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Study on Wear Performance of 6061 Al/ Nano TiCp/ Gr Hybrid Composites

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Abstract—*In this experimental study, the wear performance of 6061 Al-nano TiCp-Gr hybrid composite was investigated. The hybrid composite material was fabricated by means of stir casting technique. The wear studies were carried out on the dry sliding wear behavior of aluminium reinforced with 2% TiCp and 5% Gr hybrid composite using pin on disc method over a applied load ranges of 40N, 60N and 80N, at sliding velocities of 1.5m/s, 3m/s and 4.5m/s for five minutes. The wear rate increases either by increasing applied load or sliding velocity. The hybrid composite thus produced improve the wear performances significantly compared to the 6061 Al alloy.*

Keywords*: MMC, Stir casting, Pin on Disc techniques.*

1. INTRODUCTION

Now a days with the modern development need of developments of advanced engineering materials for engineering applications goes on increasing, for which composite material is the reliable solution. Composite materials are a combination of two or more constituents differing in form and material composition whose properties are superior in a specific application to those of the original material. The hybrid composite material is the incorporation of several different types of particulates into a single matrix. A hybrid composite material that contains two or more kinds of particulates, the advantages of one type of particulates could complement to the other particulate in case of any drawbacks. Metal matrix composites (MMC) are increasingly becoming most attractive materials for advanced aerospace and automobile industries which possess significantly improved properties such as high specific strength, specific modulus, damping capacity and good wear resistance compared to the unreinforced alloys**.** Aluminium matrix composite (AMC) are becoming better substitute for the conventional aluminium alloys because of characteristics like improved strength to weight ratio, better wear resistance, etc. Aluminium matrix composite (AMC) are currently applied in the design of components for automobiles, aircrafts, marine structures, defence assemblies, sports etc. Aluminium alloy are replacing the materials including cast iron, bronze, to manufacture wear resistant parts. The wear behavior of a composite material depends on the micro structural properties, type of loading and sliding conditions. Wear is one of the important phenomenons that occur at a materials interface. Generally lubrications are needed to reduce friction, wear and heat generated among contact surfaces. The self-lubricating materials are preferred because the solid lubricant contained in them can be automatically released during the wear process to reduce the wear. Graphite is one of the most widely used solid lubricant materials by which the wear has been significantly influenced when it has a sliding contact. AMCs reinforced with particles of Gr have been reported to be possessing better wear characteristics. The addition of Gr particulates facilitates easy machining and results in reduced wear of Al-Gr composites compared to aluminium alloy. This improves the tribological behavior of the aluminium-based composites by forming a lubricating film between the surfaces in contact and it effectively reduces friction without any additional lubrication. AMCs reinforced with TiC particulates are known for higher modulus, strength and wear resistance compared to conventional alloys and it increases both mechanical strength and wear resistance of Al alloy.

S.Suresha et al demonstrated that the increase of speed reduces wear and increase of either load (or) sliding distance (or) both increase wear. H.H.Kim et al fabricated and analyzed the wear performances of composite materials. Excessive CNTs adversely affected the material due to agglomeration (or) poor wettability with the matrix**.** K.R.Padmavathi et al analyzed the severe wear conditions, the composite material displayed higher wear rate and friction coefficient and it was clarified that the friction and wear behavior of Al-SiC-MWCNT composite is largely influenced by applied load. M.Uthayakumar at al fabricated and demonstrated that the hybrid composite material retains the wear resistance properties up to 60N load and sliding speed ranges 1-4 m/s. S.A.Alidokht et al studied the MoS_2 rich layer on the top of worn surface by which it decreases the plastic deformation in subsurface region and alleviate severe wear. The corrosion rates and coefficient of friction of hybrid composite materials increases with increase in wt% RHA. Kenneth Kanayo Alaneme et al fabricated and analyzed the wear mechanism of the composite and it observed to transform from predominantly abrasive wear to a combination of both adhesive and abrasive wear with increase in RHA wt%.

I.Saravanan et al observed the presence of TiN coating on the SS 316L surfaces which exhibits superior wear resistance and coefficient of friction. A.Baradeswaran et al demonstrated the wear resistance of the composite material increased with increasing content of B_4C particles and the coefficient of friction decreases with increased B_4C content.

2. EXPERIMENTAL WORK

A weighted quantity of the 6061 Aluminium matrix material was loaded in a graphite crucible and it was placed inside an electrical furnace. The heating rate of the electrical furnace is 8^{o}C and 15^{o}C per minute. The Al alloy was melted and it was superheated by about 50^{o}C to get the required fluidity. This molten metal was stirred using a stainless steel impeller at a speed of 500 rpm. The stirrer was designed in order to produce adequate homogenous particle distribution throughout the matrix material. The axial and radial flows are provided to avoid different stagnant zones in the liquid melt by the stirrer. The depth of the immersed impeller was approximately 2/3 of the height of the molten metal from the bottom of the crucible. The stainless steel stirrer blade was coated with zirconia to avoid the reaction between the stainless steel and Al alloys at higher temperatures. The Nano TiCp (3%) and Gr (10%) reinforcements was mixed and preheated at 900^{o}C for two hours before being added to the matrix melt. The particle size of nano TiCp is 53nm and Gr is 27 microns. This preheating process is very helpful to improve the wettability between the aluminium and titanium carbide. The reinforcement's mixture was added to the molten melt and the slurry was consciously stirred using a stirrer. The composite slurry was then poured into the mild steel die, which was preheated to 300^{o}C.

Fig. 1. a)wear test specimen (b) Pin on Disc wear setup

Fig. 1. (b) Pin on Disc wear setup

The tribological behavior of the 6061 Al alloy –Nano TiCp-Gr composite material was evaluated by pin on disc method. The wear tests were carried by using a pin on disc wear tester in a dry sliding conditions at the room temperature under the varying applied load (40N,60N,80N) as well as varying sliding velocity (1.5 m/s,3 m/s,4.5 m/s) for 5 minutes. The cylindrical pins were machined from the composite material with the dimensions of 8mm diameter and 25mm in length is shown in Fig.1 (a) The specification of wear and friction monitor-TR201(pin on disc monitor) are ASTM standard G99 , wear disc diameter of 100mm ,thickness 6 to 8mm, frictional force of maximum 100N. The Pin on disc wear setup is shown in Fig.1 (b). The weight of the pin was measured before and after each wear test using an electronic digital weight balance with an accuracy of 0.1mg. The wear rate and weight losses were calculated from the wear tested samples.

RESULT AND DISCUSSION

3. TRIBOLOGICAL BEHAVIOR OF 6061 AL-TICP-GR COMPOSITES

3.1 Effect of sliding velocity on coefficient of friction:

The coefficient of friction of hybrid composite materials with sliding velocity is shown in fig 2. The hybrid composite material performs better than the 6061 Al alloy when it is compared with their coefficient of friction. The 6061 Al/ TiCp/ Graphite composites when tested under dry sliding wear condition under varying sliding velocity, the coefficient of friction is gradually decreasing with the sliding velocity beyond 3 m/s and the applied load of 60N and 80N. This is because of the graphite particle which is present in the hybrid composite material pulls out from it,.when the load and sliding velocity is increased which acts as a self-lubrication which tends to reduce the friction between contact surfaces. But the coefficient of friction of the material under the applied load of 40N and varying sliding velocities is goes on increasing because the graphite particle does not pulls out under the lighter load.

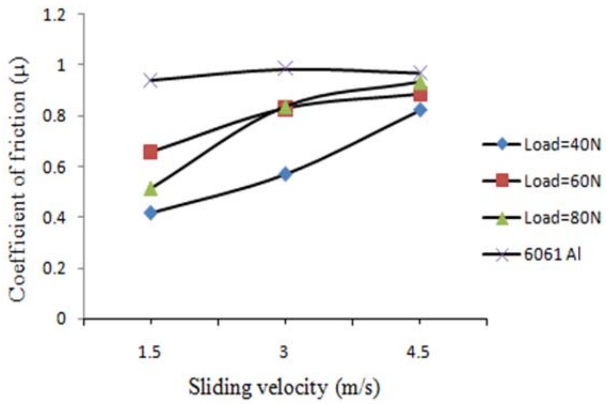

Fig. 2: Coefficient of friction of hybrid composites

3.2 Effect of sliding velocity on weight loss:

The effect of sliding velocity on weight loss is shown in fig 3. During the wear test, the pin was pressed against the counterpart rotating against an EN 8 steel disc by applying the load. The frictional traction experienced by the pin during sliding with the disc was observed continuously by a PC-based logging system. After the wear test, the specimen was removed, cleaned with acetone, dried and weighed in electronic weighing machine with an accuracy of 0.1mg to obtain the weight loss due to wear occurred by the contact surfaces. The graphite particles pull out from the specimen, acts as third body abrasive particle at higher load and sliding velocity in which more heat and friction are generated. It is observed that more deformation occurred and weight loss is rapidly increasing with increase in both sliding velocities and applied loads.

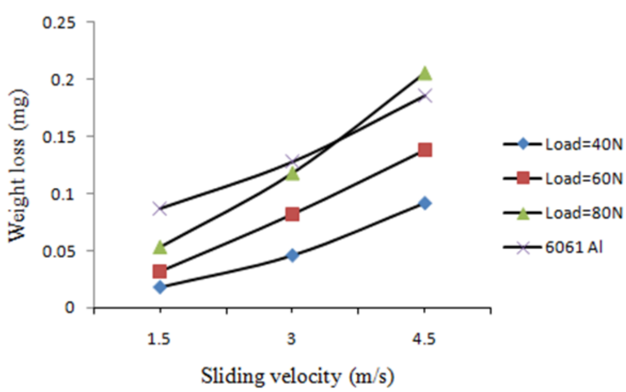

Fig. 3: weight loss of hybrid composites

3.3 Effect of sliding velocity on wear rate

The effect of sliding velocity on wear rate is shown in fig 4. It is observed that the wear rate of the hybrid composite material is lower when compared to the unreinforced 6061 aluminium alloy. When the sliding velocity and applied load increases, high heat is generated which in turns occurrence of peeling off and thrown out of layer of the composite pin is observed. The graphite particles which present in the material, pulls out at higher load and velocity which acts a third body abrasive material by which more deformation occurs. It is observed that the wear rate is increased when the sliding velocity and applied load is increased and also reported that composites exhibited mild wear rate at applied load of 60N.

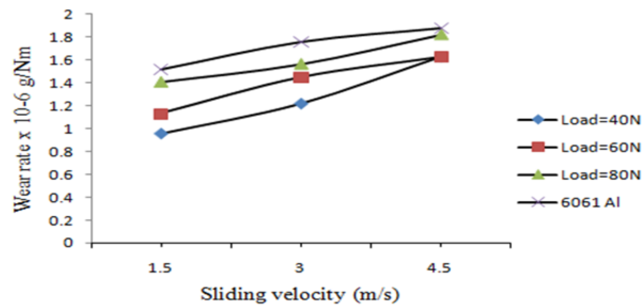

Fig. 4 wear rate of hybrid composites

4. CONCLUSION

The tribological behavior of 6061 Al/ Nano TiCp / Gr hybrid composites was studied and the following conclusions can be drawn from the investigation:

1. 6061 Al/Nano TiCp/Gr hybrid composites were fabricated by stir casting techniques. The reinforcement particles were distributed uniformly in the matrix
2. The wear rate of hybrid composite increases with increase of sliding velocity and applied load but wear rate is lower than unreinforced 6061Al matrix materials. The presence of reinforcements in the matrix restricts the plastic deformation matrix during wear process.
3. The coefficient of friction of hybrid composite significantly decreases with increase of sliding velocity and applied load. The coefficient of friction of 6061 Al matrix is higher than hybrid composites
4. The weight losses of both hybrid composites and unreinforced 6061 Al matrix increased with increase of sliding velocity and applied load but the weight loss of hybrid composite was less than the 6061 Al matrix.
5. The experimental results indicated that wear rate of hybrid composites were mainly depended on the presence of reinforcement in the matrix, applied load and sliding velocity.

REFERENCES

[1] Rohatgi.P.K, Ray.S, Asthena.R, Narendranath.C.S, Interfaces in cast metal matrix composites, Mater. Scie. Eng. A 1993:162:163-174

[2] S.Balasivanandha Prabu, L.Karunamoorthy S.Kathiresan, B.Mohan, Influence of stirring speed and stirring time on distribution of particles in cast metal matrix composite, Mater. Process. Technol. 2006:171:268-273

[3] Uthayakumar M, Aravindan S,Rajkumar K, Wear performance of Al-Sic-B4C hybrid composites under dry sliding conditions materials and design 2013:47:456-464

[4] Dora Siva Prasad , Chintada Shoba, Nallu Ramanaiah, Investigations on mechanical properties of aluminium hybrid composite,Mater. Res. Tech 2014:3(1):79-85

[5] Suresha S, Sridhara B.K, Wear characteristics of hybrid aluminium matrix composites reinforced with graphite and silicon carbide particulates , Compos. Scie. Tech. 2010:70:1652-1659

[6] Nesrine Hentati , Mohamed Kchaou, Anne-Lise cristol, Denis Najjar, Riadh Elleuch, Impact of Post-curing duration on mechanical, thermal and tribological behavior of an organic friction material , Material and design 2014:63:699-709

[7] Sakip Koksal, Ferit Ficici, Ramazan Kayikci, Omer Savas, experimental optimization of dry sliding wear behavior of in situ Alb2/Al composite based on taguchi's method, Materials and design 2012:42:124-130

[8] Baradeswaran A, Elaya Perumal A, Study on mechanical and wera properties of Al 7075/Al2O3/graphite hybrid composite , Compos.PartB 2014:56:464-471

[9] Himanshu Kala, Mer K.K.S, Sandeep Kumar, A review on mechanical and tribological behaviors of stir cast Aluminium Matrix composite, Proce. Mater. Sci. 2014:6:1951-1960

[10] Garcia-Cordovilla C, Narciso J, Louis E. Abrasive wear resistance of aluminium alloy/ceramic particulate composites. Wear 1996;192:170–7

[11] F.M. Hosking, F.F. Portillo, R. Wunderlin, R. Mehrabian, Composite of Al alloys: fabrication and wear behavior, Mater. Sci. 1982: 17: 477–498

[12] Cem.S, Okumus,Serdar aslan, Ramazan karslioglu, Deniz Gultekin, Hatem akbulut, Thermal Expansion and Thermal Conductivity Behaviors of Al-Si/SiC/graphite Hybrid Metal Matrix Composites, Mater. Sci. 2012:18:1392-1320

[13] Padmavathi K.R,Dr.Ramakrishanan R, Tribological behavior of Aluminium Hybrid metal matrix, Compos. Proc. Engg. 2014:94:660-667

[14] Alidokht S.A, Abdollah-Zahed A,Assadi H, Effect of applied load on the dry sliding wear behavior and the subsurface deformation on hybrid metal matrix composite, Wear 2013:305:291-298

[15] Shorowordi K.M., Laoui T., Haseeb A.S.M.A., Celis J.P. and Froyen L., Microstructure and interface characteristics of B4C, SiC and Al_2O_3 reinforced Al matrix composites: a comparative study, Mater. Process. Technol., Vol.142, pp.738-743, 2003.

[16] Kim H.H, Babu J.S.S,Kang C.G, Fabrication of A356 aluminium alloy matix composite with CNTs/Al2O3 hybrid reinforcements ,Mater. Sci. Engg. A 2013:573:92-99

[17] Murakami T,Kajino S,Nakano S, High-temerature friction and wear properties of various sliding materials

[18]

[19] against aluminium alloy 5052, Tribology international 2013:60:45-52

[20] Kiran T.S, Prasanna Kumar M, Basavarajappa S, Viswanatha B.M, Dry sliding wear behavior of heat treated hybrid metal matrix composite using Taguchi techniques, Materials and design 2014:63:294-304

[21] Saeed Baazamat, Mohammad Tajally, Ehsan Borhani, Fabrication and characteristic of Al- based hybrid nanocomposite reinforced with $WO_3$and SiC by accumulative roll bonding process, Alloys and Compounds 2015:653: 39-46

[22] Mohammad Shahadat, Tjoon Tow Teng, Mohd. Rafatullah, Mohd. Arshad, Titanium-based nanocomposite materials: A review of recent advances and perspectives, Colloids and Surfaces B: Biointerfaces, 2015:126:121-137

[23] Eskandari H, Taheri R, A novel technique for development of Aluiminium alloy matrix/TiB2/Al2O3 hybrid surface nanocomposite by friction stir processing, procedia Mater. Sci. 2015:11:503-508

[24] Saravanan I, Elaya Perumal A, Vettivel S.C,Selvakumar N,Baradeswaran A,Optimizing wear behavior of TiN coated SS316L against Ti alloy using Response Surface Methodology, Materials and design 2015:67:469-482