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WEAR BEHAVIOUR OF CuZn34Al2 BRASS MATERIAL

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Abstract

In this study, the wear behaviour of special brass CuZn34Al2 produced through two different methods (centrifugal cast and green mould cast) was investigated. The wear tests were carried out using a pin-on-disc type apparatus, at a linear sliding speed of 0.2 and 0.3 ms^{-1}, under the loads of 10 N, 20 N, 30N and 40 N and sliding distance of 600 m, in ambient air at room temperature, dry sliding conditions. Pearlitic ductile iron disc was used as counter abrader. A correlation between hardness and wear rate was established for the investigated the centrifugal cast and the green mould cast brass specimens. The wear rate of sample produced by green cast method was found to be high especially at 0.3 ms^{-1} sliding speed and under 40N load. However, the wear rates of the other green cast samples tested at other parameters were found slightly lower.

Key Words: Wear, Brass, Centrifugal Cast Method, Pearlitic Ductile Iron Disc.

1. Introduction

Brass is a material widely used in friction parts of machines, as bearing liners, bushing, etc. Properties such as high strength and ductility, fatigue strength, wear resistance are necessary for this material, and it is important to understand microstructural changes during its service life [1-3]. For many applications, brass is usually the first choice of materials for home equipments, electrical and all precision engineering industries [4].

In the automobile industry, particularly in the manufacturing of components, where resistance to wear is the chief requirement, high-strength brasses are commonly used. High-strength brasses are suitable mainly for engineering areas where high strength to support heavy loads and/or high resistance to wear and corrosion are required. The main advantages of high-strength brasses are further improvement of mechanical properties by heat treatment as well as their low cost [5–7].

Brass alloys having a higher Zn content contain both α and β phases at room temperature. The β phase has an ordered bcc crystal structure and is harder and stronger than α phase; consequently, $\alpha+\beta$ alloys are generally hot worked [4]. High-strength brasses can be mainly classified as $\alpha+\beta$ or β brasses, containing the alloying elements such as aluminium, silicon, iron, manganese, and tin [7]. Aluminium increases the corrosion resistance of brasses by forming a protective Al_2O_3 oxide film on their surfaces. Iron is virtually insoluble in the α and β phases and is only present in the form of silicides. Iron particles increase the formation rate of nucleation and recrystallization centres and retard the following grain growth. Silicon increases the corrosion resistance, wear resistance (due to silicide formation), and workability of brasses. Manganese increases the ultimate tensile strength, ductility, and wear resistance of the brasses. Nickel decreases the tendency of the brasses to corrosion cracking. Lead is particular alloying element, since it precipitates along boundaries as low-melting-temperature layer and results in the hot-shortness of the brasses.

Brass is widely used for production of bearing materials in industrial service. The heads of rolls made of ductile iron used in rolling mills rotate in brass bearing. A thorough review has been made of previous work concerning the parameters on the wear characteristics of extruded brass against steel disc used as counter abrader [2, 3, 6-9]. Most of the investigations were concerned with the identification of a change in the

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resulting heat treatment, environments and composition [6-9]. There is little published work concerning the effects of the casting parameters on wear characteristics [6]. Also, most of the previous work was carried out against steel disc as counter abrader materials [1-9,11-13]. However, adequate information is not available on the brass materials produced by centrifugal cast and green mould cast methods. Similarly, adequate work is not available for pearlitic ductile iron disc materials.

The aim of this study is to establish relationship between wear parameters and material properties of special brasses which were produced through centrifugal cast and green mould cast methods were examined.

2. Materials and Method

2.1 Material production

Copper alloy was melted in a graphite crucible using a crucible furnace. The molten alloys were poured from temperatures approximately 50 ^{o}C above their liquidus temperature, into green sand mould and centrifugal casting moulds were pre-heated to 250 ^{o}C. Molten copper alloys were poured into a horizontal centrifugal casting machine rotating at 1000 rpm. The outer diameter of the cylindrical casting was 120 mm, the wall thickness was 15 mm, and the length of the casting was 900 mm. The chemical composition of materials is given in Table 1.

For optical microscopy examination, standard metallographic procedure was applied to the samples (grinding, polishing and etching in a solution of 1 g $FeCl_3$ and 20 ml HCl in 100 ml water). In the present work, optical examination of samples was carried out using a Nikon DIC optical microscope. The grain size measurements were also carried out using MSQ Plus 6.5 type Image analyser.
the telecommunications rooms need to be covered with a component having electrostatic characteristic. When this system is used,
the gaps between ferroconcrete and ground become suitable for all kinds of installation transition. Thus, many difficulties which architects have experienced up to now disappear and their designs get flexibility.

The raised floor system is formed with the placement of the panels on the legs, the height of which can be adjusted. The legs can be raised easily in the case of demand, and they can be changed according to the properties of the usage area on the panels. The general sizes of the panels are 60 × 60 cm. The raised floor system transfers the weight to the infrastructure via the legs. If the thickness, the under-cover coating, and legs of the panel are chosen by the propeties of the weight on the system, the panels can be used easily in all of the offices. Thanks to this system, all kinds of gaps on the undercoating can be covered aesthetically, contemporarily, and fast without looking at the size of the place.

Application areas where the raised floor systems are mostly preferred are: general offices, meeting/ concert halls, training hails, administration buildings and corridors, computer rooms, telecommunications rooms, web-design offices, cafeterias, bathrooms and lavatories, storage areas, lobbies and reception areas, offices doing business of printing out and printing.

The raised floors were actually developed for the places which host computers were put in. However, nowadays there is an ever-increasing area of usage in the buildings which both are hoped to be restored, and have just been finished to be built. Although the raised floor system with modular panels has high launching cost, it is preferred for the flexibility and advantages it provides for the later changes. Thus, 'Conformity to Change', which is an important factor for the modern office environments can be provided easily with the raised floor systems. The raised floor system consists of the materials which are explained below shortly:

Table 1. Composition of the alloy (% Weight)

Cu	Zn	Al	Fe	Pb	Mn	Sn	Si	Ni	Sb
62.95	31.72	2.55	0.64	0.96	0.31	0.49	0.26	0.07	0.064

Hardness measurement was also carried out on the samples under the load of 5kg with a Vickers indenter. Centrifugally cast samples and green sand mould cast samples have the hardness of 175 and 205 HV5, respectively. Microhardness measurement was also carried out under 200 g load with a Vickers indenter. For each samples, ten hardness measurements were carried out.

2.2 Wear Tests

Dry sliding wear tests were performed using a pin-on-disc type wear apparatus [10]. The test materials in the form of pins of 6,25 mm in diameter and 50 mm in length were made to slide against a as-cast pearlitic ductile iron (%C 3.2,%Si 2.8,%Mn 0.27,%P 0.023,%S 0.017, %Mg 0.04) disc of hardness 220 HB and 90 mm in diameter. The disc was ground to a surface finish of approximately 0.15 μm (CLA). The wear tests were carried out at two different sliding speeds of 0.2 m s^{-1} and 0.3m s^{-1} under the loads of 10 N, 20 N, 30N and 40 N and sliding distance of 600 m, in ambient air at room temperature under dry sliding conditions. Prior to testing, test samples were ground against 800 grit SiC paper, and then cleaned in acetone, dried and then weighed using an electronic balance having an accuracy of 0.1 mg. The samples were then placed to the wear apparatus and the sliding wear tests were carried out at different sliding speeds and loads. After each test, the specimen was removed, ultrasonically cleaned in acetone and weighed with a balance to an accuracy of 0.1 mg. The wear rate of the pins is defined as the weight loss, W, divided by the applied load, N
K=W/N,
Where K has the units of weight loss unit load (g/N)

3. Result and Discussion

3.1 Microstructure

Figure 1 shows the microstructures of the brass produced by green sand mould cast and centrifugal cast methods. It can be seen that dendritic grains of green sand cast samples are larger than those of the centrifugal cast samples. Actually, the rate at which a casting cools affects its microstructure, quality, and properties. The structure of green sand casting process, often large with thick walls, may be the result of slow cooling. This increases the grain size and leads to a coarse microstructure (Fig. 1(a)). Coarse grains can allow elements of an alloy to separate, which also weakens the casting. Conversely, centrifugally cast parts (metal mould) generally cool more quickly and results in microstructure with smaller grains (Fig. (b)) having less alloy segregation. Microscopic examinations revealed that light coloured needle shaped α-phase precipitated in dark coloured β-phase matrix in the microstructures. Also, there are grey coloured areas in the microstructure. Some researches [5,6] reported that Mn_5Si_3 intermetallics in microstructure are grey in colour.

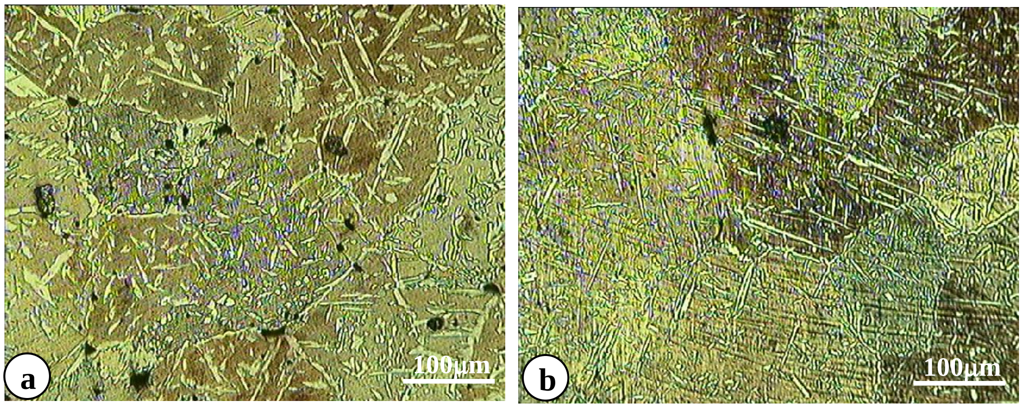


Figure 1. Microstructure of the specimens (a) green mould cast (b) centrifugally cast

3.2 Wear Behaviour

Fig. 2 shows the effect of applied load on the wear rate in the load ranges of 10–40 N and at 0.2 m/s and 0.3 m/s sliding speeds. At the sliding speed of 0.2 m/s, wear rate of the green mould cast sample increases with increasing applied load up to 20 N. However, beyond 20 N, the wear rate of s sample decreases. While wear rate of centrifugally cast sample decreases with increasing applied load as shown in Fig. 2 (a). At the sliding speed of 0.3 m/s, wear rate of the green mould cast sample decrease with increasing applied load up to 30 N. However, under 40 N applied load, wear rate of sample increases significantly. While wear rate of the centrifugally cast sample decreases with increasing applied load in Fig. 2(b). At the both sliding speeds, centrifugally cast samples shows lower wear rate than green mould cast samples under the load range of 10–40 N (Fig. 2 (a) and (b)).

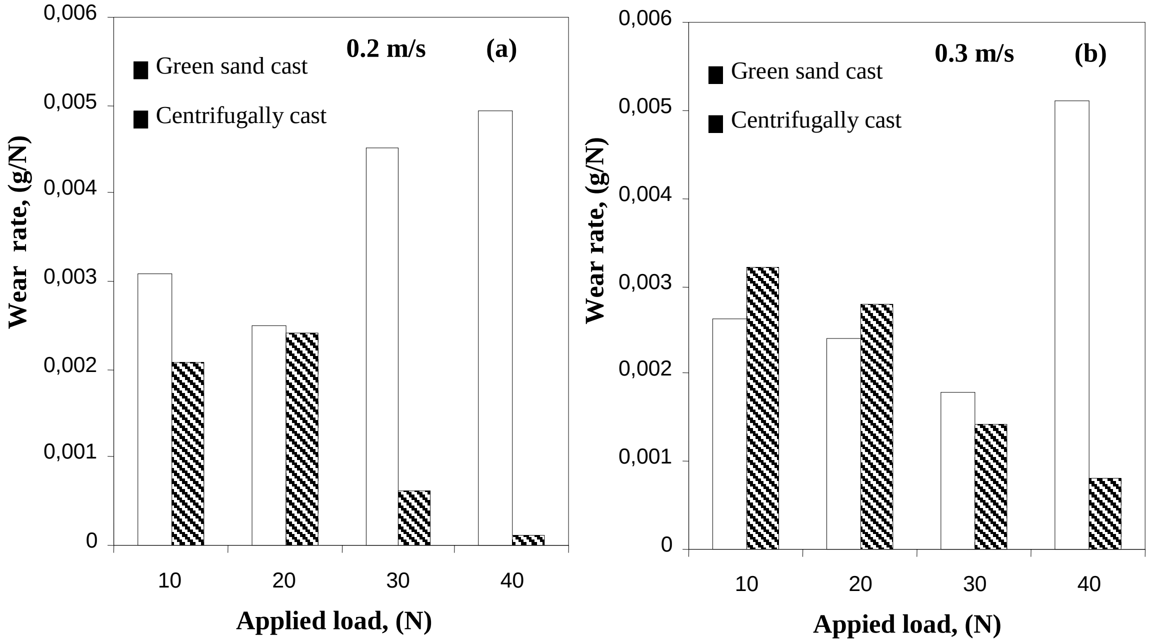


Figure 2**.**Variation of the wear rate of the samples under various applied load at the sliding speeds of (a) $0.2ms^{-1}$ (b) $0.3\ ms^{-1}$)

The curves in Fig. 3 show the wear rate as a function of hardness for the centrifugally cast and green mould cast samples. The centrifugally cast samples, which are harder than the green mould cast samples, show lower wear rates. Wear rate-hardness relationship in Fig. 3 exhibits that wear rate under 30 and 40N loads and at 0.2 m/s sliding speed abruptly decreases with the increase in hardness from 175 to 205 HV5. Under 10 and 20N loads, the wear rate decreasess with increasing hardness (Fig. 3(a)). Wear rate at $0.3\ ms^{-1}$ sliding speed and under 30 and 40N loads decreases with the increase in hardness from 175 to 205 HV5, while at the 10 and 20N loads, the wear rate increases with increasing hardness (Fig. 3(b)). Moreover, the effect of applied load on wear rate becomes more prevailing at higher loads. In general, the weight loss of the pin materials increases linearly with increasing sliding distance and applied load. Since wear rate is the ratio of wear volume to sliding distance in a certain wear condition, wear rate decreased with increasing sliding distance, although weight loss increased with increasing sliding distance.

Feyzullahoglu et al. [11] observed that for WM-2, WM-5 and CW619 brasses, weight loss increases linearly up to a certain sliding distance attains a maximum value for 115N applied load, but with further increase in sliding distance weight loss has a decreasing trend. The centrifugally cast brass is harder than the green mould cast brass and for that reason, wear rate of the centrifugally cast brass is lower than that of green mould cast brass (Fig. 3 (a) and (b)). Wear of brass material depends on hardness of the alloy, α ve β phases present in microstructures and the alloying elements present in Al and Mn [6,7]. Previous studies also report the reduction in wear rate with increasing materials hardness.

Wear of materials is, to a certain extent, directly connected with hardness and matrix structure [12,13]. Harder materials have comparatively low wear rate, and the results presented here are consistent with this fact.

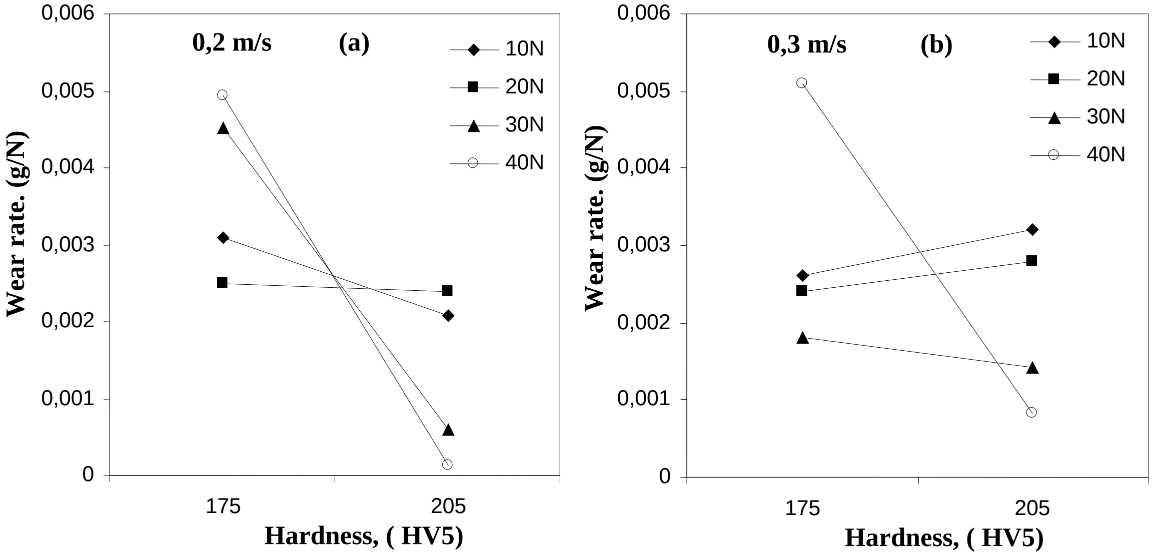
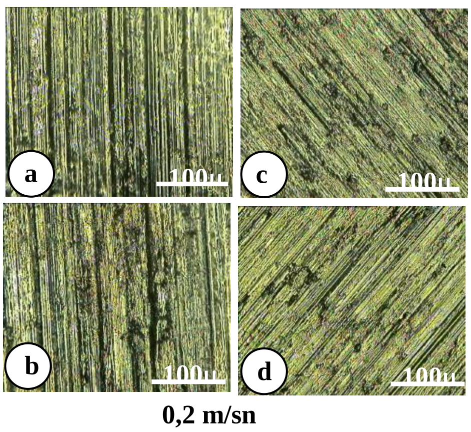


Figure 3. The effect of hardness on the wear rate of the samples depending on applied load at sliding speeds of (a) 0.2 ms^{-1} (b) 0.3 ms^{-1}.

Worn surfaces of the samples are shown in Figs. 4 and 5 for the sliding speeds of 0.2 m s^{-1} and 0.3 m s^{-1}, respectively. Visual examination of the worn surfaces indicates that wear tests lead to rough surfaces. This is also evident in Figs. 4 and 5 with wide and deep grooves. During the wear tests, wear is progressed by ploughing action of the pearlitic ductile iron disc by forming grooves in the wear tracks aligned paralel to the sliding directions. This indicates the abrasive wear mechanism. In some regions of wear tracks, microcracks perpendicular to the sliding direction are also observed. These results are in good agreement with the result of Çetin [14], who studied dry sliding wear behaviour of a CuZn34Al2 alloy against a as-cast ferritic ductile iron disc.

The green mould cast samples show wider and deeper grooves under 40N applied load. However, the grooves of the centrifugally cast samples are not as wide and deep as those of the green mould cast samples under the same load. These can be seen clearly from Fig. 4(a,b) and Fig. 5(a,b). Delamination was also observed on the samples worn at 0.2 m s^{-1} and 0.3 m s^{-1} and under 40N applied load, (Fig. 4 (a) and Fig 5 (b)). Wear surfaces of centrifugally cast samples (Fig.4(c,d) and Fig. 5(c,d)) are smoother than those of green mould cast samples. With increasing applied load from 10 N to 40 N, wear surface of the samples formed shows deeper grooves and local detachment of the pin material as seen in Fig. 4 (d) and Fig. 5 (d). As a result, increasing applied load increased the deformation for the both materials (Fig. 4 and Fig 5).



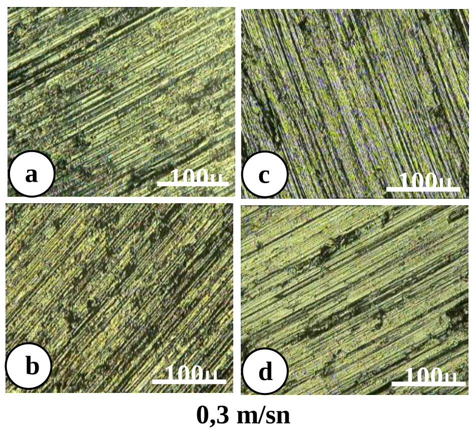


Figure 4. at 0.2 m s^{-1} and

Figure 5. at a linear sliding speed of 0.3ms^{-1},

Photograph of the surfaces of the samples worn on Pearlitic ductile iron disc green mould cast (a) 10 N (b) 40N and centrifugally cast (c) 10N (d) 40N)

Microhardness measurements were performed on polished cross-sections. The curves in Fig. 6 show the hardness as a function of depth beneath the worn surface for the centrifugally cast and green mould cast samples at the sliding speeds of 0.2 m s^{-1} and 0.3 m s^{-1} and under 40N applied load. The hardness values towards the surface are quite high. As the distance from the surface increases up to 150 m, the hardness decreases sharply. After this distance, the hardness almost remain the same.

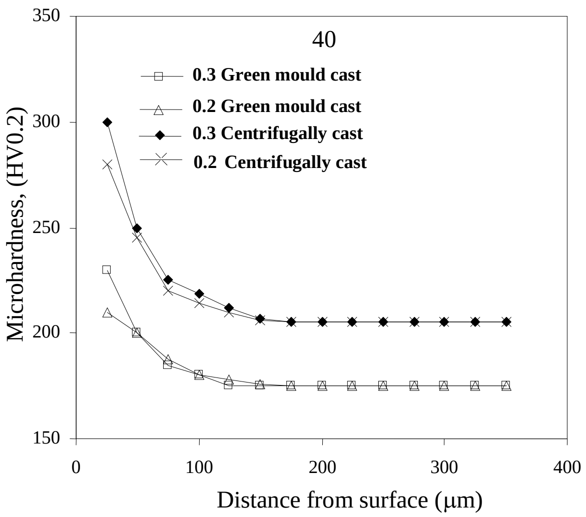


Figure 6. Microhardness as function of depth below the wear surface for the samples tested at the sliding speeds of 0.2 m s^{-1} and 0.3 m s^{-1} and under 40N load

4. Conclusion

In this study, room temperature dry sliding wear behaviour of brass produced through centrifugally cast and green mould cast method were investigated by pin on disc wear tests. The following conclusions can be drawn from this study:

i) The microstructure of the centrifugally cast brass have finer grains than the green mould cast brass. Decreasing grain size leads to increase in hardness.
ii) The hardness of centrifugally cast sample is higher than that of green mould cast sample.
iii) The wear rate of centrifugally cast sample was found to be less than that of the green mould cast sample under the same tribological conditions.
iv) At the sliding speed of 0.2 m/s, wear rate of the green mould cast sample increased with increasing applied load while wear rate of centrifugally cast sample decreased with increasing applied load
v) At the sliding speed of 0.3 m/s, wear rate of the green mould cast sample decreased with increasing applied load up to 30 N. However, further increase beyond 30 N, increased wear rate considerably. On the other hand, wear rate of the centrifugally cast sample decreased with increasing applied load.
vi) The experimental results show that the wear rate and hardness values of the centrifugally cast brass was found to be better than those of the green mould cast brass.

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