUT)

Multi-Attribute Utility Theory (MAUT) is one of methods used to evaluate the process in the organization (Schafer, 2001). Hence, MAUT has a strong relationship with maintenance activities where it is in the process in the organization. The common denominator of all these dimensions is the utility for the evaluator. For example, a digital camera can be evaluated on the value dimensions quality of image, flash, viewfinder, operation time, and handling (Schafer, 2001). In order to evaluate attributes, it is necessary to construct a scale representing the properties of the levels of an attribute. A scale from 0 (worst) to 10 (best) serves as measure of the evaluation (Schafer, 2001). “Stiftung Warentest” uses MAUT over many years in order to evaluate products and presenting them to the public. Even newspapers print the results in a shortened form, by publishing the value dimensions, the evaluation of the products with respect to these dimensions and the overall evaluation of the products. This indicates that an evaluation according to MAUT can be easily understood. However, it should be noted that it is not trivial to identify the value dimensions of an object and of all attributes being relevant for the evaluation. Of course, it is much easier to understand them, once they have been defined. This is probably the reason why people use more simpler evaluation schemes when evaluating objects or just rely on the schemes of consumer organisations which they do understand (Stiftung Warentest.2000).

2.3 Maintenance Criterion

Rahayu Agustina Puji et al. (2019) said that maintenance is a series of multidisciplinary activities involving many things, ranging from technical, administrative, and managerial, information and equipment, which are carried out during the life cycle of an item, workplace, work equipment, or means of transportation, to maintain the value of an asset which includes reliability, availability, and productivity. (Nurcahyo et al., 2010) said successful of production depend on some KPI (key Perform Indicator) such as breakdown of production machinery, machine parameter data, operational records documents, operator check sheet, and consumer complaints.

Finding crucial criterions that were collected from different literature on machine performance, and the ability for ethical maintenance decision-making to evaluate machines and the necessary maintenance activities that make the maintenance strategies selection easier (Al Meanazel et al., 2020). There are 6 criterions that become important to determine optimum maintenance strategy, ie: Cost, Safety, Add value, Historical data, Feasibility, equipment status (Al Meanazel et al., 2020). (Naji & Mousrij, 2018) define importance of the six strategic maintenance performance

criteria, is OEE, Maintenance cost, Asset condition, spare parts management, health, safety, and employee occupancy rate.

Increasing productivity through smart maintenance planning by including productivity as one of the objectives of the maintenance organization (Gopalakrishnan et al., 2019). Many activities that production and maintenance has the same objective. The biggest issue is about production capacity and production planning. Time for the production and the maintenance activities should be get balanced portion. Preventive maintenance and production scheduling are related to each other due to well scheduled preventive maintenance will reduce the likelihood of machine down time that can interfere production (Nurcahyo et al. 2016). Selected focus of optimization in preventive maintenance is to determine effective periodic replacement scheduling of significant part (Nurcahyo et al. 2016). Integrating lot-sizing and preventive maintenance strategy of the system that satisfies the demand for all items over the entire horizon without backlogging and which minimizes the expected sum of production and maintenance cost (Aghezzaf et al., 2007) are the example of the solution activities.

Some research was focus on printing Industry maintenance management strategy by searching the criterion that affected maintenance model. (Triantaphyllou et al.,1997) presented AHP model with four maintenance criteria: Cost, repairability, reliability, and availability. (Zaim et al., 2012) present four selection criteria are considered, these are: Added value adding, cost, safety, and implementation. and they use sub criterion as follow: 1 value adding: On time delivery, profit, Quality, Image. Cost: Hardware, software, training, inventory of spare part. Safety criterion: Internal environment, external environment, personel. Implementation: Technology, Desire of workers, Desire of top management, and decision of service company.

3. Methods

Developed optimization models are still unable to fully cover the gap between academic research and the industrial, since the industrial environment is highly complicated and fluctuates with different factors and variables that are not fully documented and analyzed (Ding & Kamaruddin, 2015). difficult to identify an optimal maintenance policy that actually suit for a manufacturing system. Maintenance performance is characterized by a high level of complexity due to its multi-criteria nature (Naji & Mousrij, 2018). Decision analysis capability to find the best maintenance strategy is often missing in existing real condition or not completely utilized. the input parameters are subjected to uncertainty. However, in practical situations, these parameters are either estimated from real life data or based on experts' knowledge.

systematic methodology structures with three main characteristics, including effectiveness, flexible, and easy implementation, could be a stepping stone to reduce the existing gap (Ding & Kamaruddin, 2015). The target of this structured methodology should be able to identify the root cause of the problem, rank the significant criteria, collect effective information, and perform accurate optimization analysis

MAUT is one of the Multi Criteria Decision Making (MCDM) to make decisions by considering all the factors of attributes that have an impact on preferences or decisions. The MAUT method is strongly influenced by the weight of the criteria from the respondents (Emovon, 2016). The advantages of this MAUT technique can be applied in the financial, actuarial and engineering fields with the utility function formed for consideration of two scales, namely the best and the worst (Jansen, 2011).

In the application of the MAUT method to determine the most important maintenance activity variables in the printing business. In this study, the criteria and weights determined are shown in the Table 1.

Table 1. Criteria and Weights of Maintenance Activity Variables.

Criteria Name	Weight
Schedule of Maintenance	9
Spare Parts Replacement	9
Maintenance Budget	8
Technician Availability	8
Expertise of Technicians / Employees in Performing Maintenance	8
Technician / Employee Training Related to Printing Equipment Maintenance	8
Recording of Maintenance History	10
Recording of Breakdown Equipment	7
Total	67

The steps sequentially in the Multi-Attribute Utility Theory (MAUT) method are as follows (Schäfer, 2001):

1. Determination of options for optimal decisions. The options in this study include: maintenance scheduling, spare parts replacement, maintenance budget, technician availability, expertise of Technicians / employees in performing maintenance, technician / employee training related to printing equipment maintenance, maintenance history, and recording of breakdown equipment.
2. Determination of the utility function by considering risk preferences so as to form a maximum or minimum multi-attribute utility function based on the decision maker's perception of risk.
3. Determination of preference by multiplication technique between weight and utility function additively. After the additive value is obtained, a rank is performed for each preference.

The criteria are arranged based on Zaim's (2012) research which divides the sub-criteria of added value, cost, security, and implementation. This study considers the implementation criteria of maintenance activities including schedule of maintenance, spare parts replacement, maintenance budget, technician availability, expertise of technicians / employees in performing maintenance, technician / employee training related to printing equipment maintenance, recording of maintenance activities, recording of breakdown equipment. Alternative considerations from the questionnaire results of 30 SMEs Printing Outlet in Jabodetabek Indonesia. The hierarchical model is built in Figure 1 according to the research goal, namely Determine the Activity Level of Maintenance SMEs Printing in Jabodetabek Indonesia.

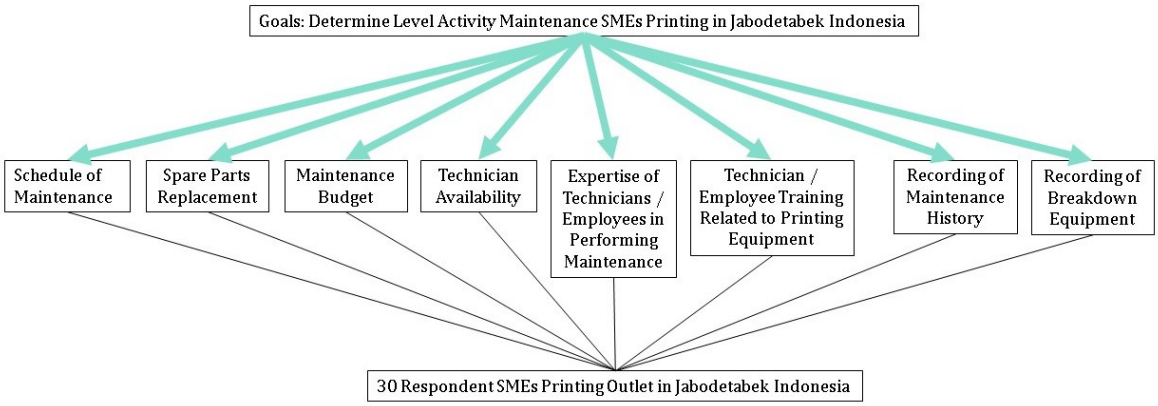

Figure 1. Hierarchy of Maintenance Activities Decision in Printing Industry

4. Discussion and Result

4.1. Maintenance Activities

We conducted a survey of 30 respondents in Jakarta, Bogor, Depok, Tangerang and Bekasi (Jabodetabek). From the survey, it is generally found that 33% of Small and Medium Enterprises (SMEs) Printing in Jabodetabek adopt Preventive Maintenance (PM) while the remaining 67% use Breakdown Maintenance (BM). Figure 2 shows the distribution and type of maintenance for Small and Medium Enterprises (SMEs) Printing by location where the most use of Preventive Maintenance is in the City of Jakarta with a proportion of 50%.

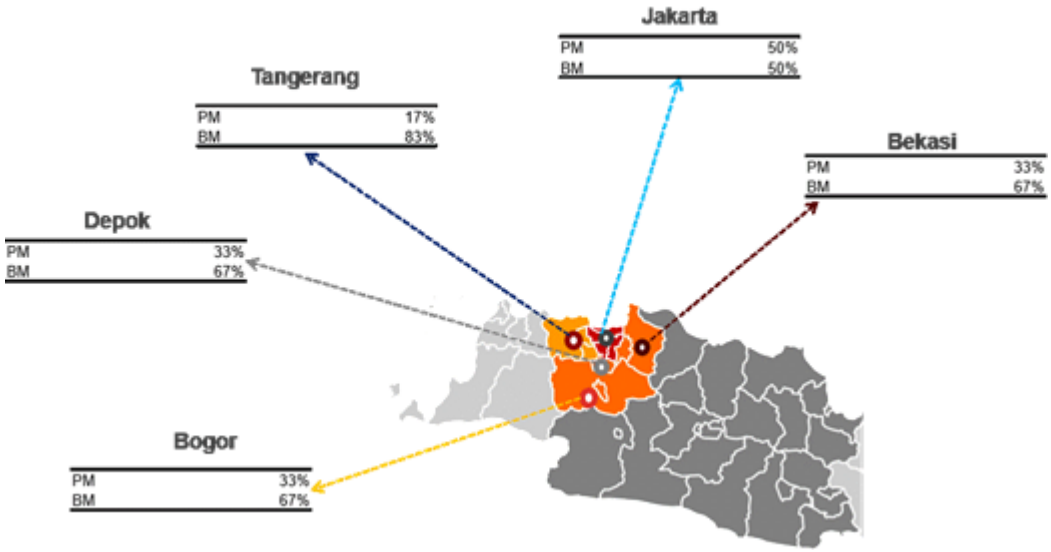

Figure 2. Distribution Map of Maintenance Small and Medium Enterprises (SMEs) Printing in Jabodetabek

We identify the maintenance costs of each respondent. Based on the survey results, it is known that business actors must at least leave 15%-25% of their net profits for maintenance costs. Figure 3 shows that to carry out preventive maintenance, Small and Medium Enterprises (SMEs) Printing costs 17%-25% of their net income, this cost is slightly higher than Small and Medium Enterprises (SMEs) Printing which uses breakdown maintenance where the cost is spent by Small and Medium Enterprises (SMEs) Printing who implement breakdown maintenance of 15% -20% of their net income and in general both PM and BM users do not complain about any disruption to their production

activities. From Figure 3, it can be concluded that in general, the selection of the type of maintenance has no effect on production activities in Small and Medium Enterprises (SMEs) Printing, while the selection of the type of maintenance for BM requires more economical costs than PM. On average, choosing the type of BM maintenance can reduce maintenance costs by 22%.

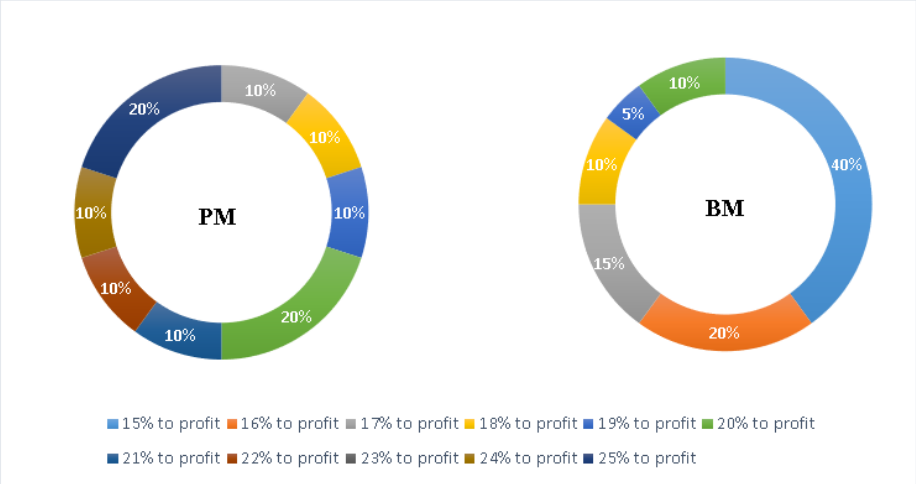

Figure 3. Maintenance Costs by Type

On the other hand, most of the Small and Medium Enterprises (SMEs) Printing in Jabodetabek have recorded maintenance activities. This is in accordance with what is shown in Figure 4 where 42% of Small and Medium Enterprises (SMEs) Printing in Jabodetabek have recorded full maintenance activities, 37% recorded some maintenance activities while 21% did not record maintenance activities. Meanwhile, 42% of the machines at Small and Medium Enterprises (SMEs) Printing in Jabodetabek are rental machines, 34% are machines that they get by buying new and 25% of them buy used machines (Figure 5). New machines get a guarantee for 1-2 years, 67% used machines have no warranty and the rest get a warranty for 1 year, while by choosing machine rental 85% of them get a free maintenance fee for 1 year (Figure 6).

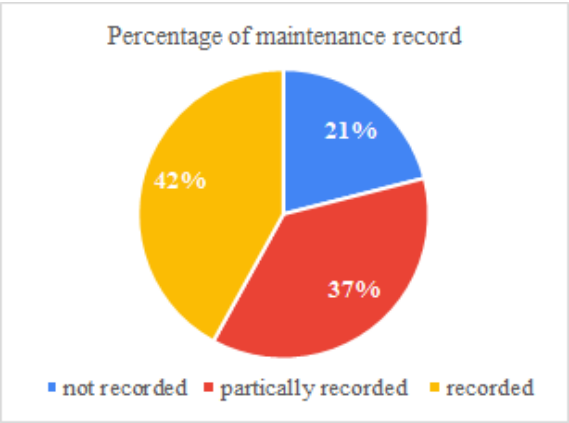

Figure 4. Percentage of Maintenance Record

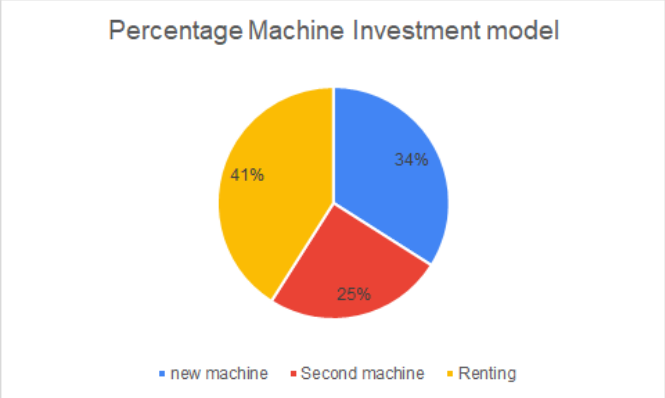

Figure 5. Percentage Machine Investment Model

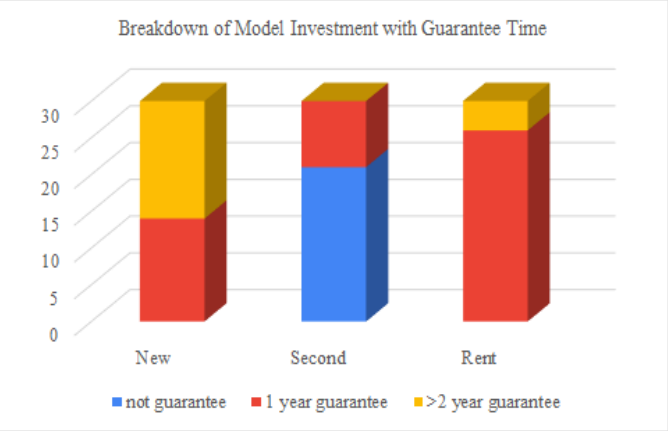

Figure 6. Machine Guarantee

4.2 MAUT

We collect data related to the level of importance of an attribute maintenance based on the preferences of Small and Medium Enterprises (SMEs) Printing in Jabodetabek businesses. The attributes that we tested were schedule of maintenance, spare parts replacement, maintenance budget, technician availability, expertise of technicians / employees in performing maintenance, technician / employee training related to printing equipment maintenance, recording of maintenance history and recording of equipment breakdown. Table 2 shows the results of the analysis based on MAUT. Based on Table 2, 3 important attributes in Small and Medium Enterprises (SMEs) Printing in Jabodetabek maintenance activities, respectively, are expertise of technicians / employees in performing maintenance, spare parts replacement and maintenance budget with preference values of 85.93%, 36.54% and 23.61% in respectively. Meanwhile, the 3 least important attributes are technician / employee training related to printing equipment maintenance, technician availability and recording of maintenance history. Meanwhile, the 3 least important attributes are technician / employee training related to printing equipment maintenance, technician availability, recording of maintenance history.

Table 2. MAUT Result.

Attributes	Preference	Rank
Schedule of Maintenance	-4.19%	5
Spare Parts Replacement	36.54%	2
Maintenance Budget	23.61%	3
Technician Availability	-40.62%	7
Expertise of Technicians / Employees in Performing Maintenance	85.93%	1
Technician / Employee Training Related to Printing Equipment Maintenance	-58.43%	8
Recording of Maintenance History	-40.58%	6
Recording of Breakdown Equipment	-2.27%	4

5. Conclusion

Multi-Attribute Utility Theory (MAUT) is used to select several important criteria in the most trending maintenance strategy for Small and Medium Enterprises (SMEs) of the Printing Industry in Jabodetabek Indonesia. The practical implication shows that for 30 respondents they have a minimum performance indicator allocating a budget for maintenance of 15-25% of net profit. This condition is supported by the condition of the machines used by Small and Medium Enterprises (SMEs) Printing in Jabodetabek. They choose new utilities and rental utilities that have a 1-2 year maintenance guarantee. As for Small and Medium Enterprises (SMEs) Printing in Jabodetabek, 67% choose Breakdown maintenance over Preventive Maintenance, but they keep records of maintenance history well. The processing of the survey results shows that the selection of the type of maintenance has no effect on production activities for Small and Medium Enterprises (SMEs) Printing in Jabodetabek. Meanwhile, from a cost perspective, breakdown maintenance has proven to be more effective than PM. By changing the type of maintenance from PM to BM, Small and Medium Enterprises (SMEs) Printing in Jabodetabek can save maintenance costs by 22%, the selection of BM is right, supported by the preference results using MAUT that technician / employee training related to printing equipment maintenance, technician availability and recording of maintenance history is not required in terms of maintenance of Small and Medium Enterprises (SMEs) Printing in Jabodetabek. There are 3 things that must be considered in machine maintenance at Small and Medium Enterprises (SMEs) Printing in Jabodetabek, namely expertise of technicians / employees in performing maintenance, spare parts replacement and maintenance budget so that expertise, spare parts and budget availability are absolute things that must be available to support BM activities.

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