CHARACTERIZATION OF COPPER-TIN-ZINC (Cu-Sn-Zn) ALLOY

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Abstract

Requisite for advanced materials with high hardness, high tensile strength and improved wear properties has been drastically increased in recent times. The main work is to fabricate copper-Tin-zinc(Cu-Sn-Zn) alloy by powder metallurgy technique and to investigate its characteristics like Wear Test, microstructure. Abrasive wear characteristics of sintered bronze powder pre-forms were investigated in this thesis work. Sintered bronze powder pre-forms of one composition were tested, considering one compacting pressures and one sintering temperature. The wear tests were conducted using a purpose built pin-on-disc apparatus against silicon carbide abrasive paper under multi-pass conditions at room temperature. Abrasive wear studies were conducted under various testing conditions such as applied load, Constant sliding velocity, Time in seconds and abrasive grit number. The wear is measured by means of loss in weight. Relationships between the weight loss and the sliding velocity, weight loss and applied load, Specific wear rate and abrasive grit size were established.

Keywords: *Abrasive Wear, Compacting, sintering, Pin on Disc, Wear Rate, Tribo- graphs.*

1. Introduction

Copper-tin-zinc (Cu-Sn-Zn) alloy has attracted tremendous research interests due to its unique properties, including gorgeous color, high corrosion resistance , remarkable solder ability. Cu-Sn-Zn alloys have been fabricated by different methods, such as melting, powder metallurgy and electrodeposition. Among these methods, Powdermetallurgy is an effective method to fabricate Cu-Sn-Zn alloys because of its simple process and high environment adaptability. Powder metallurgy is the study of the manufacture process of products from metal powder with these following stages: characterization, mixing powders, compacting, until sintering (heating). Powder metallurgy (P/M) might be chosen as the preferred route for the manufacture of a product. In broad terms, these reasons separate into two categories: (i). Cost effectiveness, P/M is the most cost effective of a number of possible options for making the part and (ii). Uniqueness, some characteristic of the product (e.g. combination of chemical constituents, control over microstructure, control over porosity etc.) can be created by starting from a powder feedstock, which would be very difficult or sometimes impossible in conventional processing.

“Tribology” and “maintenance’ play an important role in upkeep of machinery for reliable and safe operation, thereby increasing the productivity. In the literature survey it was studied that about 70% of failures in mechanical components are due to tribological causes and, as a rough estimate, one third of world’s energy resources appear as friction in one form and wear in the other form and most of these result in waste. This shows the importance of tribological study and tribological treatments in industries resulting in considerable savings. Wear is related to interactions between surfaces and more specifically the removal and deformation of material on a surface as a result of mechanical action of the opposite surface.

2.0 Experimentation

2.1 Preparation of Specimens

Atomized powders like copper-Tin-zinc (Cu-Sn-Zn) were obtained from the Carborundum powder Company Ltd., Cochin, Kerala, India. Commercially available water proof silicon carbide (SiC) abrasive papers of different grit grades, such as 1/0, 2/0, 3/0 and 4/0 were selected as abrasion counter face. The samples were prepared by conventional powder metallurgy process. A die was designed as shown in figure 1(a,b) and fabricated to prepare solid cylindrical specimens of diameter 15.27 mm. Compacting was done using the hydraulic compression testing machine of capacity 200 tonnes at room temperature as shown in figure 2. Compacts were prepared with two different compacting pressures of 390 Mpa on the given mass of the powder. The green compacts were obtained as shown in figure 3. The green compacts were coated with alumina paste to prevent the oxidation of preforms during sintering. The pre-forms were sintered in a muffle furnace as shown in figure 4, to temperature of 600^0c and maintained at this temperature for more than an hour. Then the preforms were air cooled at room temperature. The diameters of the sintered preforms were reduced from 15.27 mm to 8 mm by turning operation.

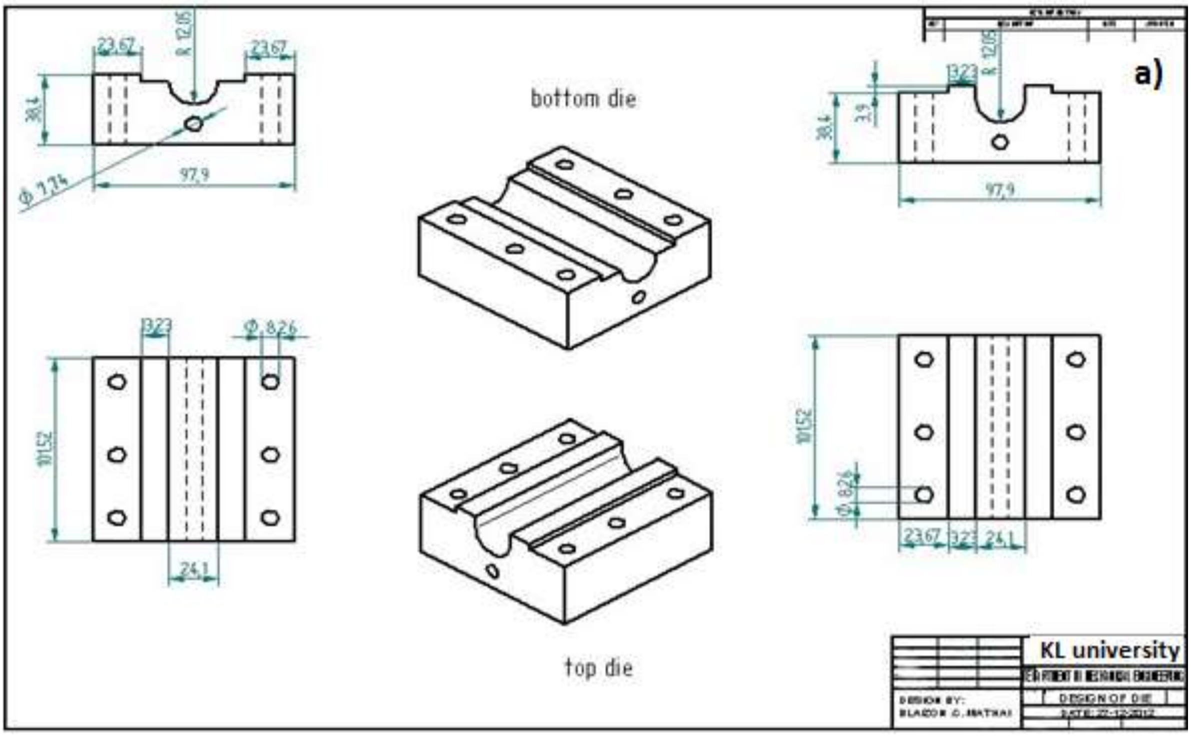

Figure 2.1: Schematic diagram of the split type Die used for compacting

Figure 2.2: Prepared Green compacts

Figure 2. 3: Compaction done at UTM machine

Figure 2.4: Sintered in muffle furnace

3.0 Abrasive Wear Test

Abrasive wear tests were conducted on a purpose built pin on disc apparatus at multipass condition. The photograph of the apparatus is shown in figure. 2.5. Abrasive paper was cut to the diameter of the disc and pasted over it. The pin was fixed in the holder at proper height to ensure uniform contact of its flat surface at the other end. This height was maintained constant for all the tests. The wear tests were carried out at various loads (0.5 kg to 3 kg) and different abrasive grit grades (1/0, 2/0, 3/0 and 4/0). The initial weight of the test pin was measured using a single pan digital balance of accuracy 0.1 milligram. At the end of each run, the specimen was removed, thoroughly cleaned of worn particles and reweighed. The difference in weight gives the weight loss. The wear was measured by this loss in weight, which was then converted to wear volume using density data [7].

Figure 3.1: Tribometer **Figure 3.2: Loads applied** **Figure 3.3: Trial Run**

3.4 Abrasive wear test- Specific wear rate, Wear volume, Sliding velocity calculations

The formulae used for the calculation of specific wear rate, wear volume and sliding velocity are given below,

- Specific wear rate = $\text{Wear volume}/_{L \times D}$ in mm^3/Nm

Where,

Wear volume = $\frac{\pi \times D2 \times l}{4}$ mm^3

L = applied load in N
D = diameter of specimen in m
l = height of the specimen in m

- Weight loss = initial weight – final weight

- Sliding velocity = πDN

Where,

D = diameter of the specimen in m
N = rated speed in rpm

4.0 RESULTS AND DISCUSSIONS

4.1 TRIBOGRAPHS

The results of Tribo-graphs lead to friction and wear data, generally referred to as tribo-data, which are system dependant characteristics presented in form of Tribo-graphs. Tribo-graphs are graphical representation of a measured friction of a measured friction or wear quantity as a function of

- Operational parameters, for example, load, speed, abrasive grit size, or compacting pressure.
- Structural parameters, for example material pairing, hardness, roughness, or microstructure.
- Interaction parameters, for example contact stresses, film thickness to roughness ratio, or lubrication modes.

The graphical representation of this thesis work is based on operational parameters.

Figure 4.2: Effect of load in weight loss when tested in abrasive grit paper 1/0

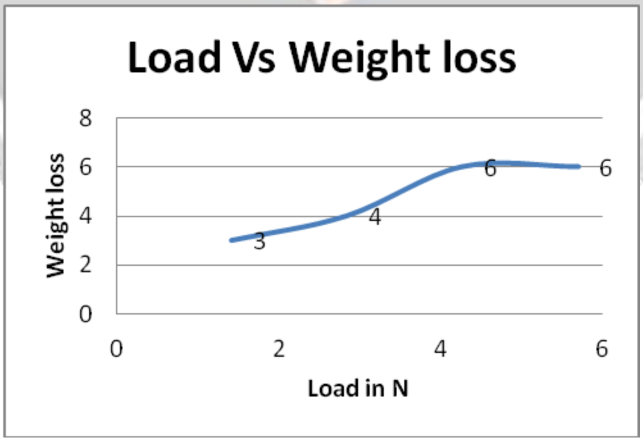

Figure 4.3: Effect of load in weight loss when tested in abrasive grit paper 2/0

Figure 4.4: Effect of load in weight loss when tested in abrasive grit paper 3/0

Figure 4.5: Effect of load in weight loss when tested in abrasive grit paper 4/0

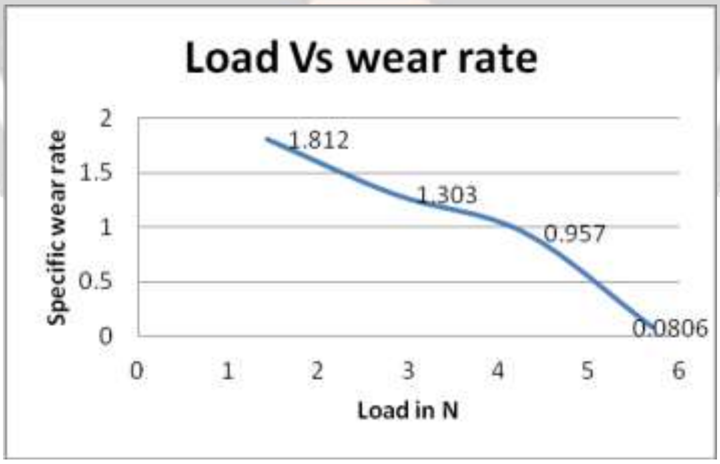

Figure 4.6: Effect of load in specific wear rate when tested in abrasive grit paper 3/0

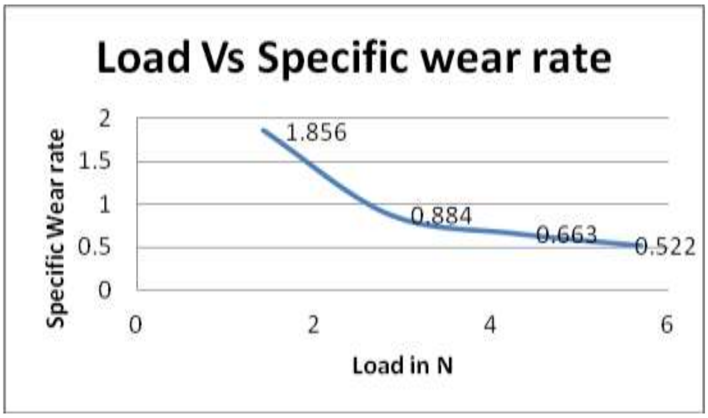

Figure 4.7: Effect of load in specific wear rate when tested in abrasive grit paper 4/0

- Figure 4.2, 4.3, 4.4, 4.5 shows the graph between weight loss and applied load for room temperature and compacting pressure. Different abrasive grit papers are used to obtain the deviations. A gradual increase in the weight loss is observed as the applied load is increased. By comparing the curves for different grit sizes its observed that maximum weight loss is for grit size for 1/0 and decreases as it comes down to 4/0
- Figure 4.6, 4.7 shows the graph between specific wear rate and abrasive grit size for constant temperature and compacting pressures. The applied loads were varied to obtain the deviations. A gradual decrease in the specific rate is observed as the abrasive grit size increases. By comparing the different curves it is observed that maximum specific wear rate is for 1.422N and decreases as the applied load increases.
- The compacting pressures are varied to obtain different curves. The weight loss initially decreases as the sliding velocity increases, reaches a critical value and then it increases.

5.0 SEM MICROGRAPHS

5.1 Microstructure

Microscopic examinations could satisfy many purposes and one of the key persistence of it in materials engineering is examining defects in materials. Defects in a material determine important properties and performing microstructure examinations helps to develop relations between the microstructure of the material and its properties. Defects and imperfections are crucial factors and there are many types of defects. The material defect this particular experiment will focus on is an area defect.

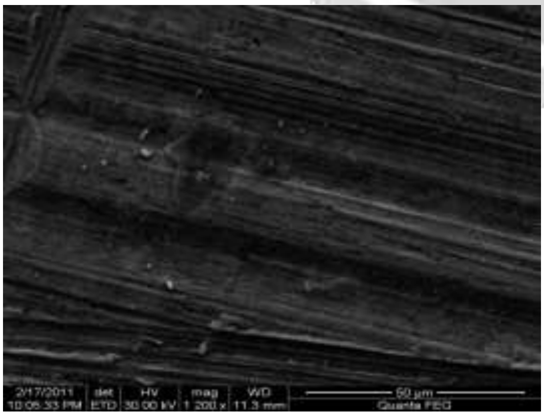

Figure 5.1: Load 1.422 – Grade 1/0

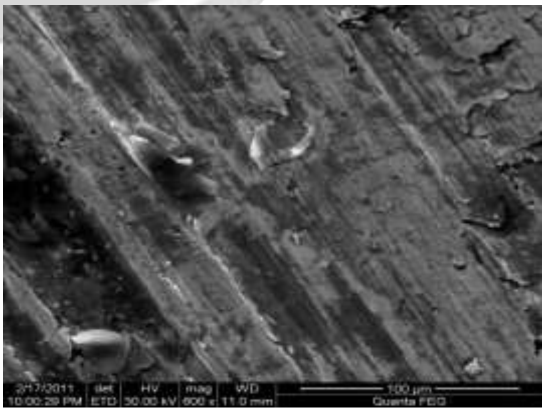

Figure 5.2: Load 5.698- Grade 1/0

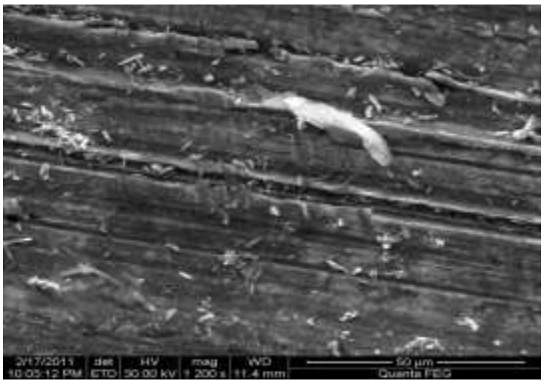

Figure 5.3: Load 5.698- Grade 2/0

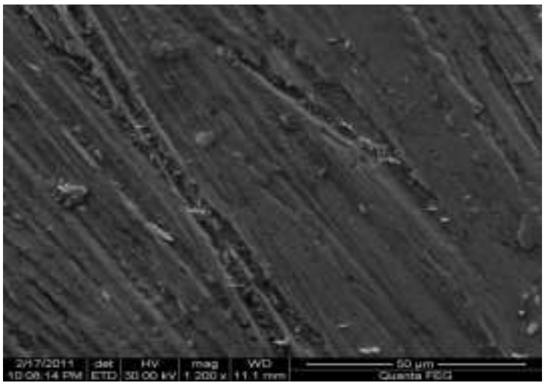

Figure 5.4: Load 5.698- Grade 3/0

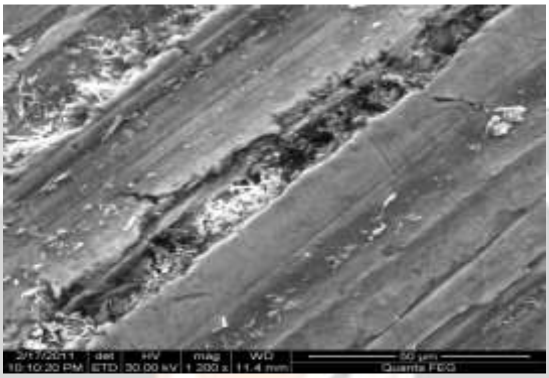

Figure 5.5: Load 5.698- Grade 4/0

- Figure 5.1, shows abrasion markings with parallel ploughings. Material spread out laterally during the sliding wear. Lipping was predominantly noticed. The depth of the plough markings reveal that considerable amount of material was removed during the sliding wear.
- Figure 5.2, the image was characterized with parallel ploughings. The plough marks were with relatively shallow than previous SEM fractograph. This concludes relatively lesser material was lost during the sliding wear. The plough marks were densely packed and minimal material was peeled off from the surface.
- Figure 5.3, characterized with bright features. The bright features can be probably oxides formed. They attribute the chance of three body abrasion. The plough marking was lesser in number due to the bright featured oxides. The material removal is minimal compared to the previous fractograph. The percentage of increasing zinc stearate attributes the lesser wear encountered during sliding wear.
- Figure 5.4, showed lesser material removal during sliding wear compared the previous image. The plough markings are non-parallel in schema. The plough markings were relatively less shallow than the previous SEM fractograph. The presence of cold welded particles was predominantly seen. And those particles caused hindrance to the abrasive wear of the fresh new surface.
- Figure 5.5, was characterized with most predominant amount of bright oxides. The oxide flakes were clearly seen. Lesser amount of material loss due to sliding wear was presented in the fractograph compared to the previous instances. The reason may be attributed to the increased amount of zinc stearate which acted as oxide forming agent which in turn formed a protective layer further excluding the chance of material loss
  during sling wear.

6.0 CONCLUSION

From the tribo graphs reported,

1. It was found when the applied load increases weight loss increases.
2. The wear is directly proportional to applied load on the specimen.
3. Weight loss is also directly proportional to wear.
4. When the abrasive grit size increases the specific wear rate decreases.
5. It is noted that the abrasive grit size is inversely proportional to wear rate.
6. The weight loss initially decreases with increase in sliding velocity, reaches an optimum value and then increases.

7.0 References

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