

Research Article

Application of Fuzzy Logic method for optimisation of Wear Parameters of Composite Polytetrafluoroethylene (25 % carbon filled PTFE)

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Abstract

Fuzzy logic is an optimisation technique used to predict the Behaviour of any problem. In this paper an experiment was conducted on composite Polytetrafluoroethylene filled with 25% carbon material on pin-on-disk machine to find out wear parameters. In this study, the effects of varying load, sliding distance and sliding velocity on wear was experimentally examined and analyzed with the help of Design Expert 7 software. This data is optimized by using a Fuzzy Logic concept.

Keywords: Fuzzy Logic, wear test, Composite Polytetrafluoroethylene (PTFE)

1. Introduction

The Fuzzy Logic tool was introduced in 1965, also by Lotfi Zadeh, and is a mathematical tool for dealing with uncertainty. It offers to a soft computing partnership the important concept of computing with words⁷. It provides a technique to deal with imprecision and information granularity. The fuzzy theory provides a mechanism for representing linguistic constructs such as “many,” “low,” “medium,” “often,” “few.”

In general, the fuzzy logic provides an inference structure that enables appropriate human reasoning capabilities. On the contrary, the traditional binary set theory describes crisp events, events that either do or do not occur. It uses probability theory to explain if an event will occur, measuring the chance with which a given event is expected to occur. The theory of fuzzy logic is based upon the notion of relative graded membership and so are the functions of mentation and cognitive processes. The utility of fuzzy sets lies in their ability to model uncertain or ambiguous data, Fig. 1.1, so often encountered in real life. It is important to observe that there is an intimate connection between Fuzziness and Complexity. As the complexity of a task (problem), or of a system for performing that task, exceeds a certain threshold, the system must necessarily become fuzzy in nature.

Real world problems (situations) are too complex, and the complexity involves the degree of uncertainty – as uncertainty increases, so does the complexity of the problem. Traditional system modeling and analysis techniques are too precise for such problems (systems), and in order to make complexity less daunting we

introduce appropriate simplifications, assumptions, etc. (i.e., degree of uncertainty or Fuzziness) to achieve a satisfactory compromise between the information we have and the amount of uncertainty we are willing to accept. In this aspect, fuzzy systems theory is similar to other engineering theories, because almost all of them characterize the real world in an approximate manner [S. N. Sivanandam 2007].

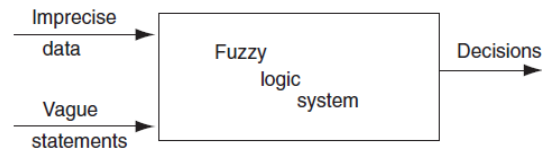


Fig. 1. A fuzzy logic system which accepts imprecise data and vague statements[S. N. Sivanandam 2007].

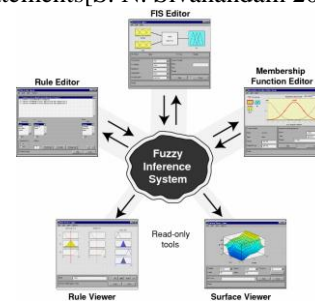


Fig. 2 Fuzzy logic toolbox graphical user interface tools

2. Experimental work

An experiment is carried on Pin On disk machine on composite Polytetrafluoroethylene (PTFE). A study of the effects of varying load, sliding distance and sliding velocity on friction and wear is tested. A data of wear is

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obtained for plain PTFE material. The number of tests to be conducted was decided by the Taguchi experimental design method [(L₉, (3³)] orthogonal array as shown in table 1 [S.Basavarajappay, 2005].

Table 1. Cumulative Experimental Wear Data of Composite PTFE

Trail No.	Load L Kg[A]	Velocity m/s[B]	Sliding dist. Km[C]	Wear(μ)
1	1	1.57	2	36
2	1	3.14	4	45
3	1	4.71	6	60
4	2	1.57	4	64.5
5	2	3.14	6	62
6	2	4.71	2	72
7	3	1.57	6	123
8	3	3.14	2	135
9	3	4.71	4	273

In this work, trials were conducted on composite Polytetrafluoroethylene (PTFE) material. For conducting the test three input parameters like load, sliding distance and sliding velocity are divided into three categories like Low, Medium and High. From these three different input parameters we get one output i.e. wear as shown in table 2.

Table 2. Fuzzy matrix example

Input 1	Input 2	Input 3	Output
Low	Low	Low	Low
Medium	Medium	High	Medium
High	Low	High	High

In Fuzzy Inference System (FIS) mamdani system is used. In FIS editor all input and output parameters are entered as given in table no.1. These values are shown in figure 2. For input parameters Gaussian curve is selected and for output parameters triangular parameters is selected. The value of three input parameters are filled in membership function as shown in figure 3 and output parameter in figure 4.

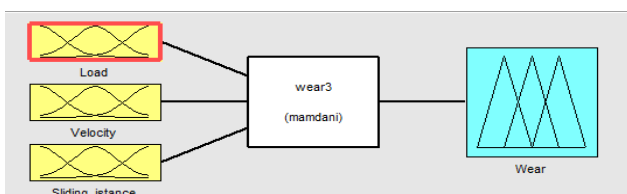


Fig.2 FIS editor for this problem

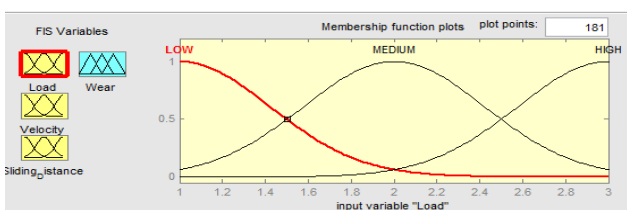


Fig.3 Input membership function of load

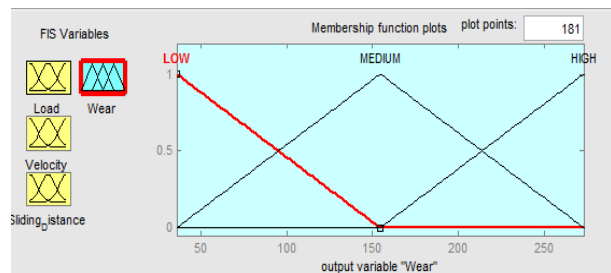


Fig.4 Output membership function of wear

Rules are applied by taking the information from table 2. Three rules are applied as shown in figure 5. The rules can be viewed in rule viewer as shown in figure 6 and the surface can be seen in figure 7. The output parameters are checked from rule viewer by changing the three input parameters from low to high values. All the values are matching with the output parameters. From this we can get information that by keeping the three input parameters at different levels we can get output in the three levels like “Low”, “medium” or “high”.

1. If (Load is LOW) and (Velocity is LOW) and (Sliding_Distance is LOW) then (Wear is LOW) (1)
2. If (Load is MEDIUM) and (Velocity is LOW) and (Sliding_Distance is MEDIUM) then (Wear is MEDIUM) (1)
3. If (Load is HIGH) and (Velocity is LOW) and (Sliding_Distance is HIGH) then (Wear is HIGH) (1)
4. If (Load is HIGH) and (Velocity is MEDIUM) and (Sliding_Distance is LOW) then (Wear is LOW) (1)
5. If (Load is LOW) and (Velocity is MEDIUM) and (Sliding_Distance is MEDIUM) then (Wear is LOW) (1)

Fig.5 Different rules for the function

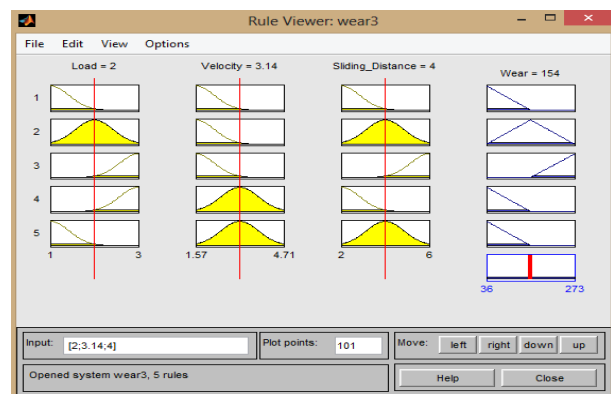


Fig.6 Rule Viewer

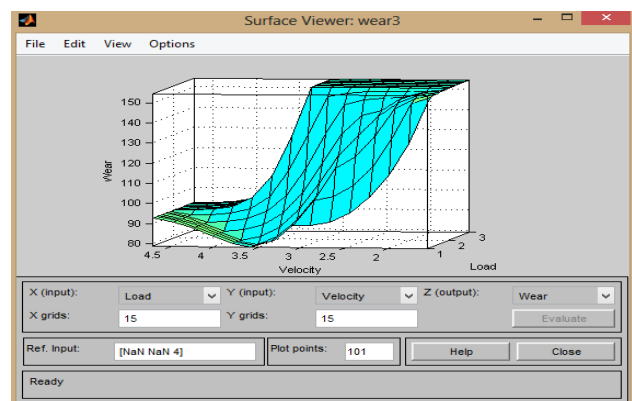


Fig.7 Surface Viewer

The graph between three parameters can be viewed from the surface viewer. A 2D graph can be plotted between input and output parameters as shown in figure 8.

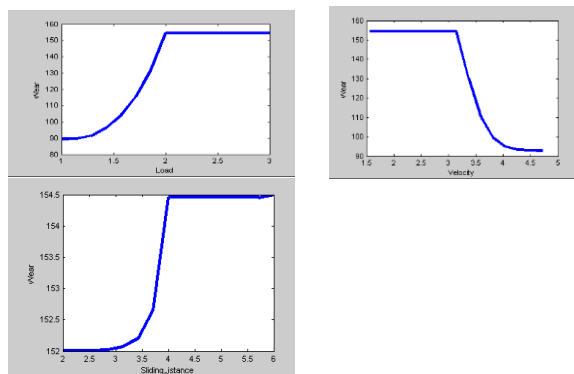


Fig.8 Wear v/s load, velocity & sliding distance

Figure 8 indicates that as load increases wear increases upto 2kg. and beyond 2 kg it remains constant. Similarly, upto 3 m/s wear remains constant and beyond that it reduces drastically.

The output values are divided in the symmetrical way. The output wear can be grouped in three categories like “Low”, “medium” or “high”. The predicted values of Low wear is from 36-115, medium wear is from 115-194 and high wear is from 194-273 as shown in table3.

Table 3.Comparison between experimental and predicted wear values

Trail No.	Load L Kg [A]	Velocity m/s[B]	Sliding dist. Km [C]	Wear (µ)	Predicted wear
1	1	1.57	2	36	Low
2	1	3.14	4	45	Low
3	1	4.71	6	60	Low
4	2	1.57	4	64.5	Low
5	2	3.14	6	62	Low
6	2	4.71	2	72	Low
7	3	1.57	6	123	Medium
8	3	3.14	2	135	Medium
9	3	4.71	4	273	High

Conclusion

Fuzzy logic is an important tool to find optimum parameters for wear analysis. By selecting three range of different input parameters, output wear can be predicted only by forming some rules. Different output parameters are checked by changing the three input parameters like load, velocity and sliding distance. The readings are matching with the experimental values. As minimum wear is expected, six trials are giving satisfactory results.

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