Journal of materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 4, Page 1168-1172

http://www.jmaterenvironsci.com /

Influence of High Temperature on Surface Hardness of AA7050 Hybrid Composites

R. Ranjith*, P.K. Giridharan

Sri Ranganathar Institute of Engineering and Technology, Coimbatore – 641110, Tamil nadu, India.
Kumaraguru College of Technology, Coimbatore – 641049, Tamil nadu, India

Received 10 Jul 2016,
Revised 29 Dec 2016,
Accepted 10 Jan 2017

Keywords

- ✓ EDM,
- ✓ High temperature,
- ✓ Wear,
- ✓ Stir casting,
- ✓ Hardness,
- ✓ Metal matrix Composites

ranjith.mecs@gmail.com
Phone: +91 989 477 9442

Abstract

In this work, Aluminium alloy AA7050 used in manufacturing of Main Landing Gear links was reinforced with boron carbide particles and silicon carbide particles fabricated through stir casting. The potassium fluotitanate was added as flux material to overcome the wetting problem. The composites were subjected to high temperature through electric discharge machining and its impact on surface hardness of composites was analysed. The pin on disc test was performed on the composites at a high load of 490N. The hardness of as cast, worn surface and electric discharge machined surface were compared. It was found that hardness of the composites exposed to high temperature was lower than as cast due to particle detachment. At high loads particles detached due to delamination wear. The worn surface hardness was higher than as cast composites due to presence of ferrous which was transferred from counter disc due to abrasion.

1. Introduction

The aluminium alloy reinforced with hard ceramics particles shows improved mechanical and tribological properties which satisfy the demand of high strength to weight ratio. Aluminium alloy AA7050 has high mechanical properties and high fracture toughness along with a high resistance to exfoliation and stress corrosion was used in the manufacturing of Main Landing Gear links. The hardness of the composites increases with increasing silicon carbide particles due to higher dislocation density [1-3]. Upon heat treatment hardness value gradually increases with time and peak hardness value was 25% higher than the as cast values [4]. The percentage increase in hardness value is approximately equal to percentage of the hard ceramic materials added [5-7]. The hardness value of composites increases with increasing $MoSi_2$ particles and after certain point it starts decreasing due to particle agglomeration [8]. Hardness of the hybrid composites was greater than that of the base alloy due to the presence of hard Ceramic particles in the matrix materials [9-13]. The surface hardness of the aluminium composites was lower than electric discharge machined surface [14]. The MRR increases with an increase in pulse on time and then decreases with further increase in pulse on time [15, 16]. The peak current and pulse duration are significant factor which decides the performance of the EDM process [17]. In this paper an attempt is made to compare the hardness of Electric discharged machined surface and wear surface hardness of the Aluminium hybrid composites.

Table 1: Chemical composition of AA7050

Element	Zn	Mg	Cu	Fe	Cr	Si	Mn	Al
Content %	6.30	2.58	1.83	0.28	0.27	0.06	0.05	Balance

2. Experimental procedure

Aluminium alloy AA7050 having chemical composition as shown in Table.1 was selected as matrix material. The preheated B_4C particles of 7.5wt% and SiC particles of various proportions 0, 2.5, 5, 7.5, 10wt% added to the melt when charge reaches 850ºc. Aluminum requires a melting temperature of about 1100ºC for complete

bonding of reinforcing particles. At such high temperature, melt leads to the formation of intermetallic compounds such as AlB_2, Al_3BC, and Al_4C3 due to the chemical reaction. To overcome this an equal proportion of K_2TiF_6 is used as the flux material, it reacts with molten aluminium and releases titanium which coats the reinforcing particles as shown in Fig. 1, hence bonding of matrix and particles achieved. The uniform distribution of particles was shown in Fig. 2 and presence of titanium was conformed through EDAX as shown in Fig. 3.

Table 2: Casting Process Parameters

Parameters	Value	Units
Melting Temperature	850	(ºC)
Preheating temperature of B_4C	250	(ºC)
Preheating temperature of SiC	250	(ºC)
Preheating temperature of mould	400	(ºC)
Stirring time	5	(min)
Stirring speed	750	(rpm)

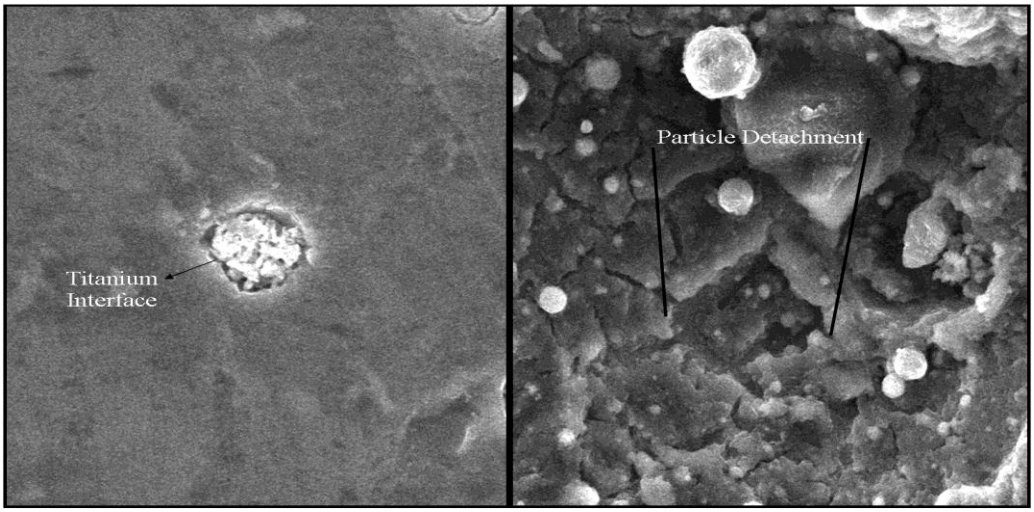

Figure 1: Titanium interface and particle detachment in AA7050/B_4C_p/SiC_p Hybrid Composites

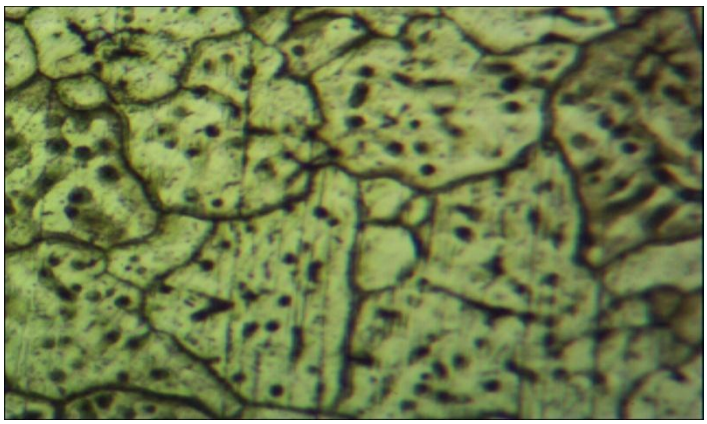

Figure 2: Optical micrograph of AA7050/B_4C_p/SiC_p Hybrid Composites

The mixture is stirred for 3minutes at 750rpm using mechanical stirrer and after the addition of flux once again it is stirred for 2minutes. It was machined to eliminate surface defects. The melt is poured in the preheated (400ºC) permanent mild steel mould of diameter 25mm and height 300mm. The casting process parameters were shown in Table.2. The wear tests were conducted on hybrid composites using pin on disc tribometer at a

load of 490N. The die sink electric discharge machining was performed on composites, the machining parameters were shown in Table.3. Trial experiments were conducted on large number of specimens (AA7050) to find out the process parameters. The parameter which shows combination of better material removal rate and surface roughness were selected for studies. The Rockwell hardness test was performed on 10 different places of three specimens for cast, wear and electric discharge machined surface of the composites and average was taken.

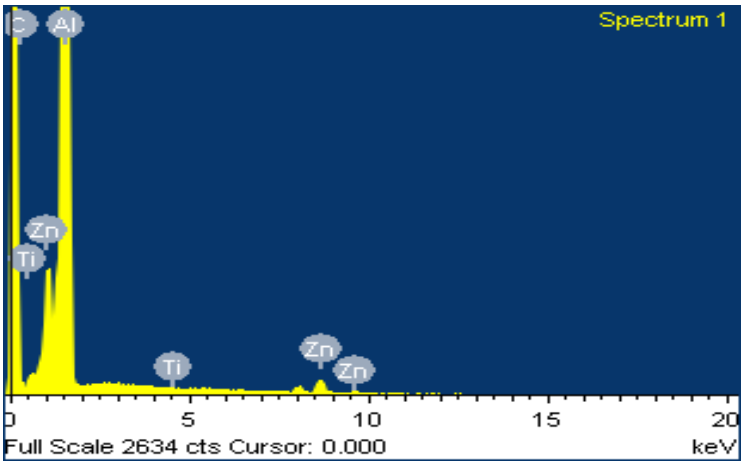

Figure 3: EDS of AA7050/B_4C_p/SiC_p hybrid composites

Table 3: EDM Process Parameters

Parameters	Value	Units
Voltage	50	Volts
Current	3	Amp
Gap control	4	mm
Pulse on time	4	µs
Pulse off time	1	µs
Machining time	5	min

3. **Results and discussion**

3.1. *Hardness of as cast composites*

The hardness of the composites increases with increase in weight percentage of SiC particles as shown in Fig. 4 due to the presence of hard ceramic phase. It is also attribute by the fact presence of titanium coated silicon carbide reduces grain size which increases hardness due to hall petch effect. When silicon carbide particles are added to the composites, hardness values increases, after reaching certain level and it starts decreasing due to inverse hall petch effect.

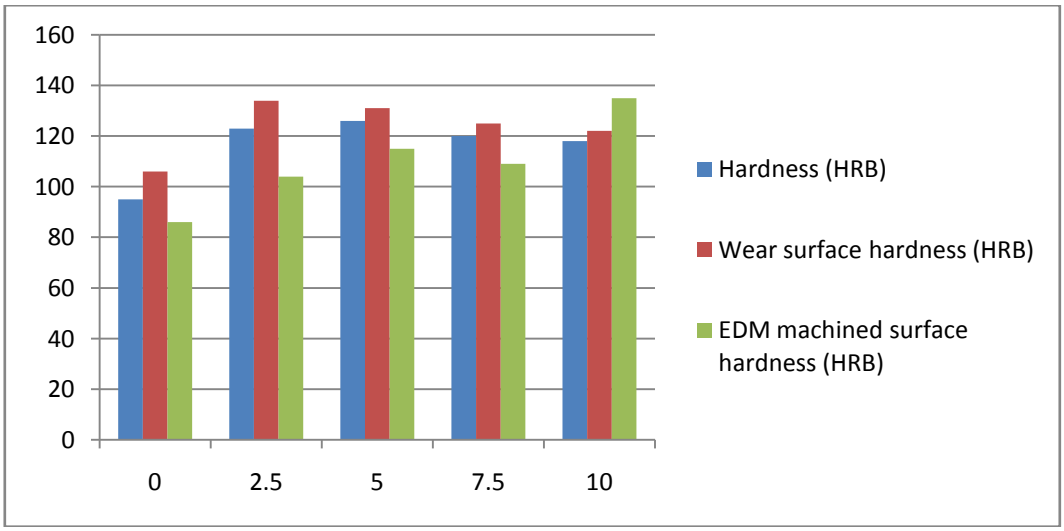

Figure 4: Surface Hardness of AA7050/B_4C_p/SiC_p hybrid Composites

3.2. *Hardness of worn surface*

The hardness of the worn surface was higher than the as cast composites. When the composite pin slides over the steel surface delamination wear occurs. Silicon carbide particles present in the composites gets detached and enter into the contacting surface. At such high loads pressure exerted by SiC particles was very high and third body abrasion takes place. It abrades material from the counter face due to which some of the ferrous material from steel disc is transformed to aluminium pin. This transformation of material leads to the formation thin layer between the contacting surfaces which are termed as mechanically mixed layer. The presence of ferrous in the EDAX was clear evident for the transformation and the formation of Mechanical mixed layer as shown in Fig. 5.

The hardness value of the wear surface is directly proportional to the amount of ferrous content present it. The wear surface hardness of the AA7050/7.5B_4C_p/SiC_p composites was decreased with increase in weight percentage of silicon carbide particles as shown in Fig. 4. This is attributed by two facts 1) at higher weight percentage agglomeration of particles occurs 2) the worn surface hardness decreases with decrease in corresponding as cast composite hardness. The surface topography of EDM surface, as cast surface and worn surface was shown in Fig. 6.

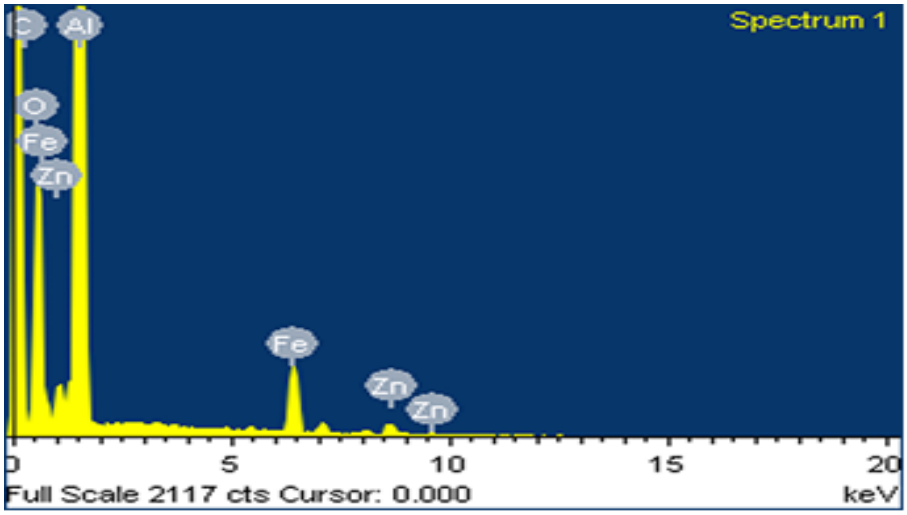

Figure 5: EDAX analysis of worn surfaces

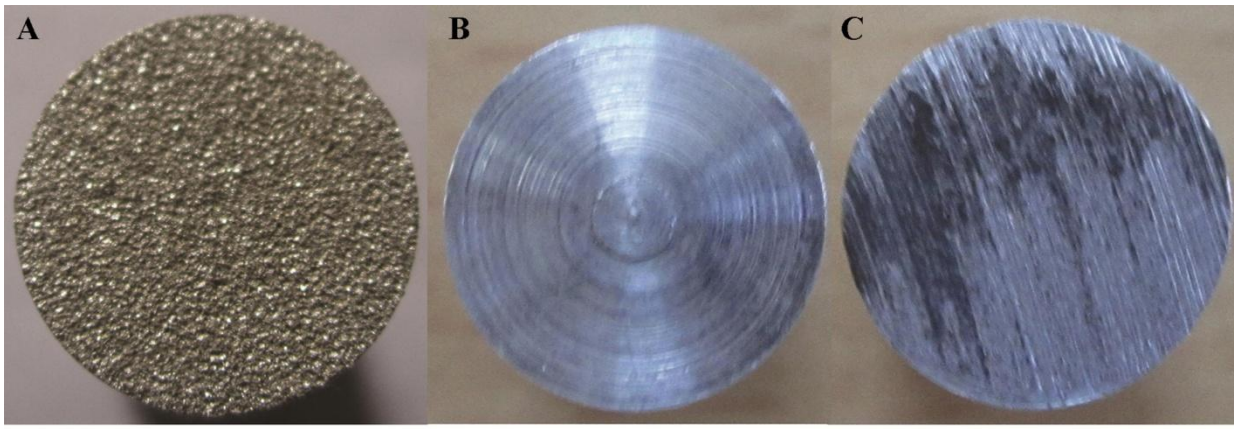

Figure 6: Surface topography of A) EDM surface B) As cast surface C) Worn surface

3.3. *Impact of high temperature on Hardness of composite*

The EDM surface hardness value of the unreinforced aluminium alloy was higher than as cast condition. Due to the impact of heat, materials get melted and machining takes place but some melted material solidifies during the flushing action and forms thermo effected layer [18-20]. The hardness value of this heat-treated layer is nominally higher. The reinforced silicon carbide particles possess low thermal conductivity and high meting point compare to that of aluminium alloy. Hence while electric discharge machining was performed materials surrounds the materials get melted and particle detachment from the surface occurs due to which electric

discharge machined hardness decreases. The detached silicon carbide particles increases the gap distance hence decreases current intensity. At higher weight fraction due to high density of silicon carbide particles, the particles are not suspended inside the gap due to which material melted in quicker manner and re-solidifies. Due to this recast layer hardness value of the composites increases.

Conclusions

The AA7050/B_4C_p/SiC_p composites were successfully fabricated through stir casting technique. K_2TiF_6 was added as flux to overcome wetting problem between aluminium and hard ceramic materials. The influence of high temperature on composites was and following results were concluded.

1) The hardness of the as cast composites increases with increase in weight percentage of reinforcement due to grain refinement, once after it reaches the critical point its starts decreasing due to inverse hall petch effect.
2) At high load delamination wear occurs, due to which SiC_p enters into the contacting surface and exerts very high pressure. It abrades and transfer ferrous from counter disc to hybrid composites leads to increase in worn surface hardness value from 106HRB to 134HRB when it reinforced with 2.5 weight percentage SiC particles. On the other hand it reduces from 134HRB to 122HRB owing to the poor formation of mechanically mixed layer.
3) The hardness of EDM machined surface was higher in aluminium alloy AA7050. This is due to deposit of re-solidified material on the work surface. The EDM hardness value of the composites was lower than aluminium alloy due to increased gap distance. At higher weight percentage hardness increases due to higher re-solidification rate.

References

1. Ranjit Bauri., Surappa M.K., *J. Mater. Process. Technol*. 209 (2009) 2077.
2. Aruria D., Adepu K., Bazavada K., *J. Mater. Res. Technol*. 2(4) (2013) 362.
3. Gode C., *Composites Part B*. 54 (2013) 34.
4. Ali Kalkanl., Sencer Yılmaz., *Mater. Des*. 29 (2008) 775.
5. Karamıs M.B., Alper Cerit A., BurhanSelc-uk., FehmiNair., *Wear*. 289 (2012) 73.
6. Michael Rajan H.B., Ramabalan S., Dinaharan I., Vijay S.J., *Mater. Des*. 44 (2013) 438.
7. Rosenberger M.R., Schvezov C.E., Forlerer E., *Wear*. 259. (2005) 590.
8. Sameezadeh M., Emamy M., Farhangi H., *Mater. Des*. 32 (2011) 2157.
9. Baradeswaran A., Elaya Perumal A., *Composites Part B*. 56 (2014) 464.
10. Baradeswaran A., Vettivel S.C., Elaya Perumal A., Selvakumar N., Franklin Issac R., *Mater. Des.* 63 (2014) 620.
11. Prasad D.S., Shoba C., *J. Mater. Res. Technol.* 3(2) (2014) 172.
12. Ranjith R., Giridharan P.K., *High Temp. Mater. Processes*. 19(3–4) (2015) 291.
13. Vijaya Ramnath B., Vijaya Ramnath B., Elanchezhian C., Jaivignesh M., Rajesh S., Parswajinan C., Siddique Ahmed Ghias A., *Mater. Des*. 58 (2014) 332.
14. Hu F.Q., Cao F.Y., Song B.Y., Hou P.J., Zhang Y., Chen K., Wei J.Q., *Procedia CIRP*. 6 (2013) 101.
15. Gopalakannan S., Senthilvelan T., *Measurement*. 46 (2013) 2705.
16. Torres A., Puertas I., Luis C.J., *Precision Engineering*. 40 (2014) 33.
17. Muthuramalingam T., Mohan B., *Arch. Civ. Mech. Eng*. 15 (2015) 87.
18. Ranjith R., Giridharan P.K., Devaraj J., *High Temp. Mater. Processes*. 20(2) (2016) 93.
19. Rozenek M., Kozak J., Daibrowski L., Eubkowski K., *J. Mater. Process. Technol*. 109 (2001) 367.
20. Debaprasanna, P., Siba, S.M., Jambeswar, S., and Layatitdev, D., *Measurement*. 46 (2013) 3581.