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Research Article

To Study the Effect of Heat Treatment on Wear Properties of Cu-10%wt.Zn

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Abstract

Cu-Zn alloys in particular find wide application in architecture, electrical, mechanical, marine and plumbing equipment. We aim to study effect of heat treatment on the wear resistance of Cu-10% wt Zn alloy. The literature review which we have studied has given us an insight into various wear mechanisms, but it did not give any direct mathematical relation between grain size and wear or the effect of heat treatment on wear. Although there is Archard's law, but it is for specific material and operating conditions. After sample preparation through casting, we have characterized our four samples using pin-on-disc test and the effect of heat treatment on our alloy Cu-10%wt Zn was studied.

Experimental Work

Casting of Brass

Equipment

The constituents of the alloy, i.e., Cu and Zn were melted in a muffle furnace. The furnace we used could reach temperatures up to 1500°C.

Steps for Alloy Making

To carry out the wear tests on Cu-10%wt.Zn alloy, the alloy was made by casting by choosing appropriate parameters and the weight of copper and zinc. The melting was done in a muffle furnace. The method followed for casting process is explained below:

Copper weighing 540 g was kept in a crucible and then kept in the programmable muffle furnace. The temperature of the programmable muffle furnace was then made to reach 1100°C. The copper was melted and then 60 g of zinc was added and stirred with an iron rod to obtain a homogenous copper-zinc alloy. The mixture was then allowed to heat for further 30 min to ensure mixing and formation of alloy of required composition. The crucible was then taken out of the furnace and the oxide layer was removed. After removal of oxide layer, the alloy was then poured inside the die cast and was allowed to cool.

Heat Treatment

Equipment

For the heat treatment processes, muffle furnace was used to carry out the processes.

Metal Weight

Copper 540 g and Zinc 60 g.

Procedure for Heat Treatment

The samples of brass casted were heat treated to obtain different grain structure, so the effect of heat treatment on wear could be studied. The heat treatments chosen were annealing, normalizing and quenching. The four samples and their conditions are shown in Fig. 1.

Annealing 30 min 460°C, Quenching 30 min 460°C, no heat treatment 30 min 460°C, normalizing 30 min 460°C. The temperature chosen was 460°C because above it the danger of oxidation was there and, therefore, it would lead to loss of material (Table 1.)

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Figure 1.Type of Heat Treatment Time Temperature (Celsius)

Annealing

The sample was heated to 460°C in the muffle furnace for 30 min. Then it was allowed to cool inside the furnace for slow cooling.

Quenching

The sample was heated to 460°C in the muffle furnace and then allowed to stay at that temperature for 30 min. The sample was then taken out and quenched in water for rapid cooling.

Normalizing

The sample was heated to 460°C in the furnace for 30 min. The sample was then allowed to cool in air at room temperature for gradual cooling.

Microstructural Characterization

Equipment

The microscope used was an inverted metallurgical microscope. The eye piece lens was of 10× magnification and the objective lens was of varying magnifications. Images of magnification1000× can be obtained.

Steps for Microscopy

Sample Preparation

The specimens were firstly smoothened using emery paper of varying mesh sizes on a polishing machine (Fig. 2: Polishing Machine). Since brass is a soft alloy, the mesh was varied from 400–1000 (Fig. 3: Sample after grinding). After grinding, the samples were polished on velvet paper using brasso. The specimens were then etched to see the microstructure. The etchant used was 40% Nital (40 ml of nitric acid and 60 ml of distilled water).

Microstructural Analysis

The etched samples were observed under microscope at magnification of 100× and grain boundaries of the heat treated samples and sample without heat treatment were observed.

Figure 2.Normalised Sample

Figure 3.Sample after Grinding

Table 1

Type of Heat Treatment	Time	Temperature (Degree Celsius)
Annealing	30 min	460
Quenching	30 min	460
No Heat Treatment	30 min	460
Normalizing	30 min	460

Wear Testing

Equipment

The equipment used for pin-on-disc wear test is shown in the Fig. In this test, we can vary the rotating speed and the applied load on our specimen. The load applied, the rotating speed, and the time for which the load is applied determine the amount of material removal from the specimen. The load presses specimen against the rotating disc due to which wear of the surface in contact with the rotating disc takes place.

Steps for Pin-on-Disc Test

After microscopy, the samples were subjected to pin-on-disc wear testing. The initial weight of the samples was recorded. The pin was held against the rotating disc. Pin in contact with the rotating disc. Set the load to 2 kg and speed of the disc to 300 rpm. The test started and the wear was continued for approximately 30 min. After the test, the final weight of the sample was recorded. The difference between the initial and final weight was noted.

Initial Weights of the Specimens

Sample initial weight (gram) quenched 20.547 annealed 25.921 no heat treatment 21.565 normalizing 21.467. Parameters chosen for pin-on-disc test speed 300 rpm load 2 kg time 30 min.

Table 2.Initial Weights of the Specimens

Sample	Initial Weight (gram)
Quenched	20.547
Annealed	25.921
No Heat Treatment	21.565
Normalizing	21.467

Table 3. Parameters Pin-on-Disc Test

Speed	300 rpm
Load	2 kg
Time	30 min

Results and Discussion

The first casting experiment failed since there was leakage in the furnace we used, due to which the copper got oxidized as shown in the Fig 4. The gray region shows the copper oxide layer and below the layer is copper. The cast obtained from second casting is shown in the Fig. 5. Although there were some pores in the cast, the cast was acceptable for further experiments.

Figure 4.Copper Rod Oxidized

Figure 5.Cu-10%wt.Zn Alloy

Microscopy

The following are the micrographs, which were obtained for different specimens. It is observed that the quenched sample has fine grains, i.e., the lowest grain size and the annealed sample has coarse grains, i.e., the largest grain size. The grain size of the normalized and annealed sample is almost similar. The fine grain size of the quenched material can be attributed to the fact that in quenching the cooling was very rapid and the grains did not have enough energy to grow and hence it resulted in hardening of the material. Annealing leads to the softening of the material because the cooling takes place slowly and, therefore, grains have enough time to grow and become large.

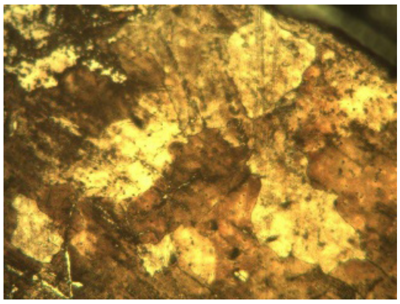


Figure 6.Annealed Sample at 100x

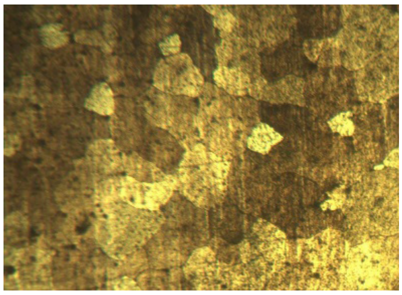


Figure 7.Normalised Sample at 100x

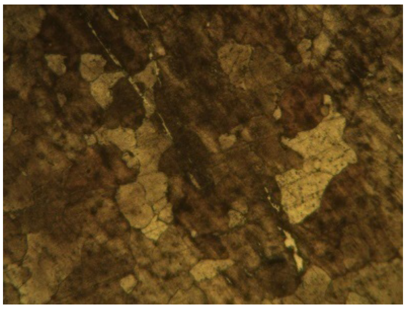


Figure 8.Quenched Sample at 100× (Fine Grains)

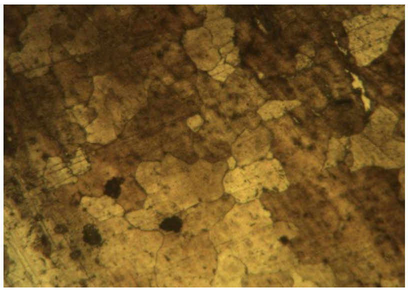


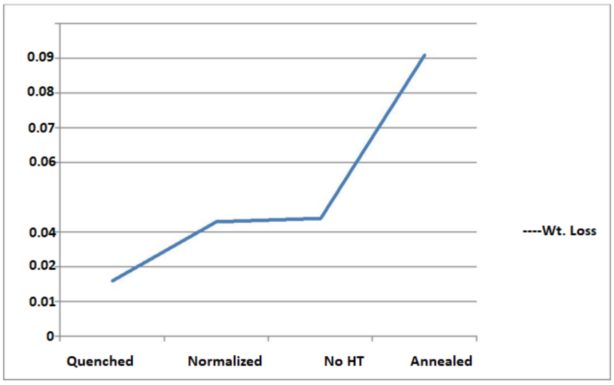
Figure 9.No Heat Treatment Specimen at 100×

Wear Testing

Table 4 shows the results of the wear test.

Table 4.Difference between Weights of the Sample before and after Wear Test and These Results are Plotted as Shown in Fig

Sample	Initial Weight (gram)	Final Weight (gram)	Initial Final - al Weight
Quenched	20.547	20.531	0.016
Normalized	25.921	25.888	0.033
No heat treatment	21.565	21.531	0.034
Annealed	21.467	21.458	0.081



The wear results show that the least worn out sample is quenched. This can be attributed to the fact that the quenching makes the material harder. The fine grains lead to less wear in the quenched sample. Annealing leads to softening of the material and, therefore, the wear in the annealed sample is relatively higher. Also, we observed that weight loss in the normalized and sample with no hear treatment sample is almost the same. It can be inferred that normalizing at 460°C has a very little effect on the grain size of the sample.

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