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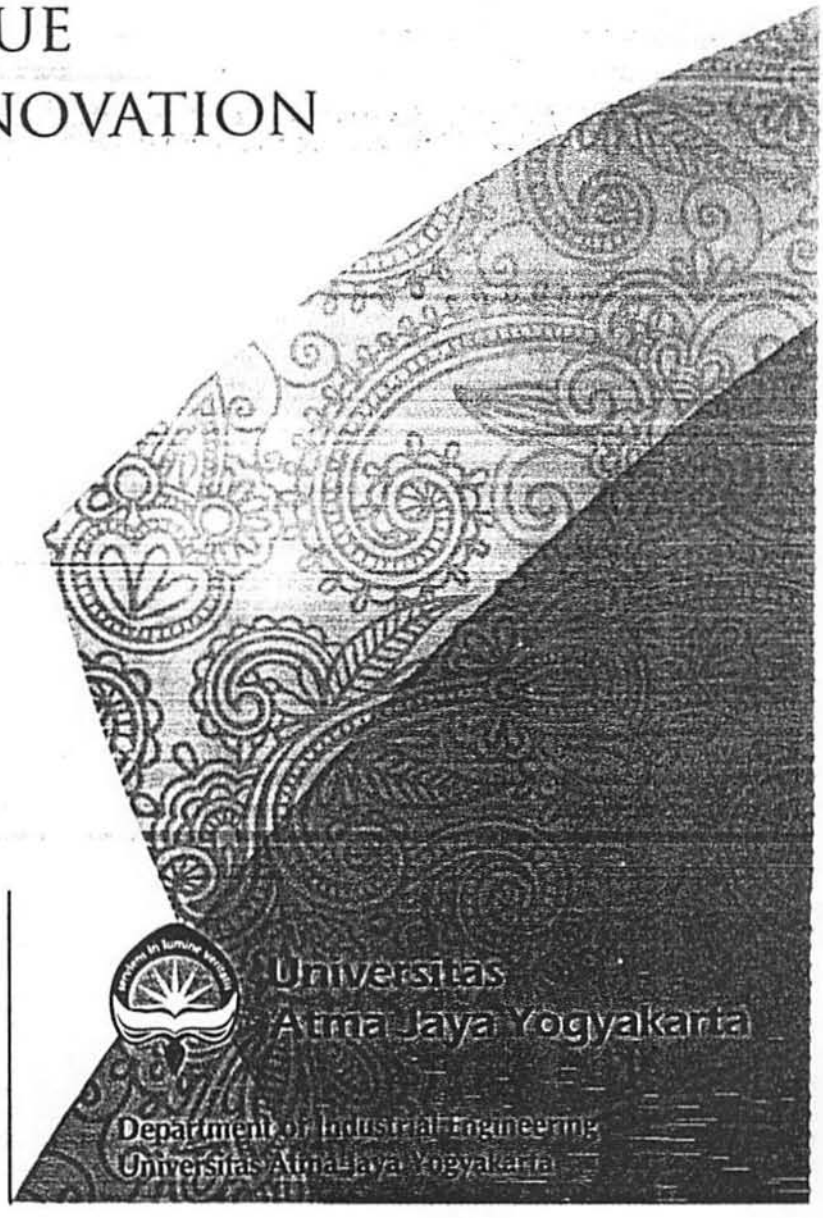

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A Fuzzy Associative Memory Modeling for Production Equipment Status Assessment

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ABSTRACT

Overall Equipment Effectiveness or OEE is the most common method to measure the performance of production particularly for equipment status assessment. OEE comprises of three elements such as availability, performance and quality. The three elements consist of at least two factors which are known as parts of Six Big Losses. However, OEE itself is most sufficient to provide information to triggers a proper maintenance response for performance improvement. This paper proposed a model to determine the maintenance status of production equipment. Fuzzy Associative Memory (FAM) is customized to meet the requirement for performing analytical capability. Basically, it analyses the proportion of events that reduced an equipment's utilization which is caused nearly by equipment. FAM aids the assessment to map a relationship between the factors and the status. The model gives two points in hedonic scale to machine with two events happened caused by machine itself. Thus the condition is interpretable for that machine maintenance requirement. Model implementable as one of modules used in Enterprise Resource Planning for production improvement.

Keywords: *Fuzzy Associative Memory, Overall Equipment Effectiveness, Performance Measurement*

1. Introduction

Controlling becomes a part of subjects in Operation and Production Management (OPM) to achieve the 4 objectives of OPM as known as right quality, right quantity, right time and right cost [1]. A production system consists of some input factors such as man, material, machine, information and capital. Thus, controlling the production factors becomes important thing to manage a good production system especially production equipment or specifically a machine. Often being a main factor for producing goods, appropriate controlling method for industrial machine is needed. It can be done by implementing good analytics platform for performing the task. [2] asserts that well-suited analytical platform helps to optimize processes in industry. As for machine, it helps to keep machine stays in good shape while in it's mission time.

Total Productive Maintenance (TPM) is a well-known method introduced by Nakajima Seiichi in 1988 for utilizing production resources and improving performance of a production system [3]. Nakajima Seiichi classifies top losses in production activates into six categories also known as Six Big Losses. Overall Equipment Effectiveness (OEE) is a method for measuring performance of a production particularly for equipment status assessment maintenance based on TPM method regarding the Six Big Losses [4]. However, there are still limitation to use OEE for assessing machine status condition as Six Big Losses comprises not only machine's fault but also other obstacle interfering production activity.

This paper proposed a model rules for assessing maintenance of production equipment status based on Fuzzy Associative Memory (FAM). This model only regards production losses caused by the equipment itself. So the equipment status becomes measureable. Case study of this paper is a cup filling machine in dessert and beverages manufacturing company (PT X). The objectives of this paper is to formulate the assessing model based on FAM and to assess cup filling machine condition in PT X using the model formulated before.

The rest of paper is arranged as follows: methodology will be described in Section 2. Membership function and the assessing rules will be explained in Section 3, while result of the measurement will be discussed in Section 4. Finally, we provide the conclusion of this paper in Section 5.

2. Methodology

As we explained before, this research has two objectives. The first objective is to make an assessing model based on FAM and the second is to assess the machine's condition using the model built before. Detail of the methods is depicted in figure 1 and figure 2.

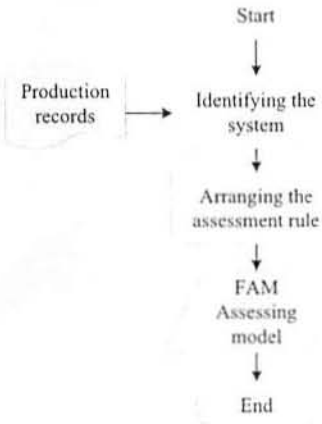

Figure 1. Model preparation flow chart

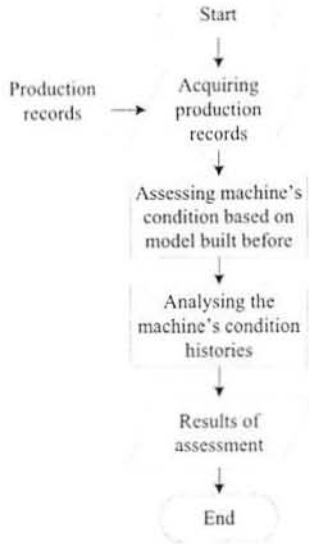

Figure 2. Machine's condition assessment flow chart

Data used in this research is production records during May to June 2014. Model is built regarding to the data obtained. Thus the model is used to assess the machine's condition. Score of machine's condition is plotted to chart with it's period of measurement as the axis. Afterward, the trend of machine's condition series is analyzed using simple linear regression to obtain the smoothing line. Correlation is also calculated to analyze the trend. Average score summarizes the information about condition of machine during one month.

3. Membership Function and Rules

Frequency and total downtime duration caused by the machine became parameters to assess machine's condition. Membership functions of frequency, total duration, and machine's condition are triangular fuzzy numbers. Frequency has 6 fuzzy sets, None (0,1). Very low (0,1,2). Low (1,2,3). Moderate (2,3,4). High (3,4,5). Total duration has 8 fuzzy sets, Too Short (0,5,10). Very Short (5,10,30). Short (10,30,60). Moderate is (30,60,240). Long (60,240,360). Very long (240,360,480). Too long (360,480). Machine's condition has 5 fuzzy sets, Good (0,1). Fair (0,2,4). Quite unfair (3,5,7). Unfair (6,8,10). Very unfair (8,10). The mapping rule is described in table 1 and table 2.

Table 1. Mapping rules

IF		THEN
Frequency	**Duration**	**Condition**
None	None	Good
Very Low	Too Short	Fair
	Very Short	Fair
	Short	Fair
	Moderate	Fair
	Long	Quite Unfair
	Very Long	Quite Unfair
	Too Long	Unfair
Low	Too Short	Fair
	Very Short	Fair
	Short	Fair
	Moderate	Quite Unfair
	Long	Quite Unfair
	Very Long	Unfair
	Too Long	Unfair
Moderate	Too Short	Fair
	Very Short	Fair
	Short	Fair

Table 2. Mapping rules (continued)

IF		THEN
Frequency	**Duration**	**Condition**
Moderate	Moderate	Quite Unfair
	Long	Quite Unfair
	Very Long	Unfair
	Too Long	Unfair
High	Too Short	Quite Unfair
	Very Short	Quite Unfair
	Short	Quite Unfair
	Moderate	Unfair
	Long	Unfair
	Very Long	Unfair
	Too Long	Very unfair
Very High	Too Short	Quite Unfair
	Very Short	Quite Unfair
	Short	Quite Unfair
	Moderate	Unfair
	Long	Unfair
	Very Long	Very unfair
	Too Long	Very unfair

FAM applied matrix operation to map the antecedent and the consequent [5]. The mechanism of FAM operation is depicted in Figure 3. The mapping rules were encoded into matrix M using correlation product encoding. Correlation product encoding was also used in operating the matrix M with matrix A to obtain B_n'. Matrix B was derived from B_n' using sum product method. This model applied winner takes all as

defuzzification method to obtain the matrix crisp value from matrix B. The methods were selected to avoid flat zone of result.

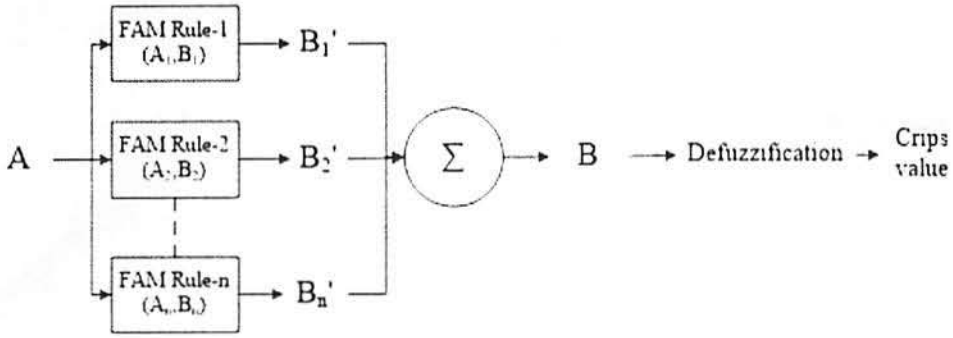

Figure 3. Model preparation flow chart

4. Result and Discussion

Machine's condition is assessed according to downtime record during May to June 2014. The graphs below show the assessment result.

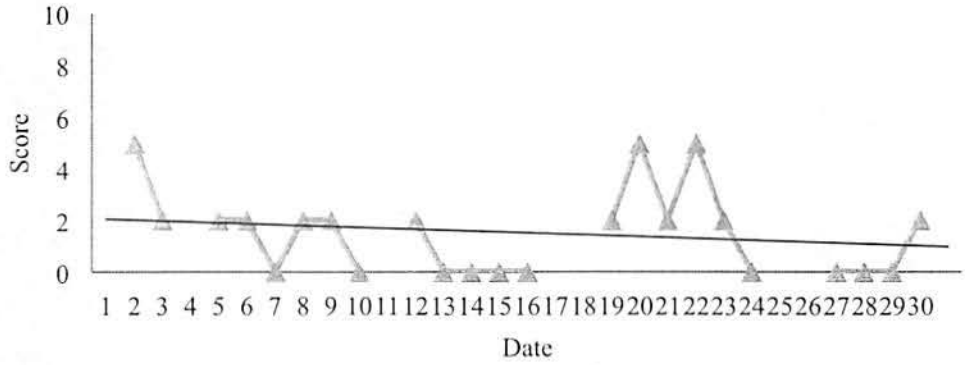

Figure 4. Machine's condition on May 2014

The highest machine's condition score on that day was plotted to the graphs. Average score for machine's condition on May 2014 is 1.52 with its correlation value shows negative value (-0.188). This shows that machine ran in fair condition without any concern shows declining of machine's condition. Negative correlation value is expected on assessing machine's condition.

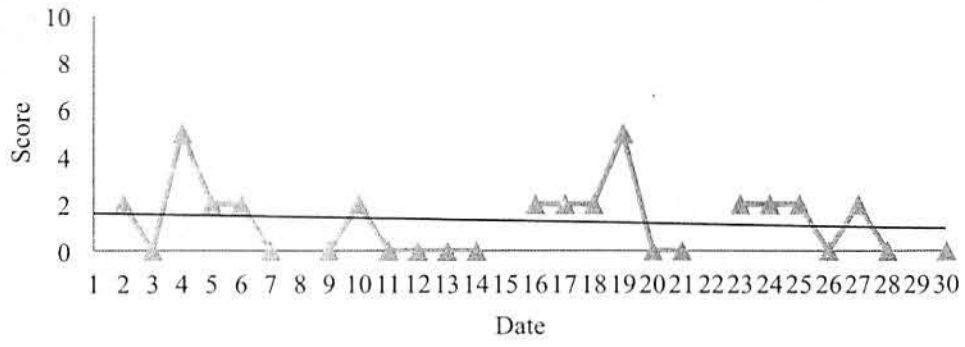

Figure 5. Machine's condition on June 2014

On June 2014, average score of machine's condition is 1.28. Same with previous month, it shows negative correlation value which is -0.125. It also shows that machine ran fairly without any concern of worse condition. For instance during May to June machine maintenance was required. Performance of machine during May to June 2014 is also measured using OEE method. The result shows OEE scores for May and June 2014 are 81.6 % and 76.5%. Which this case shows declining performance of machine during those two months. Positive

correlation value is expected in this measurement as it is only shown by result of measurement in June 2014. Average OEE score is still below the world standard which is 85% [6].

Comparing two measurement explained before, machine's condition contributes insignificantly to it's performance. It is identified by opposite results shown by each measurement. It also can be concluded that non-machine factor is the major problem interfering cup filling machine's performance in PT X. Factors affecting the machine's performance is explained using causes and effects diagram in Figure 5. However, machine breakdown is a category which has the most factors contributing to performance loss among those four according to Figure 5.

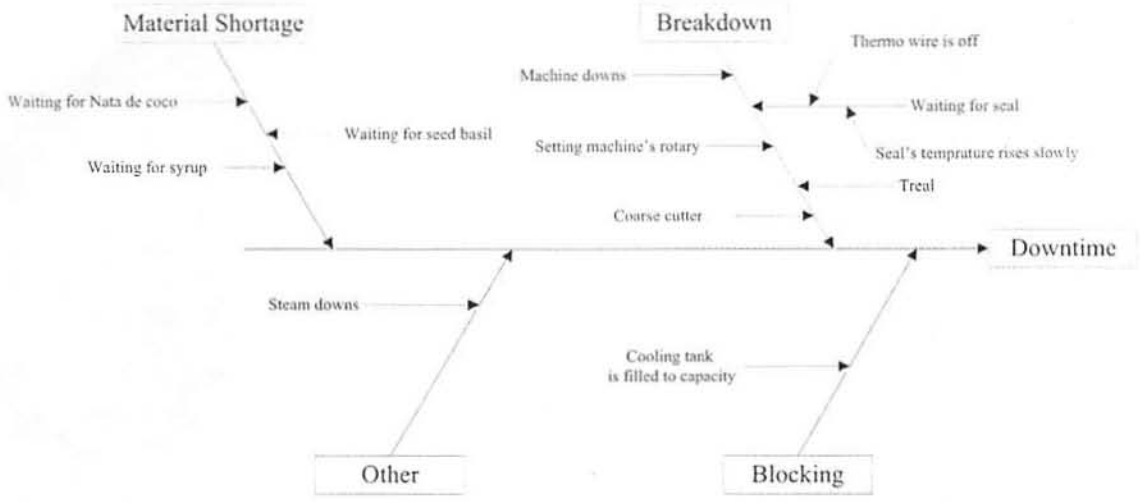

Figure 6. Causes and effects diagram showing downtime factors

This model has succeeded in assessing machine's condition based on six big losses caused only by the machine itself. Thus it can be used as a tool for supporting implementation of preventive maintenance, as the preventive maintenance is driven by statistics of machine [7]. The model also may be customized to meet the requirement of the enterprise to suit the machine they use.

There is an advantage of using FAM as the assessment model compare to Reliability approach. Unlike the Reliability method, FAM model proposed in this paper is independent to lifetime of machine factor. The calculation of Reliability involves operating time of machine and Mean Time Before Failure (MTBF)[6]. The result of assessment also depends on MTBF set in the formula. MTBF was defined as average interval time between failures [6]. Lifetime of machine affected the machine's performance[8]. Thus MTBF, which representing the performance of machine, should be adjusted in order to validate Reliability function used. Unless there will be a bias in assessing two machine which one of the machines is older than the other operating in same duration.

5. Conclusion

According to the assessment, machine ran in fair condition during observation. The average score and correlation value obtained from analyzing the time series of measurement show improvement of machine's condition during those two month. The result of this model proved that machine contributed insignificantly to performance loss, which the opposite result is shown by the OEE score, in observation. This model is applicable to support maintenance strategy for machine used utilization and improvement.

6. References

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