International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 03, March-2021

Effect of Process Parameters on Temperature of Al Alloy

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Abstract: **In recent years Cast Al-alloys has been expanding widely in aeronautical, automobile and general industries. The wear characteristics of these alloys depend upon the material morphology such as composition, size, shape and distribution of micro constituents and service conditions such as load, contact surface, contact time and sliding speed. The influence of variables viz: contact time, sliding speed, and normal pressure on wear behaviour were studied. With the increase of contact time the corresponding frictional temperature rises steadily due to the increased conversion of frictional energy into heat energy and no influence of sliding speed on the temperature rise in the specimen. The temperature rise in all the specimens increases with increasing of normal pressure on the specimens.**

Keywords: Ttribology, Al-Si-Mg-Fe alloy, Temperature, sliding speed, Normal pressure

1 INTRODUCTION

Aluminium alloys are attractive alternatives to ferrous materials for tribological applications due to their low density and high thermal conductivity.However, their uses hae been limited by their inferior strength, rigidity and wear resistance[1]. The wear of components made of Al-Si-Mg-Fe alloys depend on number of material related parameters. The use of aluminium alloys in industry is increasing owing to their high strength/density ratios and other advantage properties.In particular, the effect of alloy composition on work hardening behaviour has been investigated. This alloy showed the great initial hardness and the most surface hadening at all loads. The A3004, being the softest alloy, exhibited the most aubstantial reduction in specific wear rate with load, being the highest at 23N of all alloys by some margin, but similar to the other materials at 140N[3]. The commercially important alloys contain copper as major addition and the phase reactions, which occur are thosebetween an aluminium solid solution and the intermetallic phases CuAl2 and CuMgAl2 [4,5].AA6061 Al alloy another commercial alloy has a few Cu. The best wear resistance of 6061 Al alloy could be attributed to the highest hardeness and lowest coefficient of friction[6]. In this study, evaluation of wear characteristics of Al-Si-Mg-Fe alloys that was aged at different temperatures on pin-on disc under dry sliding system.

2. MATERIAL AND EXPERIMENTAL STUDY

The llowing raw materials were used to evaluate the wear and machining characteristics Al-Si-Mg-Fe alloy samples:

- Al-Si alloy
- Pure magnesium
- Pure aluminum
- Pure iron
- Sand mould, investment shell, and cast iron mould (die)
- Fluxing agent
- Degasifier

The alloy was prepared and chemical analysis of their ingredients was done. The chemical composition of alloy is given in Table 1. The sand mould, investment shell, and cast iron mould were employed to prepare the samples for wear tests. The melts were degasified with tetrachlorethane tablets.

Table-1: Chemical composition of alloys

Alloy	Composition determined spectrographically, %						
Element	Al	Si	Mg	Fe	Cu	Mn	Cr
%	85.22	9.0	2.0	3.5	0.01	0.25	0.02

An Al-Si-Mg-Fe alloys were melted in an oil-fired furnace. The melting losses of aluminum and magnesium were taken into account while preparing the charge. During melting, the charge was fluxed with coveral-11 (a Foseco company product) to prevent dressing. The molten metal was then degasified by tetrachlorethane (in solid form) using a plunger ending in a small inverted crucible. The melt was also modified with sodium and refined with Al-Ti master alloy in the crucible before pouring. The crucibles were made of graphite. The dross removed melt was finally gravity poured into the preheated sand mould, investment shell, and metal die. The cavity shape is cylindrical in all the methods of casting. The pin specimens were prepared from Al-Si-Mg-Fe alloys. The dimensions of the specimens was 6 mm diameter and 20mm length.

A pin on disc type friction and wear monitor (ASTM G99) was used to evaluate the wear behaviour of Al-Si-Mg-Fe alloys against hardened ground steel (En32) disc having hardness of RC 62 and surface roughness (R_a) 0.6 µm(Fig.1). The sliding behavior of the specimens under the dry frictional conditions was evaluated (fig.1).

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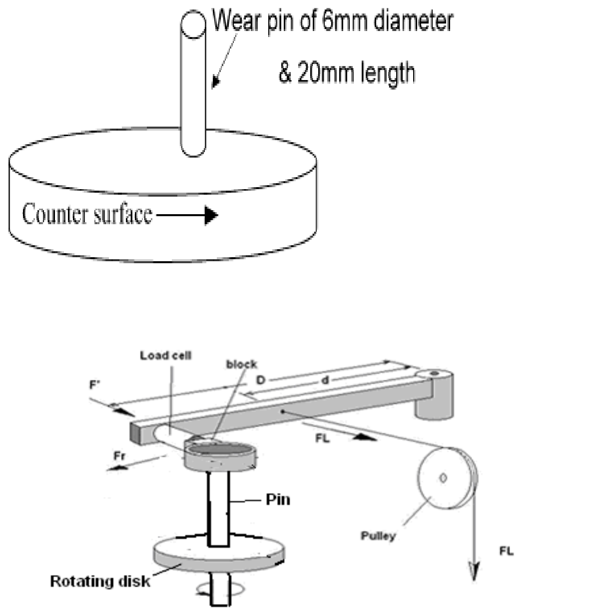

Fig.1. Schematic representation of the sliding wear experiment

Wear tests include the measurement of:

1 Weight loss using electronic weighing balance with accuracy up to 0.1 mg,
2 Temperature of pin using thermocouple, and
3 Friction force with data acquisition system

The mechanical properties and metallurgical morphology were investigated to evaluate the wear behaviour of these alloys. Temperature measurements of wear pin during the sliding were carried out with chromel-alumel thermocouple.Thermocoulpes were placed into a hole of 2 mm diameter at 1.5 mm away from sliding surface. Tempertature was recorded with the help of digital temperature indicator.

3. RESULTS AND DISCUSSION

3.1 Mechanical Properties

The mechanical properties of Al-Si-Mg-Fe alloys are given in Table-2. The mechanical properties of die cast alloy are superior to investment cast and sand alloys. The reason could be the fine grain structure in the die cast alloys. The grain structure in the casting is influenced by the solidification process.

Table-2: Mechanical Properties of Al-Si-Mg-Fe alloys

Mechanical properties	Sand cast	Investment cast	Die cast
Tensile strength, N/mm^2	199.52	213.64	234.11
% Elongation	9.1	9.8	10.2
Hardness (surface), BHN	71	75	87

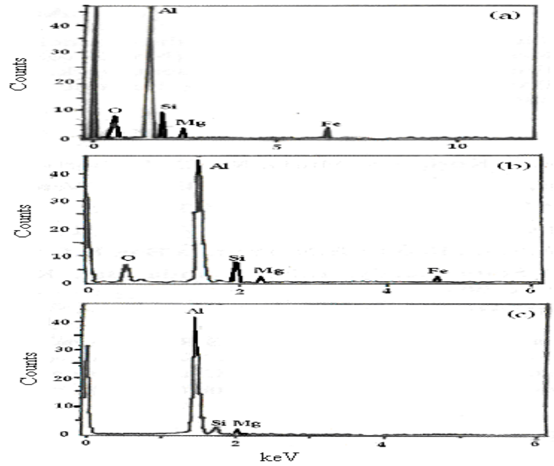

Fig.2: EDX analysis of Al-Si-Mg-Fe alloy worn surfaces (a) sand cast, (b) investment cast, and (c) die cast

3.2 Effect of Contact Time, Sliding Speed, And Normal Pressure on Temperature

The influence of contact time on the temperature generated in the specimen is shown in figure 3. The temperature rise in the specimen is proportional to its contact time with the abrasive disc during the wear test. With the increase of contact time the corresponding frictional temperature rises steadily due to the increased conversion of frictional energy into heat energy.

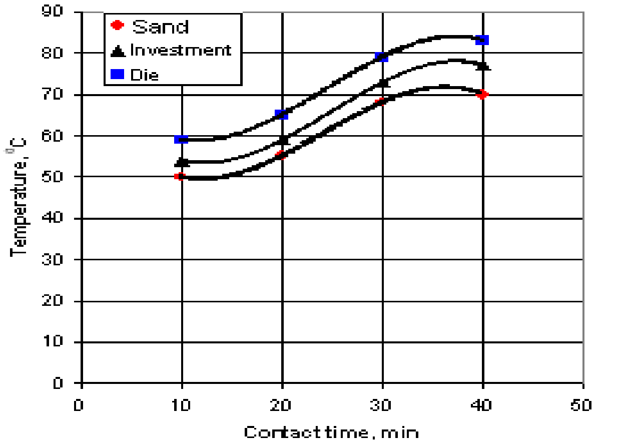

Figure 3 : Influence of contact time on temperature rise. The normal pressure and sliding speed are respectively, 0.75Mpa and 2m/sec.

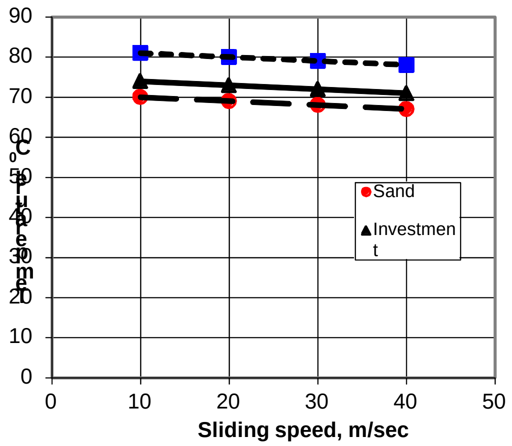

Figure 4: Influence of sliding speed on temperature rise. The normal pressure and contact time are respectively, 0.75MPa and 30min.

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The influence of sliding speed on the temperature generated is illustrated in figure 4. It is clearly observed there is no influence of sliding speed on the temperature rise in the specimen. It may be attributed to the slip phenomena, which creates new interface between the specimen and the abrasive disc continuously. Consequently, there may be interruption for the temperature flow into the specimen because the heat experienced interface is passed on by the new and cold interface. The mathematical relation between the sliding speed and the temperature rise is linear. The gradient of the curves is 0.1 only for all the specimens. The temperature rise due to change in sliding speed is negligible.The influence of normal pressure on the temperature rise of specimens is demonstrated in figure 5. The temperature rise in all the specimens increases with increasing of normal pressure on the specimens. Moreover, the increase in the normal pressure on the specimen results the plastic deformation of the wearing surface and subsequently rise in frictional temperature. The temperature rise is exponential of normal pressure on the specimen. This may be on account of wear mechanism consisting of abrasive, adhesive, and melt wear phenomena.

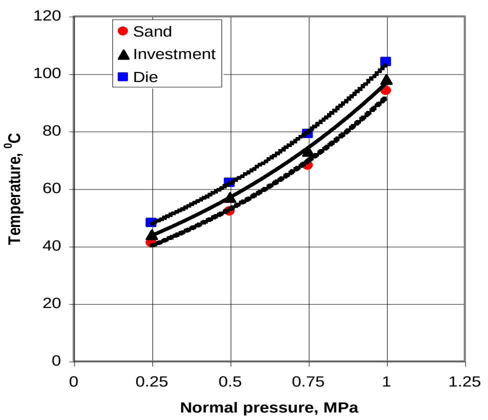

Figure 5. Influence of normal pressure on temperature rise. The contact time and sliding speed are respectively, 30min and 2m/sec

The change in hardness of the worn specimens is shown in figure 6. It can be seen that the hardness values increase after wear test. The increase in hardness in the worn specimens may be attributed to the work (strain) hardening and the frictional temperature.

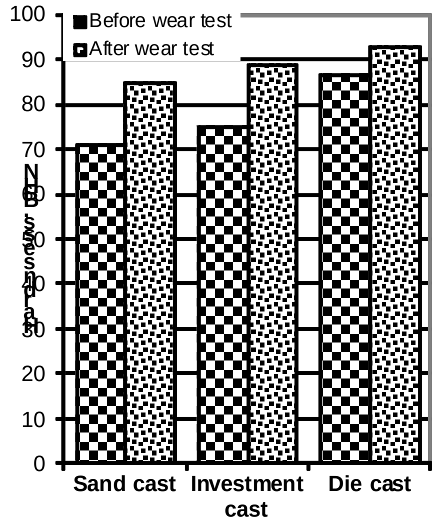

Fig.6. Hardness values of worn specimens

The microstructures of worn specimens are revealed in figure 7. The grains become finer owing to the work hardening. The increase in hardness values of worn specimens indicates that the work hardening effect dominates the softening effect. The softening of structure in the wearing specimens aids in the diffusion across the grain boundaries.

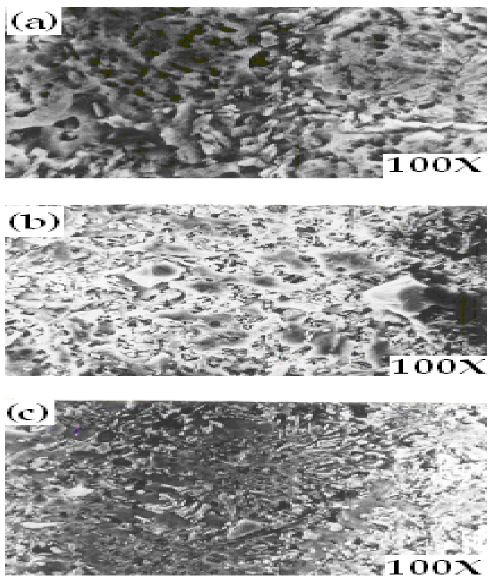

Fig. 7. TEM photomicrographs of worn surfaces (a) sand cast, (b) investment cast, and (c) die cast.

Figure 7 shows TEM photomicrographs of worn surfaces of Al-Si-Mg-Fe alloy exhibiting different wear morphologies. It is clearly seen that the wear particles are detached from the severely deformed material. Figure 7(a) and 7(b) show that the formation of abrasive grooves and particle detachment. Figure 7(c) shows the absence of large grains in die cast specimens.

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4. CONCLUSIONS

The following conclusions can be drawn fron the test results:

- The temperature increases with increasing contact time at constant normal pressure and sliding speed.
- There is no influence of increasing sliding speed on the temperature rise in the specimen at constant normal pressure and contact time.
- The temperature rise in all specimens increases with increasing normal pressure at constant contact time and sliding speed.

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