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Wear Rate Analysis and investigation of alternating material for Food Mixer Bushing

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Abstract - *Bearing contributes very essential part in an area of rotating machines. The plain bearing usually referred as bush used in many motor of home appliances subjected to different loading conditions and speeds. As result of this parameter bush or plain bearing subjected to wear, friction etc. This research or experimentation is to find out the better substitute for gunmetal bush used in food mixer application. Composites of different materials are considerably best in all aspects mechanical as well as tribological. As the wear rate is focused response parameter to reduce it the new proposed material is composite of brass and different percentages of MoS2.MoS2 gives the best anti wear properties to material.*

Key Words**: Wear, Gunmetal, Brass and composites.**

1.INTRODUCTION

As the gunmetal used in manufacturing area widely containing higher percentages of copper while studying the small application of gunmetal as a bush used in household mixer & grinder. Plain bearing is mostly refer as bush considering mostly used copper alloy for its good properties on the other hand large density and low mechanical strength are the drawbacks of copper alloy.

Friction and wear always occur at machine parts which having relative motion. This affects the efficiency of machines negatively Wear due to relative motion between components surfaces is one of the primary modes of failure for many engineered systems. Unfortunately, it is hard to exactly find component life due to wear as reported wear rates generally exhibit large scatter. An attempt has been made to study the influence of wear parameters like load, speed, type of lubricant used, temperature, and viscosity of lubricant. The main objective of the study is to evaluate the wear rate of different journal bearing materials.[1]

1.1 Wear

Wear is progressive loss or removal of material from one or both the surfaces in contact as the result of relative motion between them .Wear is the single most influencing factor which shortens the effective life of machine or its components. Wear can also be defined as a process where interaction between two surfaces or bounding faces of solids within the working environment results in dimensional loss of one solid, with or without any actual separating and loss of material. Aspects of the working environment which affect wear include loads and features such as unidirectional sliding, reciprocating, rolling, and impact loads, speed, temperature, but also different types of counter-bodies such as solid, liquid or gas and type of contact ranging between single phase or multiphase, in which the last multiphase may combine liquid with solid particles and gas bubbles.

1.2 Types of Wear

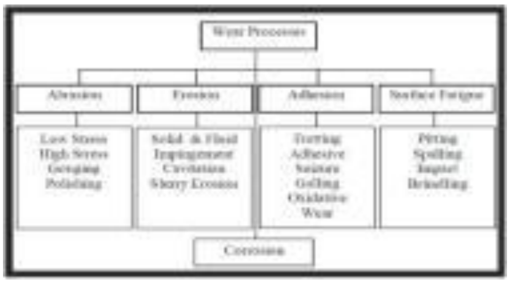


Fig -1: .Types of wear. [2]

As the household mixer is the equipment used in kitchen every day. The bush present in this mixer subjected to wear. In these paper going to focus on to invent a new composition with reduced wear rate. Finding out the another composition with lesser wear rate so existing gun metal material and proposed brass & molybdenum disulphide materials tribological characteristics to be studied.

PROBLEM STATEMENT:

Existing bush material is of gunmetal having lower mechanical strength and higher wear rate.

It is required to find out the alternative composition of material having lower wear rate than existing one for its efficient performance.

OBJECTIVE OF PROJECT:

1. To find out the alternative material for the same bearing to reduce wear rate.
2. Evaluation of wear rate for existing and proposed material of bush.

3. Design of experiment to optimize the process parameter.

2. METHODOLOGY

2.1 Determination of wear rate of existing material:

2.1.1 Existing material: Existing bush is of gunmetal also referred as red brass as it contains higher percentage of copper. To lower the wear rate brass is one of the best substitutes for gun metal with MoS2.

Fig-2: Existing bush of mixer

To investigate the wear rate of existing material pin on disc tribo meter is used. Existing material is of Gun metal. Pin of existing material withØ10×30mm.So the pin required for tribo tester are as shown in fig below

Fig3: Existing material pin

2.1.2 Experimental Setup

The materials are investigated in order to find the possible consequences of wear and friction under two conditions, i.e. dry and lubricated condition. The diameter and the length of the pins are 10 mm and 30 mm respectively. The wear rate will be relatively small in most of the machinery and engineering tool For wear measurement, we are using some apparatus and instruments which give results about the wear rate in the tools and machinery. Lubrication are subjected to avoid the excessive wear and friction when there is metal to metal contact present during the relative motion of moving parts in some engineering applications. In designing the wear and friction are the most important factors. Using pin-on-disc tribo-meter readings will be taken.

Fig -4: Pin- on- disc tribometer

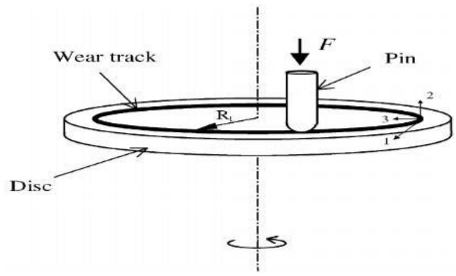


Fig-5:Pin and disc view.

2.2 Fabrication of proposed material:

2.2.1 Proposed Composite:

Brass&MoS2: Wear rate in brass considerably less as compared with white metal and the Molybdenum disulphide mixed with brass good option for wear resistance.

MoS2 with different % gives different results So it is suitable material for bearing.

Table 1: Sample preparation on %MoS2 basis.

Sample	Composition
1	Brass+2.5% MoS2
2	Brass+5 % MoS2
3	Brass+7.5% MoS2

2.2.2 Methods for fabrication of pin:

There are many methods for manufacturing pin but mainly two methods are going to consider in this paper. Methods for Sample preparation:

A) **Compacting by compressive strength testing machine(Powder metallurgy)**: Powder metallurgy is the process of blending fine powdered materials, compacting the same into a desired shape or form inside a mould followed by heating of the compacted powder in a known controlled atmospheric conditions, referred to as sintering to facilitate the formation of bonding of the powder particles to form the final part. Thus, the powder metallurgy process generally is of four basic steps, as follow (1) powder manufacture, (2) blending of powders, (3) compacting of powders in a mould or die, and (4) sintering. Compacting is mostly done at room temperature and at high pressure. Sintering is usually done at elevated temperature and at atmospheric pressure. Often, compacting and sintering are combined. Optional secondary processing often follows to obtain special properties or enhanced dimensional precision Mechanical components manufacturing by the powder metallurgy convenient for manufacturing components from a single or multiple materials (in powder form) with very best strength and high melting temperature. Powder metallurgy steps:

- Powder Production
- Blending or Mixing
- Compaction
- Sintering
- Finishing

The machine available for manufacturing of pin in PG section.

Fig6: Sintering machine.

Stir Casting: Stir casting is the method in which molten metal's, composites, additives are mixed by means of mechanical stirring.

3. Counterpart: Counterpart is of a lower to medium carbon steel. EN8 is to be selected as disc material on the basis of shaft requirement. The disc with dimensions Ø165 mm×8mm is brought from Tanmay Enterprises, Chakan MIDC, Pune.

2.2.3 Preparation of sample:
For making the sample the brass powder (CuZn30) brought from the PometonIndia pvt. Ltd. and Molybdenum disulphide (MoS2).

Fig7: Powder of Brass

Fig8: Powder of MoS2

2.2.4. Wear rate analysis of proposed material: The proposed composite pin for our experimentation will be manufactured by powder metallurgy technique which is used further for experimentation purpose. The main objective is to analyze the wear rate on pin on disc apparatus. All specifications of machines are same as mentioned in previous subtitle.

2.2.5 Taguchi method for DOE: In the design of experiment Taguchi method used because it is a problem solving tool which can improve the performance of the product, process design and system. Both analytical and experimental methods are combining in this method to determine the most influential parameter on the result response for the significant improvement in the overall performance. Design of experiment is a technique of defining and investigating all possible conditions involving multiple factors, parameters and variables in an experiment. It establishes the method for drawing inference from observation, when these observations are not exact, but subject to variations and also used to collect data. A three level L9 3 orthogonal array with nine experimental runs was selected. To observe the most influential process parameters in the preparation of composite namely [5]

(1) Load
(2) wt. % of MoS2
(3) RPM (Track radius) each at three levels were considered and are shown in table
As motioned in proceeding section all experimentation regarding to experimental aim are checked out on pin on disc tribometer. The values of Load, RPM and %MoS2 are our process parameters. In the process of DOE for the application of mixer the process parameters are load, RPM and % of MoS2.As load and RPM are as per the requirement of application. So to find out the optimum solution % MoS2 is the prime parameter.

Table 2: Process parameter and level

Sr.No	Process Parameter	Level 1	Level 2	Level 3
1	MoS2 (wt%),A	2.5	5.0	7.5
2	Load,B	6	42	2
3	Track dia,	20	50	80
	RPM,C	1680	672	420

In this research nine different composite were manufactured with different parameters and at different levels. The effect of these parameters on the response i.e. the wear rate of the composite was studied using Analysis of variance (ANOVA).

Degree Of Freedom (DOF) = number of levels -1 …… (1)
For each factor, DOF equal to:
For (A); DOF = 3-1=2
For (B); DOF = 3-1= 2
For (C); DOF = 3-1=2

The total degree of freedom is calculated as: Total DOF=No. of experiments -1 ……. (2)

The total DOF for the experiment is DOF= 9-1 = 8In the Tagauchi method the response variation were studied using signal-to-noise ratio and minimization the variations due to untrollable parameter. The S/N ratio was calculated for wear rate of the nine trial conditions to see the effect of each parameter on the response.

Table 3 : Mixer motor specification and capacity

Sr.No	Parameter	Description
1	Application	Food appliance
2	Power	1.5HP
3	Diameter of shaft	12mm
4	RPM	2800
5	Capacity	6 lit

3. TESTING OF EXISTING MATERIAL

Sliding Speed=V= (π* D * N) / 60

V = 1759.2mm/sec
So, for above sliding speed combination of different track diameter(D) and RPM to be selected

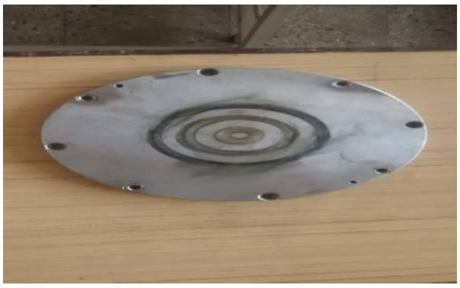


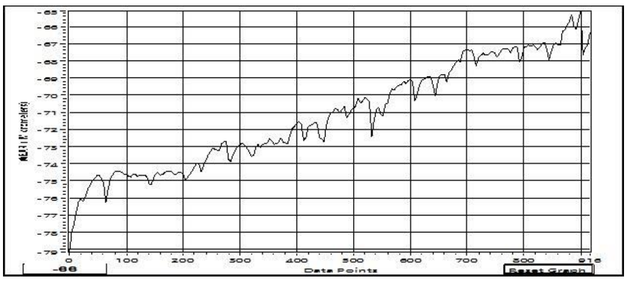
Fig9:Disc after testing.

The existing bush material is gunmetal existing gun metal wear rate evaluation is done on the pin on disc tribometer.at different loading conditions and at different track radius. These results are given below

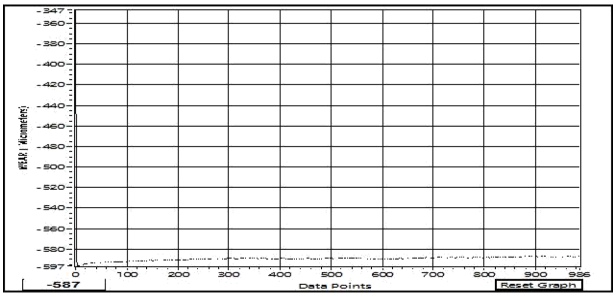
Table 4: Wear rate of existing gunmetal material

Sr.No	Normal load (N)	Track dia(mm)	RPM	Wear µm
1	6	20	1680	3
2	4	20	1680	6
3	2	20	1680	14
4	6	50	672	14
5	4	50	672	4
6	2	50	672	6
7	6	80	420	9
8	4	80	420	8
9	2	80	420	63

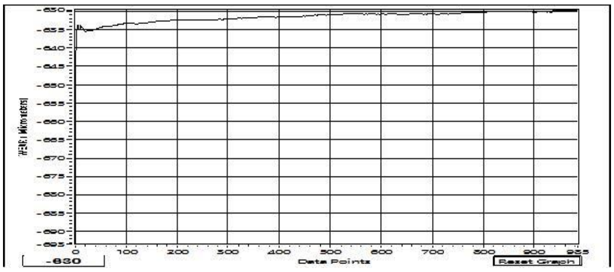
Wear rate of existing material checked at three different track diameter and at 2kg(19.62N).The graph of wear are as follow,



Graph1: Wear test at 2kg and 20mm Track diameter [Graph of existing gun metal bush material]



Graph 2: Wear test at 2kg and 50mm Track diameter [Graph of existing gun metal bush material]



Graph 3: Wear test at 2kg and 80mm Track diameter [Graph of existing gun metal bush material]

4.DESIGN OF EXPERIMENT

Design of Experiment is the powerful tool to study the effect of multiple variables simultaneously all designed experiments require a certain number of combinations of factors and levels be tested in order to observe the results of those test conditions. The experimental plan was formulated considering three parameters (variables) and three levels based on the Taguchi technique.

4.1 Taguchi Technique:

The Taguchi method was developed by Dr. Genichi Taguchi. He developed a method for designing experiments to investigate how different parameters affect the mean and variance of a process performance characteristic. The Taguchi approach to experimentation provides an orderly way to collect, analyze, and interpret data to satisfy the objectives of the study. By using these methods, in the design of experiment, one can obtain the maximum amount of information for the amount of experimentation used. This technique is a powerful tool for acquiring the data in a controlled way and to analyze the influence of process variable over some specific variable which is unknown function of these process variables. Using OA, the Taguchi method explores the entire design space through a small number of experiments in order to determine all of the parameter effects and several of the interactions. These data are then used to predict the optimum combination of the design parameters that will minimize the objective function and satisfy all the constraints. In addition to locating a near optimum objective function, the Taguchi method provides information on parameter trends and noise sensitivities thereby enabling a robust design. The parameter design phase of the Taguchi method generally includes the following steps: (1)identifying the objective of the experiment; (2)identifying the quality characteristic (performance measure) and its measurement systems; (3)identifying the factors that may influence the quality characteristic, their levels, and possible interactions; (4)select the appropriate OA and assign the factors at their levels to the OA; (5)conducting the test described by the trials in the OA; (6) analyzing the experimental data using the signal-to- noise **(S/N)** ratio, factor effects, and the analyzing variance (ANOVA) to see which factors are statistically significant and to and the optimum levels of factor. MoS_2 wt% (A), Normal Pressure (B) and Sliding Speed(C), these are process parameters are considered for the study. Process parameters setting with the highest S/N ratio always yield the optimum quality with minimum variance. The levels of these variables chosen for experimentation are given in To choose an orthogonal array the total number of degrees of freedom is to be chosen. For this experimental purpose L9 orthogonal array is chosen is shown in Table **7.** The selected of the orthogonal array is based on the condition that the degrees of freedom for the orthogonal array should be greater than, or equal to, the sum of the variables. The experiments were conducted based on the run order generated by Taguchi model and the results were obtained. This analysis includes the rank based on the delta statistics, which compares the relative value of the effects. S/N ratio is a response which consolidates repetitions and the effect of noise levels into one data point. The experimental results were transformed into signal-to-noise ratio (S/N) ratios. An S/N ratio is defined as the ratio of the mean of the signal to the standard deviation of the noise. The S/N ratio indicates the degree performance of a product or process in the presence of noise factors. There are three forms of S/N ratio that are of common interest for optimization of static problems:

1) Nominal the best(NTB):

$$SN_{NTB} = -10 \times \log_{10}(\bar{y}^2/s^2)$$

2) Smaller the better (STB) :

$$SN_{STB} = -10 \log_{10}((1/n)\sum_i^n y_i^2)$$

3) Larger the better (LTB) :

$$SN_{LTB} = -10 \log_{10}((1/n)\sum_i^n 1/y_i^2) .$$

Where n is the number of observations, yi is experimental result, and the y and s are the average and deviation of all observations in each combination, respectively. Taguchi method is using for optimization of process parameters for obtaining optimum tribological and mechanical properties. In this project work tribo-mechanical properties are wear rate, coefficient of friction and compressive strength. So from above S/N ratio coefficient of friction and compressive strength uses larger the better (LTB) S/N ratio and wear rate uses smaller the better (STB) S/N ratio.

Table 5: L9 Orthogonal Array[5]

Sr.No	A	B	C
1	2.5	6	20
2	2.5	4	50
3	2.5	2	80
4	5	6	20
5	5	4	50
6	5	2	80
7	7.5	6	20
8	7.5	4	50
9	7.5	2	80

4.2 Analysis of Variance (ANOVA):

The idea of the analysis of variance is to find out the significance of process parameters and also the percentage contributions of the factors and the interactions in affecting the response. Analysis o variance (ANOVA) was introduced by Sir Ronald Fisher. This analysis was carried out for a level of significance of 5%, i.e., for 95% level of confidence. In this research nine different composite were manufactured with different parameters and at different levels. The effect of these parameters on the response i.e. the hardness, impact and tensile strength of the composite were studied using Analysis of variance (ANOVA).

Degree Of Freedom (DOF) = number of levels -1
For each factor, DOF equal to:

For (A); DOF = 3-1=2
For (B); DOF = 3-1= 2
For (C); DOF = 3-1=2
The total degree of freedom is calculated as:
Total DOF=No. of experiments -1
The total DOF for the experiment is DOF= 9-1 = 8

4.3 Multiple Linear Regression Models:

Statistical software MINITAB R17 is used for developing a multiple linear regression equation. This developed model gives the relationship between independent/predictor variable and a response variable using by fitting a linear equation to the measured data.

5. CONCLUSION

Tests of existing material were taken at different loading as well as at different track diameter conditions.

Three graphs are taken in this paper shows the wear at 2kg loading conditions and at 20mm, 50mm, 80mm track diameter respectively. From the test it is observed that the wear rate depends on the loading condition. As the graph1 shows the absolute wear rate 14 micrometer and it is expected that further research composite of brass and MoS2 should give the less wear rate.

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