Tribological Behaviour of AA 7075 Hybrid Composite using Stir Casting Method

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***Abstract*—This work deals with the effect of hard ceramic particles on Tribological properties of AA 7075 Hybrid metal matrix composites. The liquid stir casting method has been used for preparing Hybrid metal matrix composites. AA 7075 used as base material and Al_2O_3, B_4C and TiO_2 used as reinforcement materials. Different weight percentages of reinforcement were used for three different compositions of composites. The dry sliding wear tests were done on pin-on disk apparatus by varying the applying load. The wear rate and coefficient of friction was recorded by computer. The Microstructural study was done by using Scanning Electron Microscope (SEM). From the experimentation, the wear resistances of hybrid composites were increased by increasing the weight percentage of Al_2O_3 with B_4C and TiO_2. From microstructure studies the stir casting method distributes the ceramic particles uniformly through the aluminium alloy.**

Keywords— Aluminium Alloy, Hybrid Metal Matrix Composites, Tribological Properties, SEM.

I. INTRODUCTION

Composite in recent times, there has been a great upsurge in using composite materials for various applications, especially in aerospace, defence, automotive industry, due to their enhanced properties [1-2]. Aluminium alloys are an important vital engineering material for mechanical applications due to its low density, high specific strength, high thermal conductivity and improved machinability combined with significant weight savings [3-4]. The wear resistance, creep performance can be improved in aluminium metal matrix composites by the incorporation of hard reinforcements [5]. The wear and the width of the scratches decrease with increase in volume fraction of the reinforcements whereas the micro-hardness of the AA 6061 hybrid composites decreases respectively [6]. The wear resistance increases with the addition of fly ash in AA6061 alloys & 15 % weight fraction of fly ash/AA6061 shows minimum wear condition which was prepared by stir casting method [7]. The addition of copper with 4% of Mg in aluminium alloy decreases the torque and thrust force but increases the surface roughness [8]. The harder SiC & B_4C particles improved the wear resistance and decrease the friction co-efficient AA7075 compared with the other reinforced alloy [9]. A decrease in wear rate is observed in Al/Al_2O_3 composite by incorporating carbon fibres in Al/Al_2O_3 composite [10]. Better dry abrasive wear resistance is achieved when Al reinforced with SiC & MWCNT [11]. The tribological behaviour of HMMC is greater than the pure matrix material and the wear rate can be controlled by the MMC formed on the worn surfaces of the composite [12]. The hardness and density decreases linearly with increasing the aluminium alloy content. The four –points bending strength and the fracture toughness of the composite also increases [13]. The tensile properties, electrical resistivity and hardness of the AA7075 aluminium alloy are improved by Pre-aging at various retrogression temperatures [14].

However, previously no results were reported for improvement of tribological properties by the addition of Al_2O_3, TiO_2 and B_4C particles on the aluminium alloy 7075-T6 using stir casting method. The objective of the present investigation is to show the result of tribological behaviour of AA 7075 hybrid composites by varying the weight percentage of Aluminium oxide.

II. EXPERIMENTAL PROCEDURE

A. *Material composition*

In this work, Aluminium alloy 7075 used as base matrix material is reinforced with a mixture of three types of particulates namely aluminium oxide, boron carbide and titanium oxide along with magnesium 1 % as binding element. Aluminium oxide weight percentage was varied (3-9%) and Boron carbide, Titanium Oxide weight percentage was fixed (5%).

TABLE.I. Chemical composition of AA 7075

Element	Al	Si	Fe	Cu	Ti
Wt. %	90.8	0.219	0.219	1.582	0.053
Element	Mg	Cr	Ni	Zn	Mn
Wt. %	2.306	0.205	0.037	5.403	0.071

B. *Preparation of composites*

Liquid stir casting method was used for preparing the aluminium hybrid metal matrix composites by adding hard ceramic particles. In this work 750g of AA7075 with varying weight percentage of Al_2O_3 (3-9 %) and a constant weight percentage of TiO_2 (5%) & B_4C (5%) was used. The 1% of Mg alloy was added to attain the good binding and wettability of matrix and particulates.

High temperature electric furnace was used to melt the AA 7075 for one hour at the temperature range of 750-850°C. The preheating furnace used to preheat the hard ceramic particles in the temperature of 330°C. Three different compositions of HMMC were prepared

Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 01, January-2017

individually by adding different weight percentage of hard ceramic particles into the matrix alloy. The mild steel stirrer was used to stir the molten alloy by using electric motor at the RPM rate of 550. During vortex formation of the molten alloy the preheated particles are added in the constant feed rate of 1.2-1.4 g/sec. The melt was then solidified in the preheated cast iron mould in atmospheric air. The 7075 hybrid metal matrix composites, containing different weight percentage of reinforcement particle were produced. Cast and composite were heat treated in to T6 condition. After heat treatment process the casting materials are machined to testing for required dimensions.

TABLE.II Composition code of Hybrid composites

Compositions	Code
AA7075-3%Al_2O_3-5%TiO_2-5%B_4C	C-1
AA7075-6%Al_2O_3-5%TiO_2-5%B_4C	C-2
AA7075-9%Al_2O_3-5%TiO_2-5%B_4C	C-3

III. TESTING METHODS

A. *Wear Test*

The samples for dry sliding wear test were prepared as per ASTM G99 standard. The wear specimen size of 10 mm diameter and height of 20 mm was machined from cast samples and then polished by using different size of emery paper for smooth surface. Dry sliding wear experiments were conducted using a computer aided pin-on-disc wear testing machine with the load ranging from 1.5 kg to 4.5 kg at constant sliding speed of 400 rpm. The wear tests were conducted at room temperature. During wear testing, weight loss experienced by the specimen was measured before and after testing in microns.

B. *Coefficient of friction*

The samples of hybrid composite were used to coefficient of friction test. The coefficient of friction is calculated by using computer. The frictional force between the sample and counter disk are measured in pin-on-disk apparatus and then showed in graph.

IV. RESULT AND DISCUSSION

A. *Micro structural study*

The micrographs are captured by using scanning electron microscope. The microstructure of composites at 500µm, 1000 µm and 2000 µm magnification were captured. The distribution of Al_2O_3 with 3, 6, 9 Wt. % and 5 Wt. %TiO_2&B_4C are fairly uniform throughout the matrix. This reveals the uniform distribution of Al_2O_3, TiO_2&B_4C particles and low agglomeration and segregation of particles, and porosity. The figure shows the third composition of hybrid metal matrix composites.

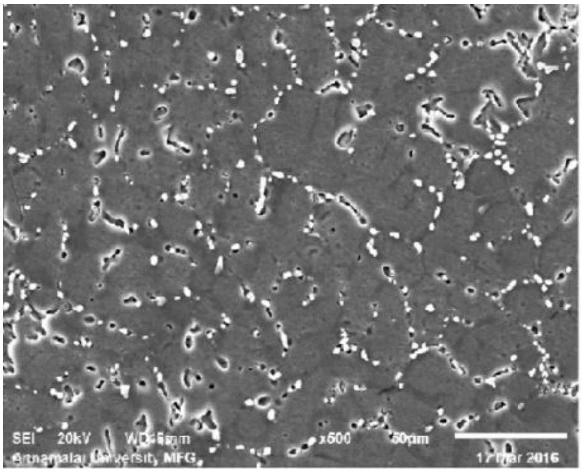

Fig.1. SEM at 500µm - sample 3

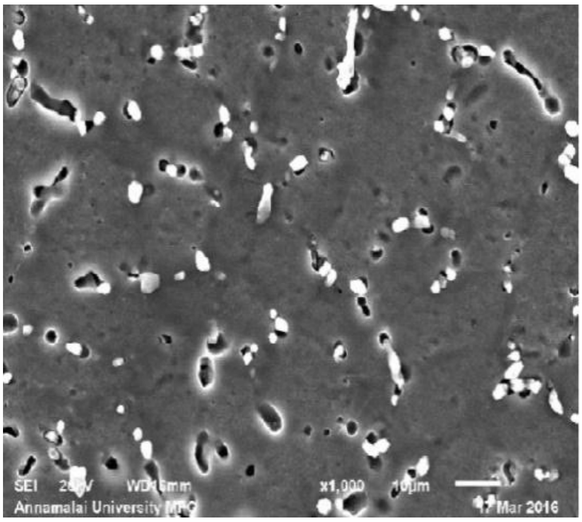

Fig.2. SEM at 1000 µm – sample 3

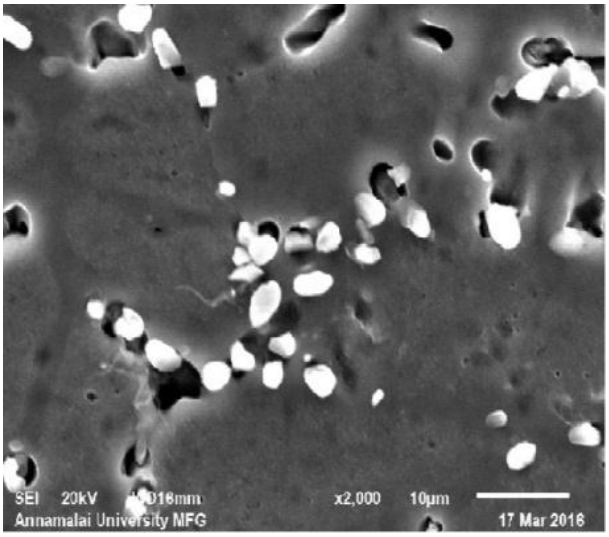

Fig.3. SEM at 2000 µm – sample 3

B. *Wear result*

The wear resistance of AA7075 - 3 Wt. % of Al_2O_3 - 5 Wt. % of TiO_2& B_4C particle content composite was lower with compared to AA7075 - 9 Wt. % of Al_2O_3 - 5 Wt. % of TiO_2&B_4C particle content composite. From the graph it shows that AA7075 - 9% Al_2O_3 - 5% B_4C - 5% TiO_2 have the highest wear resistance at maximum load conditions of 4.5 Kgf. The wear resistance of the hybrid composite was increased with increase in weight percentage of alumina& constant weight % of boron carbide & titanium oxide.

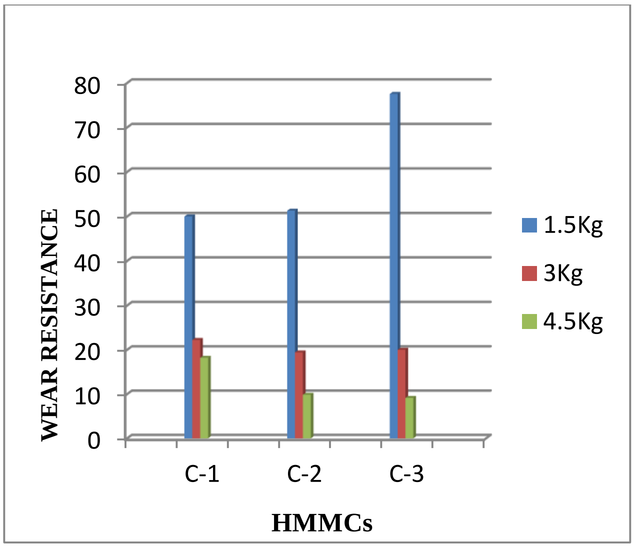

Fig.4. Wear resistance of the hybrid composites for different loads

C. *Coefficient of friction*

The coefficient of friction of AA7075-Al_2O_3-B_4C-TiO_2 hybrid composites of different composition is shown in figure. The coefficient of friction increases with increasing applied load from 1.5Kg to 4.5Kg due to the frictional force between the pin and counter face surface is increased.

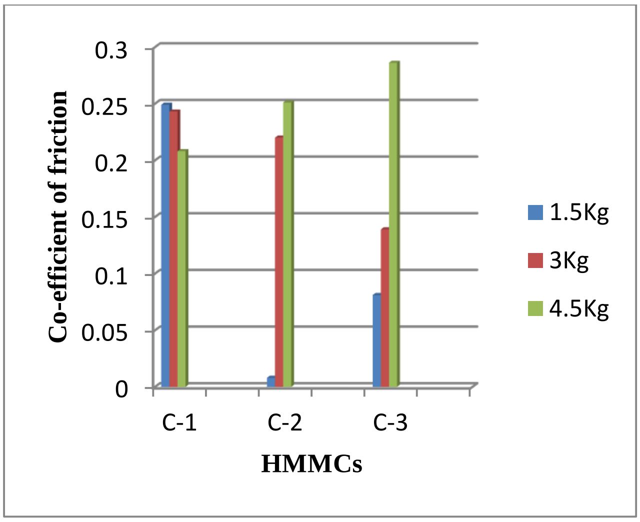

Fig.5. Coefficient of friction of the hybrid composites for different loads

From the figure it is shown that the 6 wt. % of Al_2O_3/5%of B_4C/5% of TiO_2 hybrid composites have less coefficient of friction values compared to other composition.

V. CONCLUSION

1. Three different percentages of ceramic reinforcements namely Al_2O_3/ B_4C/ TiO_2 reinforced aluminium alloy 7075 composite have been successfully prepared by stir-casting process.

2. The wear resistance gets increases by increasing the weight percentage of Al_2O_3 (3%, 6%, 9%), B_4C (5%) & TiO_2 (5%).The wear rate gets decreases by increasing the reinforcements.The microphotograph taken by SEM reveals the uniformity of the microstructure of the ceramic particles.

3. From these results, the tribological applications are achieved by AA7075/ 9 wt. % of Al2O3 /5 Wt % of TiO_2&B_4C composite.

ACKNOWLEDGEMENTS

Anna university support for the work of the authors is greatly acknowledged. It has provided extensive resources and materials for the completion of this research work successful

REFERENCES

[1] Lim T, Kim Y H, Lee C S & Han k S, J Copmas Mater, 26(7) 1062- 1086.

[2] Surappa M K, Sadhana, 28 (2003) 319-334.

[3] A.K. Mondal, S. Kumar, Dry sliding wear behaviour of magnesium alloy based hybrid composites in the longitudinal direction, Wear 267 (2009) 458–466.

[4] Poovazhagan.L, Kalaichelvan.K, Rajadurai.A and Senthilvelan.V , Characterization of Hybrid Silicon Carbide and Boron Carbide Nanoparticles-Reinforced Aluminum Alloy Composites, Procedia Engineering 64 (2013) 681 – 689

[5] Yilmaz and Butoz, 2001, “Abrasive wear ofAlO3-reinforcement Aluminium-Based MMCs, Compos.Sci.Technol., 61,2381-2392

[6] K.Umanath, S.T.Selvamani, K.Palanikumar and R.Sabarikreeshwaran , Dry Sliding Wear Behaviour of AA6061-T6 Reinforced SiC and Al2O3 Particulate Hybrid Composites, Elsevier, 694 – 702

[7] Ravi Mishra, Anilkumar H.C., H. Suresh Hebbar, 2011, Tribological Characterisation of Fly Ash Reinforced Aluminium Alloy (Al6061) Composites, International Journal of Natural and Engineering Sciences

[8] Abdalla Alrashdan, Ahmad T. Mayyas, Adel Mahamood Hassan, Mohammed T. Hayajneh, 2011, Drilling of Al-Mg-Cu alloys and Al-Mg- Cu/SiC composites, Journal of Composite Materials

[9] V.C.Uvaraja, N.Natarajan, K.Sivakumar, S.Jegadheeshwaran & S.Sudhakar, Indian journal of engineering & material sciences, 51-61.

[10] J. I. Song, K. S. Han, 1997, Mechanical Properties and Solid Lubricant Wear Behavior of Al/Al2O3/C Hybrid Metal Matrix Composites Fabricated by Squeeze Casting Method, Journal of Composite Materials

[11] K.R.Padmavathi, Dr. R.Ramakrishnan Tribological behaviour of Aluminium Hybrid Metal Matrix Composite, 660-667

[12] A.Baradeswaran, A.Elayaperumal, R. Franklin , A Statistical Analysis of Optimization of Wear Behaviour of Al- Al_2O_3 Composites Using Taguchi Technique, 973 – 982

[13] Shang-Nan Chou, Jow-Lay Huang, Ding-FwuLii, Horng-Hwa Lu The mechanical properties and microstructure of Al_2O_3/aluminum alloy composites fabricated by squeeze casting , Journal of Alloys and Compounds 436 (2007) 124–130

[14] Hongya Xua, Fen Wangb, Jianfeng Zhub, Yuxing, Xie, 2011, Microstructure and Mechanical Properties of HoAl-Al2O3/Ti Al Composite, Materials and Manufacturing Processes, 26 (4), 559 561.