Decision Support System for Industry Machine Maintenance Using Weight Product (WP) Method

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ABSTRACT

Machine maintenance management is one of the important aspects in every industry. Implementation of machine maintenance management requires the management of various types of data such as machine age, machine condition and so on. Data management with the help of a decision support system will help improve the effectiveness and efficiency of machine maintenance management. In making the right and correct decisions, it is necessary to have decision support. Without machine maintenance management, it can harm the industry because the machine maintenance schedule cannot be determined optimally, and the costs incurred by repair, maintenance and production cessation activities cannot be determined directly. Therefore, the industry needs a decision support system that is able to improve the efficiency of its machine maintenance management. This research focuses on the design and development of a machine maintenance decision support system application using the weighted product (WP) method. Weighted product (WP) method is one of the multi criteria decision making methods used to determine the final decision by using several criteria. This method can provide a reliable methodology that helps to organize the most optimized result in the presence of many different opportunities, parameters, and constraints. Research method used in this study is the Web Engineering Method. This system is developed by using PHP programming language and MySQL as a database. This system is expected to increase the effectiveness and efficiency of machine maintenance management.

Keywords: Decision Support System; Machine; Maintenance; Weight Product (WP)

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1. INTRODUCTION

Nowadays, 4.0 industry environment and circular economy are paradigm shifts for the industry. More and more machines will be used and the capability to maintain the machines become vital [1]. Circular economy is an economic system with a main focus of reducing and eventually eliminating waste [2], and considered as an innovative approach used to increase the resource efficiency in companies by keeping equipment functioning for as long as possible [3]. These condition mean that we need to be able to maintain machines. The productivity and efficiency of a machine can be seen or measured from the machine itself and its supporting tools. Machines that are used continuously will experience a decrease in machine usability. Machines used by an industry to carry out production activities must be able to produce products of good quality and in accordance with national standards that have been set in each country [4]. One of the activities carried out in dealing with continuous production is the need for machine maintenance. To achieve maximum profit then the company must have the right way by controlling costs for production needs. Production activities are one of the important activities carried out by the company, from these production activities there will be production

costs consisting of raw material costs, direct labor costs, and factory overhead costs [5]. Maintenance the machine will require no small amount of money. These costs include preventive costs. Therefore we need a good arrangement so that the implementation of maintenance activities is expected to help maximize the profit of the company. This is the main function of maintenance management. Carrying out routine maintenance is a must, especially in companies that do work continuously. This can only be done well planned. If maintenance activities are not carried out, the result will be damage to the machine.

Maintenance management is one aspect of manufacturing that can benefit from the development of information technology. Implementation of machine maintenance management requires the management of various types of data such as machine ages, machine condition and so on. Companies have differentiated their maintenance strategies by combining decisions made within the various activities that involve maintenance management [6]. Data management with the help of a decision support system will help improve the effectiveness and efficiency of machine maintenance management [7].

PT ABC is a company engaged in the assembly of electronic products. PT. ABC has several machines that are used to support the assembly process in its work. Some of the machines owned by this company have different machine ages and working hours, with their respective productivity. In order for these owned machines to continue to provide benefits to the company and to be able to support the company's activities, a company machine management mechanism is needed. The implementation of machine maintenance management at PT. ABC has not implemented a decision support system that is able to store, manage data quickly and provide alternative maintenance decisions that are appropriate for the machines operating in the company. This condition has the potential to harm the company because the machine maintenance schedule cannot be determined optimally and the costs incurred by repair, maintenance and production cessation activities cannot be determined directly. Therefore PT ABC needs a decision support system that is able to improve the efficiency of its engine maintenance management and provide alternative decisions in performing engine maintenance management. This research focuses on the design and development of a machine maintenance decision support system application at PT ABC using the weighted product (WP) method. This system is expected to increase the effectiveness and efficiency of machine maintenance management at PT ABC.

A decision support system is a computer base system consisting of three groups, which are interconnected with each other [8]. Decision Support System (DSS) is a computer system that is able to produce both the ability to solve problems and the ability to interact for semi-structured and unstructured problems [9]. In making the right and correct decisions, it is necessary to have decision support. In addition, the resulting decisions are more transparent [10]. Several research already discuss about the important of decision support system. Decision support systems (DSSs) are extremely useful when complex manufacturing processes need to be evaluated at either operational or strategic level [11]. In general, a decision support system is formed by three main components, namely: the design process, database management, and user interface management for its users [12]. In the recent decades, many businesses and industries use Decision Support Systems (DSS) to support problem solving and to reinforce their decision making in different areas. The aim of these systems is to integrate the experts' knowledge with mathematical models to support decisions [13]. DSS are high in the list of problem solving for industry, mainly due to two reasons: (i) they can provide multiple or alternative solutions to complex problems, and (ii) they are proven to save time and money [14].

Weighted Product is a decision making based on multi-criteria analysis which is very well known and is a multi-criteria decision-making method [15]. Multi criterion Decision-Making (MCDM) tools are generally applied in arriving at an optimum decision when face with multiple alternatives having multi conflicting and non-commensurable decision criteria [16]. A MCDM method can provide a reliable methodology that helps to organize the most optimized result in the presence of many different opportunities, parameters, and constraints [17]. One of the MCDM methods is the Weighted Product method which is a finite collection of decision alternatives described in terms of decision-making criteria [18]. Some of the reasons for using the WP method is that researchers use the Weighted Product Method because the calculation time is shorter, the formula is simpler and easier to remember. The WP method is more efficient than other methods classified in the MADM settlement. The second reason is that the WP method uses shorter time in terms of calculations [19].

As a vertical in a decision problem which can be expressed as a matrix form and each row i corresponding to the candidate network i and each column j corresponding to an attribute [20]. Where Xij denotes the candidate of the compound i, Wi is the associated weight j, that w is the positive power for the benefit matrix xij wj, and the negative power for the cost Xij-w.

The steps of the Weighted Product method in making decisions include the following [21]:

a. Determine the criteria that will be used in decision making.

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b. Determine the suitability rating for each alternative on each predetermined criterion. Determining preference weights on each criterion

c. Then transfer all attributes with weights as positive powers for benefits and negative for costs or costs.

d. The results of these multiplications are added together to produce a value of V for each alternative.

e. Next, look for alternative values by doing the same steps as above, only using the highest value for each use attribute and the lowest value for the cost attribute.

f. Then divide the value of V for each ideal alternative.

The Weihgted Product (WP) method is a finite set of decision alternatives described in terms of several decision criteria. So this method does not need to be normalized. The initial step of this method is to calculate the multiplication of the weights of the importance rating criteria of the alternatives.

$$w_j = w_i / (\sum w_j) \tag{1}$$

Where:

W: Weight of Criteria/subcriteria

j: Criteria

After getting the results of the improvement of the weight of importance, the next step is to find the vector S by multiplying the matrix between the values of the first alternative subcriteria raised to the power of the number of weights of the first importance and then multiplied by the second alternative subcriteria to the power of the sum of the second weights and so on, the formula for finding the vector s is:

$$s_i = \pi n_j x w_j i_j \tag{2}$$

Where i = 1, 2 .... m

S: Alternative preferences are analogized as vector S

X: Criteria value

W: Weight Criteria/subcriteria

i: Alternative

j: Criteria

n: Number of Criteria

The relative preferences of each alternative are given as follows:

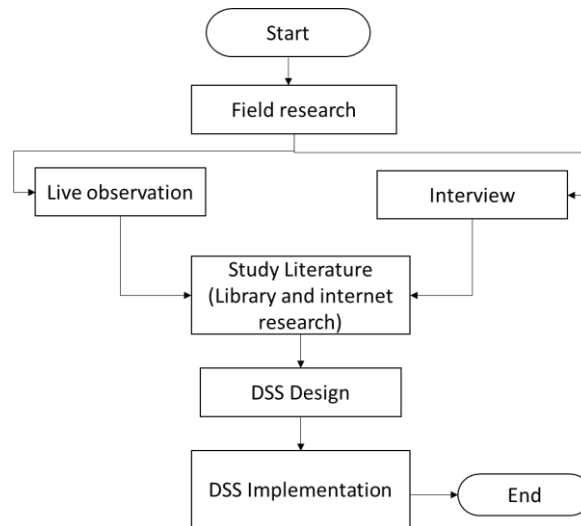$$v_i = s_i / (\sum s_i) \tag{3}$$

Where:

V: Analogous alternative preferences as vector V

S: Alternative preferences are analogized as vector S

i: Alternative

2. RESEARCH METHOD

The research method used in this research is the Web Engineering Method [22]. For the design of the DSS application, the programming language used is the PHP programming language and the MySQL database), and the design aids use UML [23]. The research method is a scientific way to carry out and to obtain the data needed in research. Certain goals and benefits. The research was conducted with the aim of obtaining the data used, but also obtaining valid data. According to [24], the techniques in data collection are: the ways to do it for get valid data and information needed to carry out study. How to collect data do by researchers carry out data collection for completion This research is as follows [25]:

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        ┌─────────┐
        │  Start  │
        └─────────┘
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     ┌───────────────┐
     │ Field research │
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┌───────────────┐   ┌───────────┐
│ Live observation │   │ Interview │
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  │   ┌───────────────┐ │
  └──▶│ Study Literature│◀┘
      │(Library and internet│
      │   research)   │
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      │  DSS Design   │
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      │DSS Implementation│──▶│  End  │
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A. Field Research.

This field research is research aimed at get primary data in the field directly from the industry :

1. Live Observation

Spaciousness With this method the researcher carry out observations directly to determine the industry machine maintenance

2. Interview.

In this method the researcher collect data by carry out interviews with industry in the selection of the industry machine maintenance.With the intention of researchers find solutions to solve problems that occur machine maintenance division and design application for determine industri machine maintenance with decision support system and using WP method.

B. Library Research

In this way, researchers carry out studies library by reading related books and journals with the problems that occur have discussed the problem and related to DSS and with the method used in study. In research studies researchers will collect data about information relevant to research or in accordance with the problem being researched. Researcher in collecting data, by reading, seeing problems that occur in the system. In addition, researchers are also looking for other related sources with the DSS.

C. Internet Research. In this way the researcher collect data from websites online, Online journal, Ebook, website, related to research, all this is intended to support the path research well. After study literature, DSS start to design and implement by using PHP programming language.

3. RESULTS AND DISCUSSION (10 PT)

Based on research method above, there are some alternatives and criterias that involved in this decision support system. The criterias and alternatives shown in table below. The criteria are used to determine which decision among several machines will be treated first. The number of machines requires criteria to filter the maintenance determination process. Alternatives are type and number of machines in a company that support their work.

Table 1. Criteria Table

Criteria_Code	Name	Weight	Type
C1	Machine condition	3	Benefit
C2	Machine age	2	Cost
C3	Working hours	5	Cost

In this research, we used three criteria that shown in table 1, that are machine condition, machine age, and working hours. Each criteria has one of two type (benefit or cost). A benefit criterion means that the higher

an alternative scores in terms of it, the better the alternative is. The opposite is considered true for the cost criteria. Each criteria also has weight that adjusted by the decision maker.

Table 2. Alternative Table

Alternative	Weight (C_1)	Weight (C_2)	Weight (C_3)
Cutting machine	3	5	5
Grinding machine	2	3	3
Mixer machine	1	2	2

Table 2 explain about alternative that must be comparing in the industry. The alternatives are cutting machine, grinding machine, and mixer machine. Each alternative has weight based on criteria.

Table 3. Machine condition Sub criteria Table

Criteria	Sub Criteria	Weight
Machine condition	Good (No error)	3
Machine condition	Average (Few error)	2
Machine condition	Poor (Machine can't be used)	1

Table 3 explain about machine condition sub criteria. The subcriteria consist of good, average, and poor when the machine can not be used. Each sub criteria also has weight.

Table 4. Machine age Sub criteria Table

Criteria	Sub Criteria	Weight
Machine age	1 year	5
Machine age	2 years	4
Machine age	3 years	3
Machine age	4 years	2
Machine age	>5 years	1

Table 4 explain about machine age sub criteria. The subcriteria consist 1 year, 2 years, 3 years, 4 years until more than 5 years. Each sub criteria also has weight.

Table 5. Working hours Sub criteria Table

Criteria	Sub Criteria	Weight
Working hours	<2 hours	5
Working hours	3 hours	4
Working hours	4 hours	3
Working hours	5 hours	2
Working hours	>6 hours	1

Table 5 explain about machine working hours sub criteria. The subcriteria consist of below 2 hours, 3 hours, 4 hours, 5 hours, and over 6 hours. Each sub criteria also has weight.

Based on the criteria and alternatives above, we implement weighted product method. Next section is implementation of decision support system. Decisison support system for machine maintenance consists of several menu.

a) Login

Figure 1 is login menu, that allow user to entry username and password that match with database.
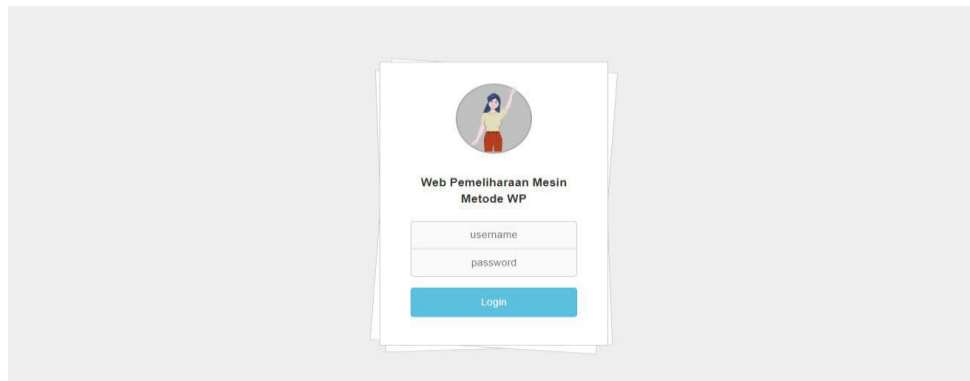

Figure 1. Login Menu

b) Main menu

If the user already input their user name and password, then figure 2 will display. Figure 2 is main menu of decision support system.

Figure. 2. Main menu

c) Criteria menu

In figure 3, user can add, delete and update critera and sub criteria of decision support system. For example, user can add another criteria that determine machine maintenance.
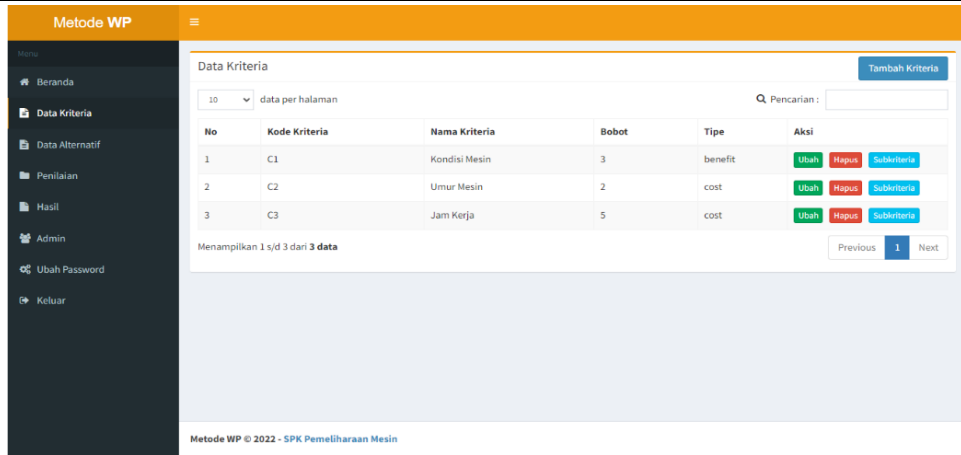
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Figure. 3. Criteria menu

d) Alternative Menu

In figure 4, user can add, delete and update alternative of decision support system. For example, user can add another machine type that will be maintenanced.
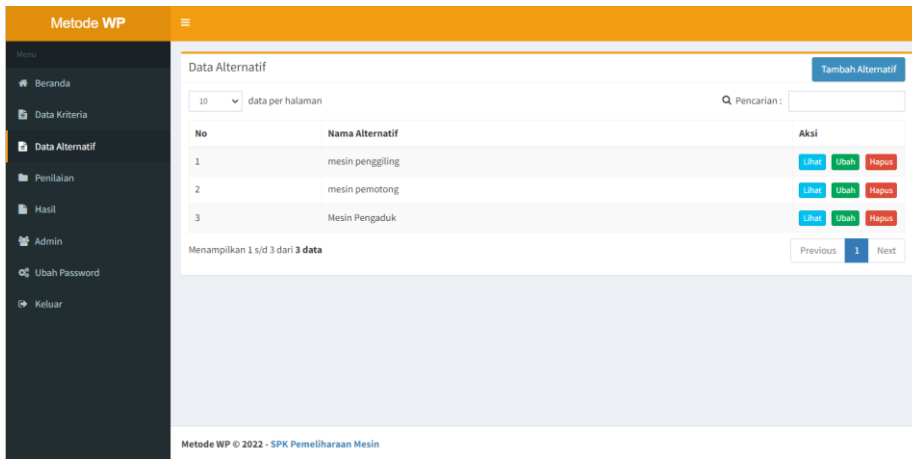

Figure. 4. Alternative menu

e) Assesment Menu (1)

In figure 5, system display the weight for each alternatives and criteria. Each alternatives will get the result (value) based on WP method.

Figure. 5. Assesment menu (1)

Decision Support System for …(Rika Yunitarini)
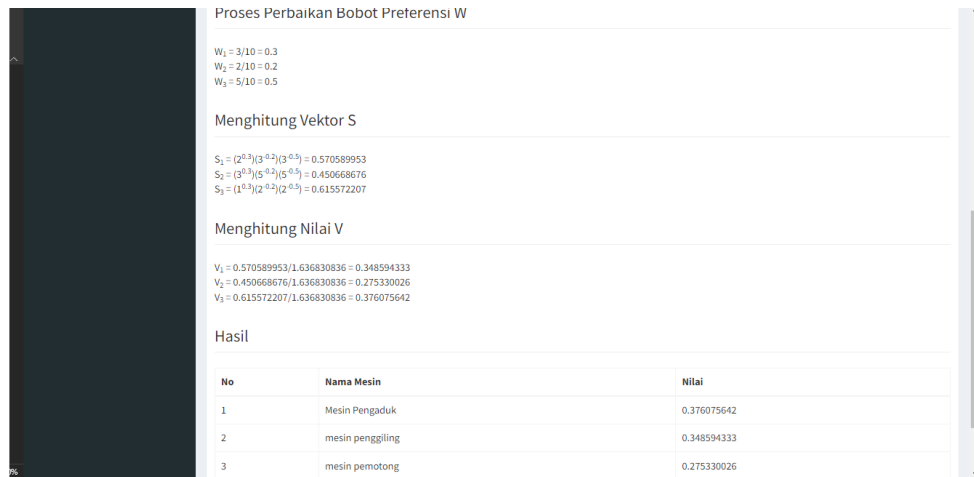
f) Assesment Menu (2)

Figure. 6. Assesment menu (2)

In figure 6, system display the assessment for each alternative based on each criteria and sub criteria. This menu contain of weight revise, vector s calculation and result of assessment.

g) Result Menu

In figure 7, there is result menu of decision support system that display the rank of each alternatives from WP calculation process and also report which machine that will be maintenanced.
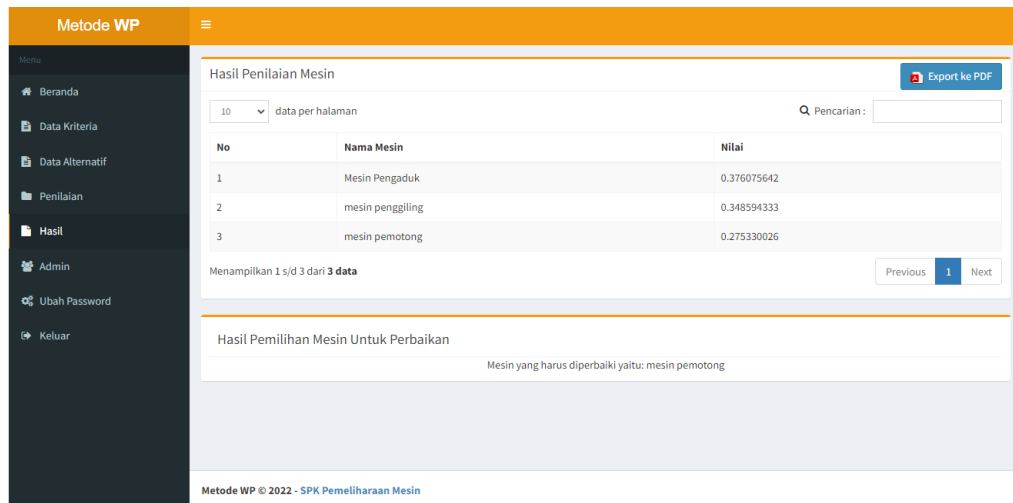

Figure. 7. Result Menu

4.   CONCLUSION

The conclusions from this research :

This system can assist employees in the maintenance of factory machines on a large scale by comparing several existing criteria. The results achieved by the system are to produce information on the name of the machine that must get maintenance. In the future, Added new features that can assist users in performing factory machine maintenance and add other decision-making system methods

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