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Research Article

Dry Sliding Wear Behaviour of Nickel Aluminide coated on Zinc Aluminium alloy Metal Matrix Composite for Anti friction Applications

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Abstract

The present investigation aims to evaluate the wear behaviour of Nickel aluminide (Ni_3Al) coated on zinc-aluminium (ZA-12) alloy composites by thermal evaporation process. A pin-on disc wear testing machine is used to evaluate the wear loss of alloy. In recent years Ni_3Al has attracted considerable interest due to their inherent properties such as withstanding high temperature etc. Further coating on ZA-12 provides good physical strength and tribological properties to ensure less wear of the material. In this paper an attempt has been made to provide an extensive performance ofNi_3Alcoated on ZA-12 to analyze the performance of the material in bush bearing of automobiles to prevent friction and wear of bearing parts.

Keywords: *Ni_3Al, ZA-12, Friction, Wear*

1. Introduction

The increase in demand for lightweight, stiff and strong materials has led to the development of metal matrix composites. The MMCs possesses excellent mechanical and tribological properties and are considered as engineering materials for various tribological applications (Sharma, *et al*, 1998), (Davis, *et al*, 1970), (Siddesh kumar, *et al*, 2014). Protective coatings are applied on the engineering materials to improve their physical, thermo chemical and mechanical properties. These coatings are used in various fields of industrial applications and in automobiles (Prchamy agaghy homaira *et al* 2002). In the automobiles bearing components failures occur through oxidation and corrosion, hence protection of these components is necessary. The use of coatings permits the separation of surface and substrate. Coating materials are designed to provide corrosion or oxidation protection at high temperature applications. Wear is a common occurrence on most plant and machinery and is often a slow and progressive process. However if the rate of wear on particular machine component is high it requires frequent repair and replacement. This may constitute a wear problem. Therefore, deciding whether a wear problem exists and requires attention calls for a degree of judgment of the circumstance (Rohatgi *et al* 1996), (Lee *et al* 1987), (Mukundadas prasanna kumar, *et al* 2006). Several studies suggest that MMCs under lubricated sliding against a smooth counter face exhibit superior wear resistance over un reinforced alloys. However, under unlubricated condition complex and often opposite results have been reported (Gieskes, *et al* 1991). The wear resistance of Ni base alloy coating can be greatly improved by reinforcing of hard phase particles. Ni_3Al has the high resistance towards corrosion and good mechanical properties and hence it can be used in structural and high temperature applications (Ganesh kumar, *et al*, 2011).The zinc alloys have outstanding bearing and wear resistance, andthis quality refers to material ability to survive continuous moving contact without sustaining damage to its surface. ZA alloys perform best under dry and lubricated wear condition, compared to the industry standards of C93200 lead tin bronze(Kubel,1987).Low coefficient of friction and good load bearing capabilities of zinc make them suitable for a variety of applications.

2. Materials selection

2.1. Nickel Aluminide

Nickel aluminide is an intermetallic alloy of nickel and aluminum with properties similar to both ceramic and a metal. Nickel aluminides have been extensively used to manufacture components exposed to high temperature environments (Dey, 2003). Intermetallic alloys have emerged as materials with vast potential for application in a wide range of technologically important areas. The two aluminides of significance in the Ni–Al system are Ni_3Al, NiAl. Ni_3Al has received considerable attention as a potential structural alloy

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(Ismail yildiz, *et al*, 2012). Ni_3Al acts as a strengthening phase in most super alloys. A super alloy, or high-performance alloy, is an alloy that exhibits excellent mechanical strength and resistance to creep (tendency for solids to slowly move or deform under stress) at high temperatures, good surface stability, and corrosion and oxidation resistance (Benegra, *et al*, 2012).

Table 1 Properties of nickel aluminide

Properties	Values
Density	7.5g/cm3
Young's Modulus	178GPa
Melting temperature	1658K
Thermal expansion coefficient	12.5*10-6/K
Yield point	500MPa
Bonding	covalent/metallic

The nickel aluminide alloy powder of CAS number-12635-27-7 was purchased which is required for the coating purpose on zinc aluminium. The coating of this nickel aluminide powder on zinc aluminium alloy was carried out by thermal evaporation process.

Table 2 Chemical composition of nickel aluminide

Composition	%
Nickel	48.83
Aluminium	51.14

2.2. Zinc Aluminium

Zinc-based alloys have been widely used as tribological components for various machines because of their lower density, excellent cast ability, fluidity, lower energy requirement for shaping and superior wear properties (Gencage purcek, *et al*, 2002). Zinc based cast alloys, commonly referred to as "ZA" alloys, has been developed during the past year and is now increasing in commercial usage. The chemical requirements for these alloys are specified in ASTM B669. Zinc alloys with aluminium are a group of the foundry alloys which have very good physical, strength and tribological properties (Prasad, 2003). Especially alloys containing aluminium from range 12-40wt%, for example alloys ZA12, ZA27, Z284, have high strength and tribological properties.

Table 3 Engineering properties of ZA-12 alloy

Properties	Values
Specific gravity	7.13
Ultimate tensile strength	310MPa
Yield strength	317MPa
Density	6.03g/cm3
Young's modulus	83GPa

3. Experimental Procedure

3.1Preparation of composite Zinc Aluminium 12 [ZA-12]

ZA-12 alloy having the chemical composition as given in the table 3 was used as the base matrix.

Table 4 Chemical composition of ZA-12 alloy

Composition	%
Al	10.5-11.5
Cu	05-1.2
Mg	0.015-0.030
ZN	88.5-89.5

Fig. 1 Composite furnace

The composites are prepared by using stir casting technique and composite furnace is used for fabrication is shown in figure 1.The required composition was initially obtained through raw ingots and then those ingots were melted in the furnace at 800^0c for two hours in stir casting machine. In stir casting process the ingots were completely melted. The stirring was continued at a speed of 400 rpm for about 5 minutes and then the molten metal were poured into the moulds and allowed to cool and then they were machined to the required standard dimensions as per ASTM G 99-95a.

3.2Experimental procedure

The wear specimens were tested under dry (unlubricated) conditions in accordance with ASTM-G99 standards using a pin-on-disc sliding wear testing machine as shown in Figure 2.

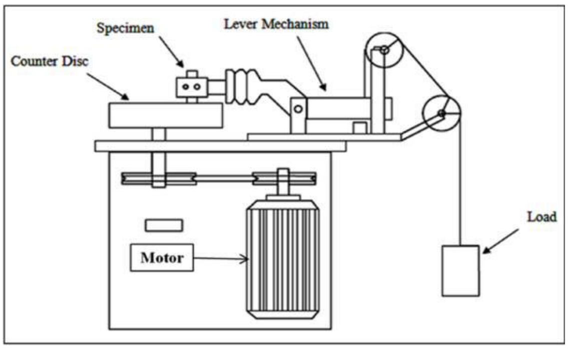

Fig. 2 Pin-on-disc wear testing machine

The apparatus consists of an EN24 steel disc of hardness 57HRc and diameter 250 mm, which is the counter face on which the test specimen slides. The chemical composition of the steel disc in weight % is 0.45 C, 0.35 Si, 0.70 Mn, 1.40 Cr, 0.35 Mo, 1.80 Ni, 0.05 S and 0.05 P.

The arrangement were made to hold a specimen and also for application of the load on the specimen. The test sample was clamped in the specimen holder and held against the rotating steel disc. A standard test procedure was employed; the pins of standard material under investigation were 8mm in diameter and 30mm in height the disc was cleaned with acetone to remove any possible traces of oil, grease and other surface contaminants. The specimen was weighed before and after the tests using an electronic balance accurate to 0.0001 g. The dry sliding wear loss was computed using the weight loss of the pin before and after the experiments. The data for the wear tests was taken from the measurements.

4. Results and Discussions

4.1 Effect of applied load on weight loss of ZA alloy composite

It is clearly observed that the coating of nickel aluminide on the surface of zinc aluminium alloy improves the sliding wear resistance in comparison with the uncoated alloy. The effect of both applied load and sliding distance were investigated in zinc aluminium alloy.

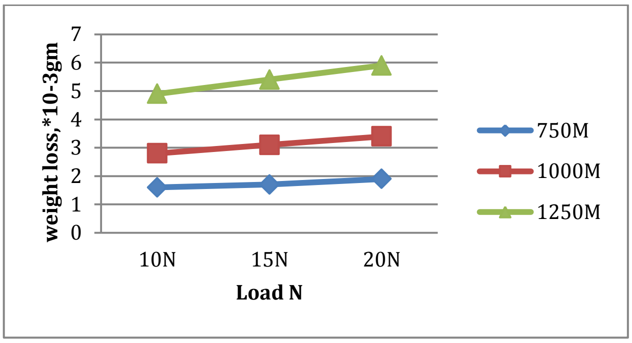

Fig.3 Effect of load on weight loss of ZA-12 alloy

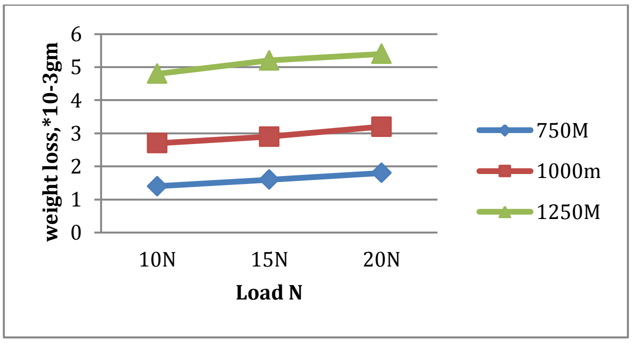

Fig. 4 Effect of load on weight loss of Ni_3Al coated ZA-12 alloy

The effect of applied load on weight loss at different load is shown in figure3, and 4. It is clearly observed from the figure 4 that the nickel aluminide coated zinc aluminium specimen wear loss is less when compared with uncoated specimens. When the load applied is low, the wear loss is quite small,which increases with increase in applied load.It can be considered that it is quite natural for the weight loss to increase with load. The experimental data suggest that there is a gradual increase in the wear rate of both coated as well as uncoated specimens.

4.2. Coefficient of friction

4.2.1 Test duration for 600 seconds

Experiments were conducted at room temperature. Figure 5 and 6 shows the variation of time v/s coefficient of friction for both non coated and coated test results. The test specimens were tested with different load of 10,15and20 N for the duration of 600sec.Ni_3Al was coated and tested for the same duration. The observation shows that 52% reduction in wear compared to non coated specimens.

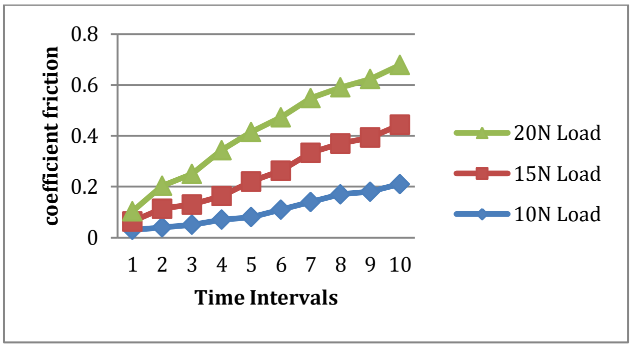

Fig. 5 Time v/s Coefficient friction without Ni_3AL coating

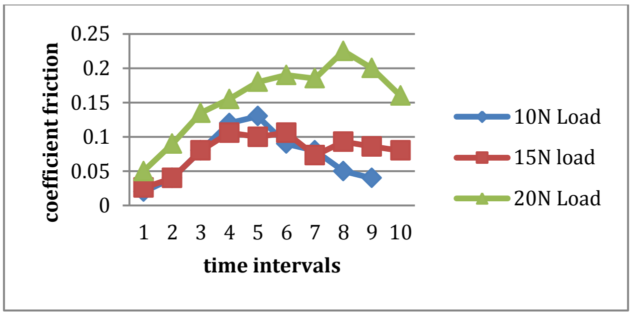

Fig. 6 Time v/s Coefficient friction with Ni_3AL coating

However figure 6 indicates that wear in the beginning started to increase and with increase in time interval decrease in the wear was observed.

4.2.2 Test duration for 800 seconds

The experiments were carried out for a sliding distance of 1000 m in 800 seconds. Figure 7 and 8 shows the variation of time v/s coefficient of friction for both non coated and coated test results.

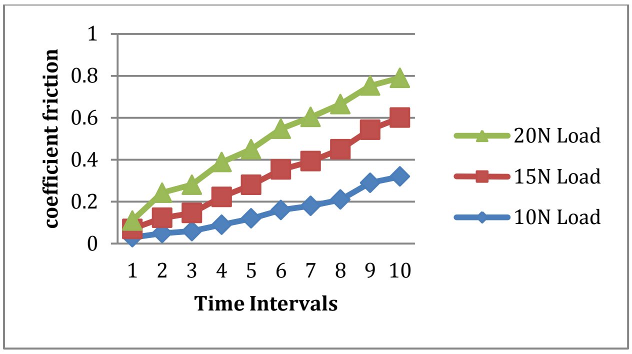

Fig. 7 Time v/s Coefficient friction without Ni_3AL coating

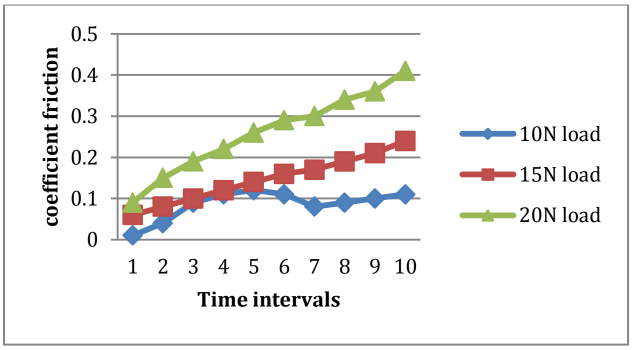

Fig.8 Time v/s Coefficient friction with Ni_3AL coating

The tests were carried out for the loads of 10, 15 and 20 N for 800 seconds. Ni_3Al was coated and tested for same duration. The observation shows that wear decreases, compared to un coated. However wear pattern indicate that coefficient of friction increases in the beginning up to 500seconds and decreases slightly and further increases. This increase in wear rate is due to the Ni_3Al powder which has been rubbed which is left on the disc. When the experiment is continued these rubbed particles gets attached to the surface and causes increase in wear rate.

4.2.3 Test duration for 1000 seconds

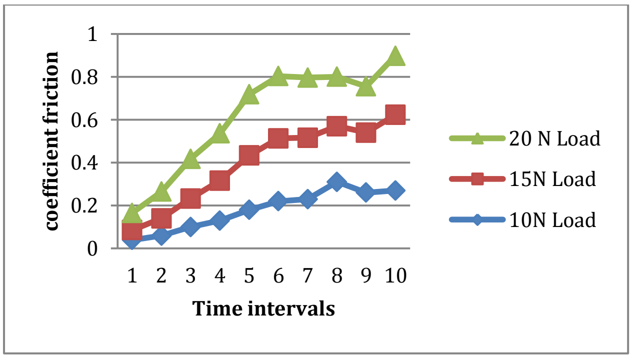

Fig.9 Time v/s Coefficient friction without Ni_3AL coating

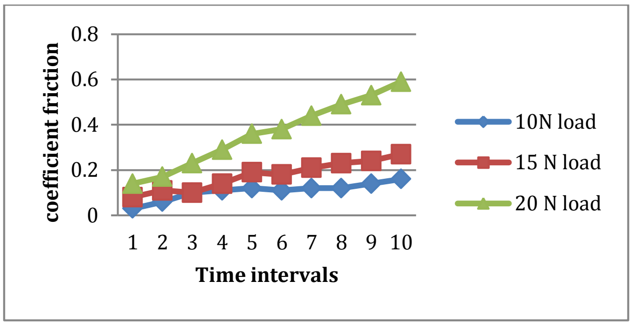

Fig.10 Time v/s Coefficient friction with Ni_3AL coating

The experiments were carried out for a sliding distance of 1250 m for 1000sec at 10, 15 and 20N loads. Figure 9 and10 shows the variation of time v/s coefficient of friction for both non coated and coated test results. The wear rate of 20N is very high and at certain time duration of 480sec the value remains constant and there after gradual increase of wear rate has been observed.

Conclusions

Zinc aluminium-12 specimens were tested at different loads and sliding distance respectively with constant velocity of 1.25m/s. The wear properties are significantly changed by coating nickel aluminide on the surface. The final conclusion is as follows:

1. Nickel aluminide coated exhibited reduced dry sliding wear loss than the zinc aluminium alloy.
2. The dry sliding wear loss of matrix alloy increased with the increase in sliding distance and duration.
3. The difference of wear loss for both non coated and coated specimens for a sliding distance of 750, 1000and 1250m were observed. Wear reduces to an extent of 52% at 750m, 36% at 1000m, and 30% at 1250m. This observed reduction in percentage of wear loss is due to the presence of worn out particles of Ni_3Al. This can be reduced if lubrication is used.

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