ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 11,November 2013

Fuzzy Modelling On Sliding Wear Characteristics of Magnesium

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ABSTRACT: Magnesium is a lightest of all the existing materials, but looking on number of its application, it is necessary for the study on wear characteristics of magnesium in order to prove it can be used in industry successfully. In this work Magnesium of is compacted by powder metallurgy technique, extruded and then machined to a size of pin and then sliding wear test is conducted on standard C45 steel disc at constant time in a pin-on-disc apparatus. The result of wear test is modelled by fuzzy logic toolbox in MATLAB and it is used for prediction of values for further experimental investigation.

KEYWORDS: Magnesium, Sliding Wear, Pin-on-Disc, Fuzzy logic, Prediction.

I. INTRODUCTION

Magnesium and its alloys are used in a variety of structural and non-structural applications. Structural applications such as clutch and brake pedal support brackets, steering column lock housings, manual transmission housings etc. Magnesium alloys are used for parts that operate at high speed and thus must be lightweight to minimize inertial forces. Magnesium alloys are valuable for aerospace applications because they are light weight and exhibit good strength and stiffness at both room and elevated temperatures. Magnesium is also employed in various non structural applications. It is also used as an alloying element in alloys of nonferrous metals. The relative position of magnesium in the electromotive series allows it to be used for cathode protection of other metals from corrosion and in construction of dry-cell, sea water, and reserve-cell batteries. Magnesium is used as ladle addition agents introduced just before the casting is poured.

Most magnesium alloys have ratios of tensile strength to density and tensile yield strength to density to that are comparable to those of other metals. The direction, temperature and speed at which an alloy is fabricated have a significant effect of wrought parts. Compressive yield strength is approximately equal to tensile yield strength of cast alloy, whereas it is considerably less than yield strength in tension. Magnesium alloys have sufficient hardness for all structural application except those involving severe abrasion. When subjected to wear by rubbing, by frequent removal of studs, or by heavy bearing loads, magnesium can be protected by inserts of steel, bronze, or non metallic materials; These materials can be attached as sleeves, liners, plates, or bushings.

Wear plays a vital role in determining the life period of products or machine elements. The lifetime of an element depends on wear. Finding and monitoring wear are relatively important in Tribological research as well as in industrial applications. Some typical examples are: measurement of dynamics of wear processes, engineering surface inspection, coating failure detection, tool wear monitoring etc. wear is erosion or removal of material from its surface or original position due to the action of another material. Wear is connected to relations between surfaces and more specifically the removal and deformation of material on a surface as a result of mechanical action of the opposite surface. Wear may also include change in dimension due to plastic dimension.

In this study sliding wear characteristics of Magnesium prepared by powder metallurgy technique and extruded to form a pin, in order to conduct pin-on-disk test. Result of wear test is modelled by fuzzy logic and values are predicted and then confirmed for accuracy.

II. EXPERIMENTAL

A. MATERIAL USED:

Magnesium powder of size 63 micron is procured from MEPCO, Madurai. Its specific gravity 1.74 g/cm^3 and ratio of air versus material density of powder is 0.85.It has a closed packed hexagonal structure, i.e. difficult to cold form, and its narrow plastic range require close control in forging. Repeated reheating causes grain growth usually formed at 100 to 200˚c. It can be extruded in temperature range of 200 to 300˚c.

B. PREPARATION OF PIN:

Magnesium is compacted with help of UTM machine at 50 ton load as shown in figure1 and then sintered in electric furnace for 1 hour at a temperature of 300˚c. Then the compacted billet is hot extruded in a 100 ton press at a temperature of 250˚c as shown in figure2. Then extruded pin is turned and faced to a diameter of 6mm and 50 mm length.

Figure 1: Compacted Billet

Figure 2: Extruded Billet

C. WEAR TEST:

Specimen prepared is used to conduct wear test for the parameters shown in table 2. Standard C45 disc is used to conduct test. Micro controller monitored by computer is used to interpret data for the experiment that is conducted.

Table 1: Parameters of wear test

Level	**Volume Fraction, %**	**Disk Speed, m/s**	**Normal Load, N**
1	5	0.8	10
2	10	1.6	15
3	15	2.4	20

Before each run both the pin and disc is polished with 400 grade emery sheet to ensure equal surface roughness before the experiment. Weigh balance is used to find the mass before and after the experiment. Result where shown in table 3.

Table 2: Levels of wear test parameters

Parameters	**Labels**	**Level 1**	**Level 2**	**Level 3**
Disc speed (m/s)	S	50	100	150
	linguistic	Low	Medium	High
Normal Load(N)	N	5	10	15
	linguistic	Low	Medium	High

Table 3: Wear test results

Runs	**Normal Load, N**	**Disc Speed, m/s**	**Co-eff. Of Friction**	**Mass Loss, g**	**Wear Rate, mg/min**
1	5	0.8	1.0158	0.0779	5.195
2	10	1.6	1.0137	0.1448	9.658
3	15	2.4	1.0139	0.0856	5.7105
4	5	2.4	1.0479	0.1054	7.029
5	10	0.8	1.0082	0.1098	7.321
6	15	1.6	1.0088	0.0975	6.5035
7	5	1.6	1.0377	0.0802	5.3475
8	10	2.4	1.0071	0.0794	5.2965
9	15	0.8	1.0050	0.0880	5.8685

III. MODELLING USING FUZZY LOGIC:

The fuzzy logic technology provides decision-support and expert systems with powerful reasoning capabilities bound by a minimum of rules. A fuzzy logic unit consists of a fuzzifier, MF, a fuzzy rule base, an inference engine, and a defuzzifier. The fuzzifier uses MF to fuzzify the input and output values. The inference engine is used for fuzzy reasoning on fuzzy rules to generate a fuzzy value. Finally, the defuzzifier converts the fuzzy value into crisp output.

For fuzzy modeling, all numeric values were replaced with linguistic values. The membership functions can be of different forms like triangular, trapezoidal, Gaussian, sigmoid, etc. The triangular shaped membership function is used in this study.

For fuzzy modeling, the numeric values are replaced with linguistic values. The linguistic variables considered for load and speed is LOW, MEDIUM, and HIGH as shown in Table 3.The membership functions for speed and load are shown in Figure 3 and 4. The membership functions used for the output responses Coefficient of friction and wear rate are presented in Figure 5 and 6. After modelling the rules as shown in figure 7 the model is used for prediction in the future.

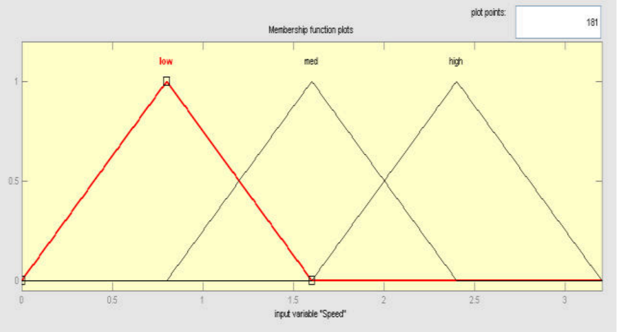


Figure 3

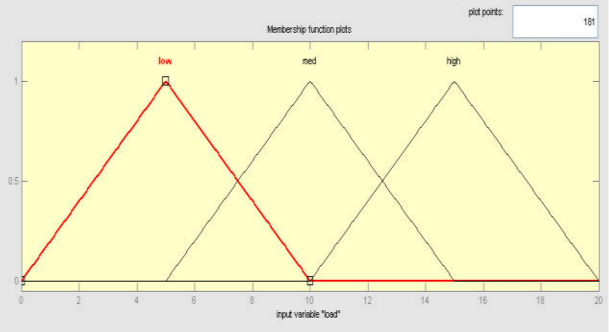


Figure 4

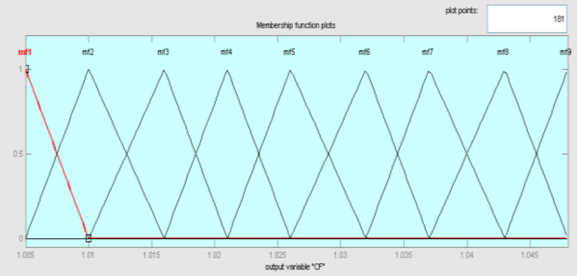


Figure 5

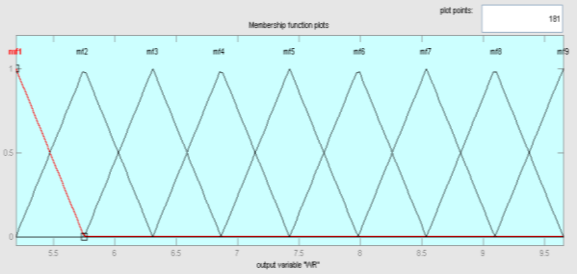
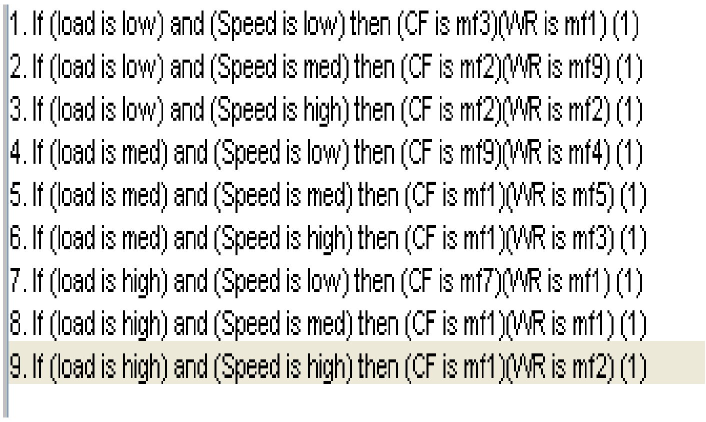


Figure 6



1. If (load is low) and (Speed is low) then (CF is mf3)(WR is mf1) (1)
2. If (load is low) and (Speed is med) then (CF is mf2)(WR is mf9) (1)
3. If (load is low) and (Speed is high) then (CF is mf2)(WR is mf2) (1)
4. If (load is med) and (Speed is low) then (CF is mf9)(WR is mf4) (1)
5. If (load is med) and (Speed is med) then (CF is mf1)(WR is mf5) (1)
6. If (load is med) and (Speed is high) then (CF is mf1)(WR is mf3) (1)
7. If (load is high) and (Speed is low) then (CF is mf7)(WR is mf1) (1)
8. If (load is high) and (Speed is med) then (CF is mf1)(WR is mf1) (1)
9. If (load is high) and (Speed is high) then (CF is mf1)(WR is mf2) (1)

Figure 7

IV. PREDICTION OF OUTPUT

With help of the module available in fuzzy logic toolbox outputs are predicted which is shown in figure 8. The predicted value is discussed in table 4 with values obtained by conformation experiment.

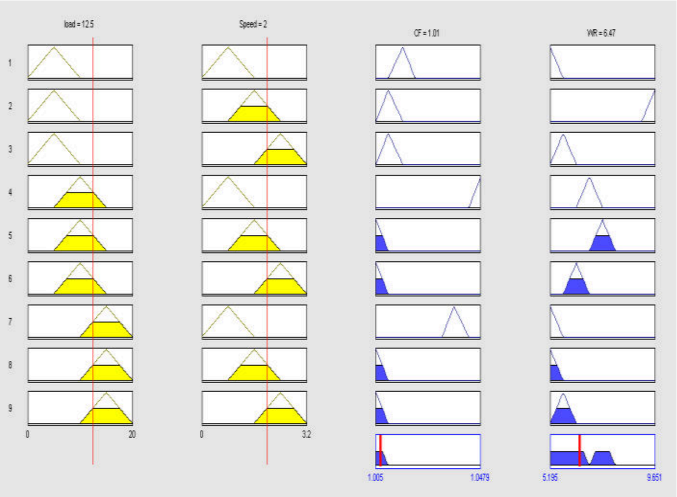


Figure 8

Table 4

Disc Speed (m/s)	Normal Load (N)	Predicted Coeff. Of Friction	Predicted Wear Rate	Coeff. Of Friction	Wear Rate
7.5	1.2	1.02	7.25	1.0213	7.2435
12.5	2	1.01	6.47	1.0098	6.4655

V. CONCLUSION

Based on the work performed, following conclusions are made:

- Fuzzy model is effective in predicting the wear if output and input values are in a defined range.
- Wear of magnesium is observed to be high and the values predicted for a range, using this method can be used for various requirements.

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