Selection of Maintenance Practice through Fuzzy Logic Based Simulation in TPM

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Abstract— The present study is a new approach for finding the suitable maintenance practice with the help of fuzzy logic rule base system. It is a decision making tool which depends upon various condition of a machine .The success of any industry depend on its optimum manufacturing cost of product and for achieving the above said factor the maintenance practice should be efficient and effective .Fuzzy base maintenance system (FBMS) has been considered for study because of the fact that fuzzy logic technique is best suited for dynamic environment where decisions are required to be taken on the basis of multi variable parameters. The study describes problem in maintenance arising due to absence of having clear criteria and strong decision constrain how to maintain failing equipment. This study mainly focused on the modeling of a 'Fuzzy Based Simulation 'for finding the suitability of maintenance methods considering downtime &frequency as a parameter.

Key-words- Maintenance Practice, Fuzzy Base maintenance system (FBMS), Downtime, Frequency.

1. INTRODUCTION

Maintenance as a function, to compare other areas in operation, is considered to be fuzzy nature. Maintenance has not led itself to systemization due to the fact that its activities are not repetitive during operation. Hence, there is no need for an iterative and systematic approach for maintenance practice. It has been observed that decision makers in maintenance often seek to be efficient before being effective. And one of the major problems in maintenance practice is the lack of a systematic, focused and adaptable approach in setting preventive maintenance instructions. Preventive maintenance instructions tend to be static, and not adaptable to changes in the shop floor. This study is concerned with the operational aspects of maintenance in terms of machine criticality and fault analysis. The FBMS seeks an efficient approach to specify the most appropriate maintenance action to follow based on different rules. Fuzzy logic is used to determine the most efficient actions to be undertaken to overcome these faults. The proposed system should able to handle multiple criteria decision environment. Moreover, the methodology facilitates and supports a group decision making process. This systematic and adaptable approach will determine what specific actions to be performed during current working session.

J.Yang et al [1] have proposed a integrated fuzzy multiple criteria decision making (MCDM) techniques for solving vendor selection problems, they utilized triangular fuzzy numbers to express the subjective preferences of evaluators with respect to the considered criteria, and also use the criterion gauges to evaluates a well known high tech manufacturing company

Kumar and Vrat [2] developed a fuzzy goal programming approach to deal with the effect of information uncertainty in the objectives of vendor selection process, and showed how the quota allocation of vendors is varied with uncertainty.

Sinha. R [3] deals the effect of strategic implementation of maintenance activity for the growth of steel industry it is growth report of Usha Alloy Steel Division India Ltd. Fuzzy logic, a mathematical system developed by Zadeh [4], helps to reduce the complexity of controlling nonlinear systems.

Similar dynamic models have been developed by Anderson et al. [5] for the capital goods industry and by Anderson and Morrice [6] for the service business and custom manufacturing. Emphasis by References [7-10]have shown that the vast majority of maintenance models are aimed at answering efficiency questions, that is questions of the form `how can this particular machine be operated more efficiently?', and not at effectiveness questions, like `which machine should we improve and how?. It is often observed that with the passes of time, the causes of breakdown of failure change, their duration of failure, frequency of failure and effect. Hence a more efficient approach is needed. This approach should be able to control preventive maintenance strategies based on an adaptable mechanism. This mechanism should be able to identify most of the effective areas where maximum benefits are expected. Here the work focuses on identifying the suitability of Maintenance practice by Fuzzy FBMS model. Therefore, the most important factors like Downtime & Frequency is taken into account. Fuzzy Logic Toolbox with MATLAB is a tool for solving problems with fuzzy. The result shows that the selection of Type of Maintenance is acceptable and suitable for the case situation considered.

2. THE FUZZY SYSTEM

The fuzzy inference system contains following five major steps.

(i) Fuzzifier (ii) Rule base (iii) Fuzzy inference engine (iv) Defuzzifier and (v) output quantity. The fuzzy inference system is shown in Figure 1.

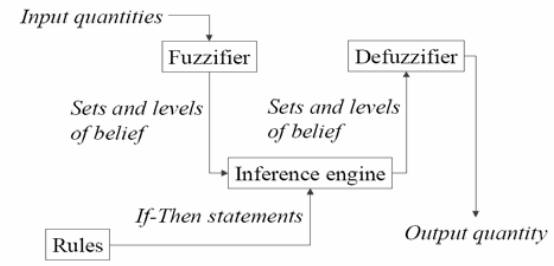

Fig. 1 fuzzy inference system

Fuzzification:

Figure 2 shows the fuzzification process of a fuzzy logic system with input and output being fuzzified with suitable membership function. Here the inputs are factors like Downtime and Frequency and output is the form of maintenance practice.

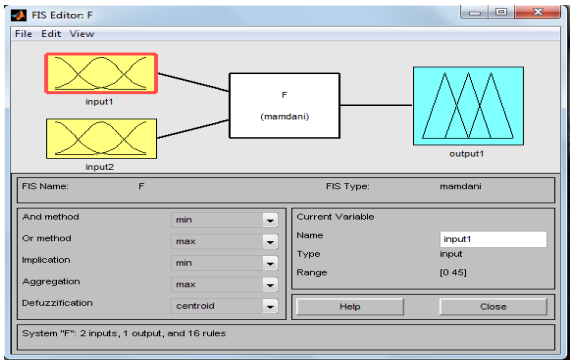

Fig. 2 shows fuzzy inference system with two Input and one output.

The first step is to take the inputs and determine the degree to which they belong to each of the appropriate fuzzy sets via membership functions. The input is always a crisp numerical value limited to the universe of discourse of the input variable and the output is a fuzzy degree of membership (always the interval between 0 and 1). So fuzzification really doesn't amount to anything more than table lookup or function evaluation.

It is assumed that both downtimes can be classified into 'Very high', `High', `Medium' and `Low'. However, frequency inputs can be classified into 'High', 'Medium', 'optimum' & Acceptable. Output is divided into five parts.i.e Break down maintenance (BM), Condition base maintenance (CBM), Total productivity maintenance (TPM), Skill levels upgrade (SLU) &Design out maintenance (DOM).The decision maker should be able to specify a maintenance practice on the basis of given two input condition.

Downtime:

Downtime is the time taken for unscheduled stopped like breakdown and adjustment. The categories are major low, medium, high, very high. If down time is between 0 – 15 than it is considered as low. If the downtime is between 20 –35 then it is considered as high. The actual division of downtime according to range of time has shown in table 1. The transfer function in fuzzy format has been shown in figure 3.

Table 1:.Range for Downtime

Set	Variable	Range(in hours)
1	Low	0-15
2	Medium	10-25
2	High	20-35
2	Very High	30-45

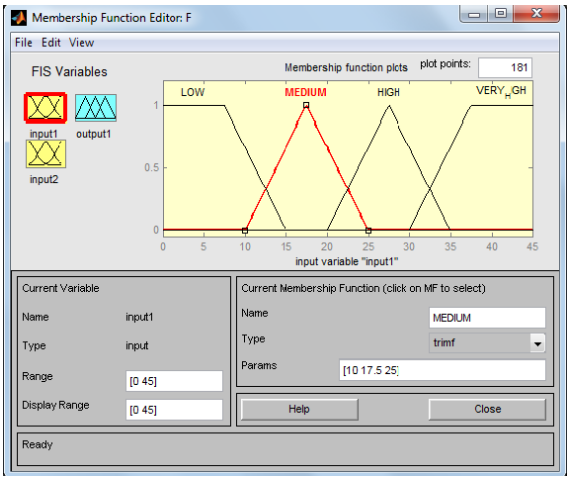

Fig.3. membership functions for downtime

Frequency:

It is defined as the number of maintenance calls per period (such as a breakdown) in the category; the measures are acceptable, optimum, medium, high. If the frequency is between 0-10 then it is considered as acceptable, and between 10-20 is considered as medium.

It can be seen through table 2 and in a form of fuzzy set in figure 4.

Table 2:.Range for Frequency

Set	Variable	Range
1	BM	0-10
2	CBM	5-15
3	TPM	10-20
4	SLU	15-25
5	DOM	20-30

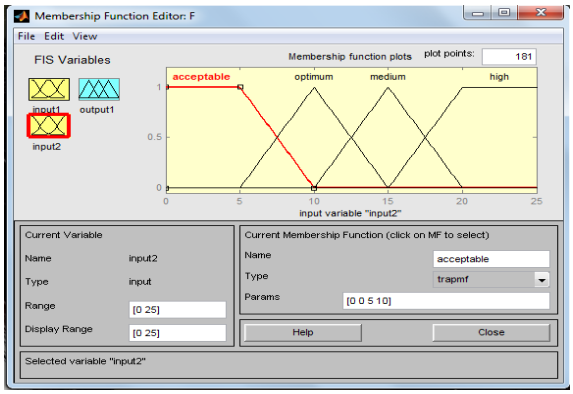

Fig.4. membership functions for frequency

Maintenance practice:

Maintenance is defined as the care of machine to avoid failure. For this purpose repair of the machine done according to requirement .The types of maintenance are Breakdown Maintenance (BM),Condition Base Monitoring (CBM), Total Productivity Maintenance (TPM,), Skill Level Upgrade (SLU) and Design Out Maintenance (DOM).It has been divided according to weight age in table 3 and in fuzzy logic(using mat lab) in figure 5.

Table 3: Range for Maintenance practice

Set	Variable	Range
1	Acceptable	0-10
2	Optimum	5-15
3	Medium	10-20
4	High	15-25

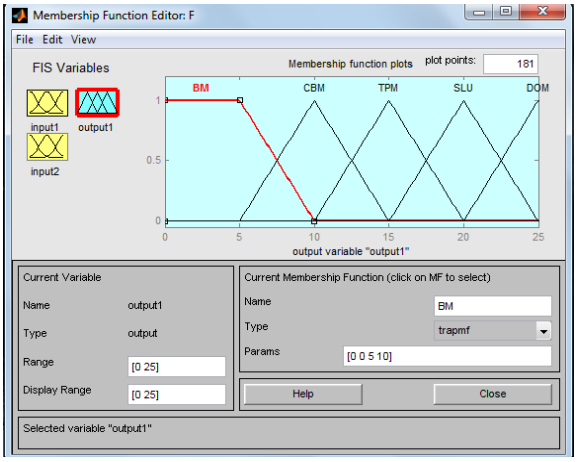

Fig.5. membership functions for maintenance practice

3. RULE EVALUTION

The rule evaluation is a platform on which one can make a relation between input and output. In the system inputs are expert rule, and fuzzy input obtained from the first step, while output is fuzzy value of maintenance practice to be carried out. Here, there are two variables, downtime and frequency and each has four subdivisions. So we need at least sixteen (4×4) rules to describe this model. These are based on if-then statement and are formed with knowledge and guidance given by expert in a manufacturing company. If –then statement has a form of "If A is X then B ix Y". Notice that the above actions are not crisp, and can be change according to the environment of each industry. The objective is to present a frame work for developing rule for the fuzzy controller. A summary of the application of each action based on the value of downtime and frequency has been tabulated given in table 4 and in fuzzy logic (using matlab) in figure 6.

Table 4: Fuzzy rules for Maintenance practice

MP / CF	BM	CBM or I	CBM	CBM& T
LOW	At a time failure	At a time failure	Monthly	weekly
MEDIUM	At a time failure	Monthly	weekly	Daily
HIGH	Monthly	weekly	weekly	Daily
VERY HI	weekly	weekly	Daily	Daily

An example of a rule can be 'IF downtime is low and frequency is acceptable, THEN Breakdown maintenance practice'. It means the component or machine, can operate till it fails .The rule can be written in matlab rule editor as: if (input 1 is LOW) and (input 2 is Acceptable) then output will be BM according to rule 1. It can be seen in mat lab format through figure 6.Another example of a rule can be, 'IF downtime is medium and frequency is high, THEN Total Productive Maintenance practice will be applicable'. In other words maintenance has to be done according to TPM . It can be seen as rule no 7, in the matlab rule editor in figure no 6.

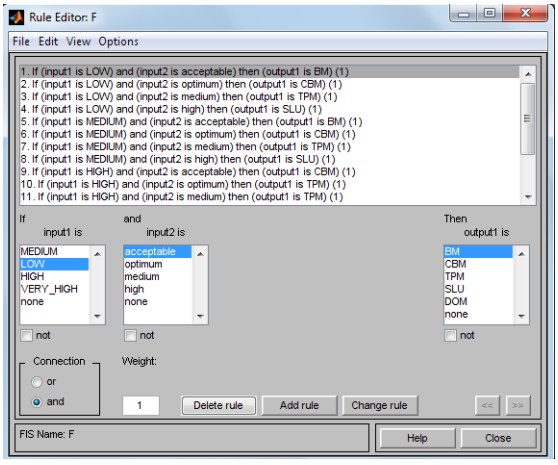

Fig. 6.for rule editor

4. DEFUZZIFICATION

The final step in the fuzzy controller is the defuzzification process. It is a process of converting fuzzification value to an equivalent crisp value of actual use. This process is based on the idea of deriving a crisp value for a fuzzy function. The defuzzification can be performed by deriving the centre of gravity of the area under the curve of the function.

5 .RESULT

With the help of fuzzy tool box of MATLAB there are two inputs that can be set within the upper and lower specification limits and the output is calculated as a point that can be translated into linguistic form. For example input data as 5, 12 has been taken resultant data as a 12.5 which means 5 points coming from input 1, as downtime(low), and 12 coming from input 2,as frequency(optimum) then ultimately output CBM maintenance practice has been obtained as 12.5 according to the fuzzy rule. It can be seen in figure7.

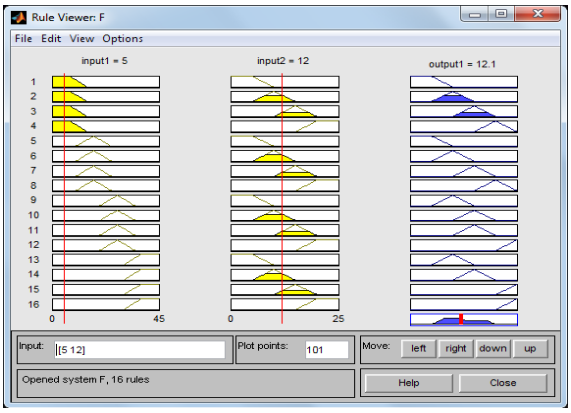

Fig. 7 Rules viewer for the membership function

CONCLUSIONS

A new model FBMS for continuous reduction of total down time has been developed with the help of exact maintenance practice selection and also reduction of the life cycle cost. The logic used throughout the development of the model is aimed at reducing the causes of breakdowns in the form of identification and analysis of different criteria such as downtime and frequency. Finding and improving the worse machines is not a new concept. However, using a formalized decision analysis approach based on multiple criteria and rule-based system is the contribution of the presented model. One of the main advantages of proposed model is that we enhance the decision making capacity of an employee for different conditions. The model can be used to understand, describe, analyze and prescribe the control of maintenance practice cost and maintenance time.

Some of the salient features of the proposed model include-

- Enhancement is decision making capacity of an employee under various situations (machine condition).

- Better understanding, describing, analyzing and prescribing controlled maintenance practice cost and maintenance time.

ACRONYMS

FBMS Fuzzy base maintenance system

MCDM Multiple criteria decision making

BM breakdown maintenance

CBM condition base monitoring

TPM total productivity maintenance

SLU skill level Upgrade

DOM design out maintenance

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