Preparation of Papers for "THE EFFECT OF HOT FORGING ON MECHANICAL AND TRIBOLOGICAL PROPERTIES OF AL ALLOY BASED MMC"

[1]Ajit Kumar Senapati, [2]Sasank Shekhar Panda, [3]Gopal Krushna Mohanta

ABSTARCT

Aluminum based particulate reinforced metal matrix composites (MMCs) are used in industries like aerospace, defense, automobile, structural engineering due to its high specific strength, stiffness, resistance at high elevated temperature and low thermal expansion. The aim of the present work is to investigate the effect of hot forging on mechanical and tribological properties of a MMCs based on the Al alloys LM6 reinforced with Fly Ash (FA) and Rice Husk Ash (RHA). The composite was prepared by using Stir casting route. Different properties such as hardness, density and wear were measured. The result of this research work shows that the FA based MMCs gives batter mechanical as well as tribological properties as compared with RHA based MMCs and un-reinforced LM6.

Keywords: LM6, Rice husk Ash, Fly Ash, stir casting, Hot Forging, mechanical and tribological properties.

1. INTRODUCTION

The improvement of material with a different combination of properties that cannot be met by the metals, conventional metal alloy, ceramics and polymeric materials. A composite is a combination of two or more dissimilar materials having a separate interface between them such that the properties of the resulting material are greater to the specific constituting components. Metal matrix composite consists of superior properties such as high strength, high stiffness, high elastic modulus, high electrical and thermal conductivity, high thermal stability and exhibits greater resistances to corrosion, oxidation and wear comparable to conventional material.

A composite produced by using the waste as reinforcements helps not only clearing environmental issues but also helps in increasing mechanical properties of the composites. Due to the increase in population, a large amount of waste materials are generated from mining, industrial and agricultural activities by the technology development.

- *Dr. Ajit Kumar Senapati is currently working as Associate professore at GIET, Gunupur, India, PH- 9437783220. Email: senapati.ajit@gmail.com*
- *Mr. Sasank Shekhar Panda, Mr. Gopal Krushna Mohanta are currently pursuing PhD in Mechanical Engineering in CUTM, India. PH:8895104466, 8280069914, Email: sekhar.4206@gmail.com, gkmohanty787@gmail.com*

The composites formed out of aluminum alloys are of wide interest owing to their high strength, fracture toughness, wear resistance and stiffness. Further these composites are of superior in nature for elevated temperature application when reinforced with ceramic particle.

Aluminium became an economic opponent to Steel in engineering applications because of its excellent combination of properties. Now a days, more Aluminium is consumed (on a volumetric basis) than all other non-ferrous metals/alloys including copper. The high utility index of Aluminium is due to many of its unique properties such as light weight, low density, good thermal and electrical conductivity, good fabric ability and superior corrosion resistance.

Normally automobile industry wants al based particulate composites to manufacturing piston, engine blocks, disc rotors brakes, drum, connecting rod, internal combustion engine cylinder liners and drive shafts. Among aluminium alloy LM6 is a popular choice for matrix material. It is primarily due to its good mechanical properties, weld ability and fluidity characteristics and it contains silicon as its major alloying elements.

By utilizing fly ash as reinforcement we can improve the hardness of metal matrix composites due to the ceramic reinforcements which are so hard. Rice husk is an agro based waste material which is in large quantities available in rice producing countries like India. It is also a good additive for composite material. Use of the Agro-industrial waste not only solve but also their storage and handling as a threat to the environment.

2. MATERIALS USED:

The pure form of aluminum is very soft in nature due to which the tensile strength, hardness are very low. To have an enhancement in its mechanical and tribological properties different reinforcements are added to it. In this research work following materials have been used for the fabrication of Al alloy based MMCs.

2.1. LM6 Alloy

In this experiment we have used LM6 alloy as a matrix material, which is an aluminium-silicon alloy which contained 12.249% of Si. In table-1 the chemical compositions of Lm6 alloy are given. LM6 alloys are chosen for their good strength-to-weight ratio, ease of fabrication at reasonable cost, good thermal conductivity, high strength at elevated temperature, excellent corrosion resistance as well as good castability and wear resistance properties. Thus, these alloys are suitable for aerospace, automotive and military applications. These Aluminum-silicon alloys are used to produce pistons therefore, known as “piston alloy”.

Table-1: Chemical Composition of Al-Si Alloy [Wt. %]

Compound	Wt %	Compound	Wt %
Si	12.2491	Ti	0.0672
Co	0.0174	Zn	0.0944
Fe	0.4353	Ni	0.0264
Cu	0.08	Sn	0.0632
Mn	0.1601	Cr	0.0199
Ca	0.0802	V	0.0146
Al	86.754		

2.2. Fly ash

Fly ash (FA) particles (usually of size 0-100micron), is used as reinforcing agent for the fabrication of MMCs. FA, which are extracted from residues generated in the combustion of coal can be used as reinforcement materials. Particulate reinforced aluminium matrix composites are gaining importance because of their low cost with advantages like isotropic properties and the possibility of secondary processing. The high electrical resistivity, low thermal conductivity and low density of fly ash may also helpful for making a light weight composites. The chemical composition of Fly Ash is given in Table-2.

Table-2: Chemical Composition of Fly Ash

Compound	Wt %
SiO2	63.34
Al2O3	23.6
Fe2O3	4.97
CaO	1.23
MgO	0.56
Na2O	0.11
K2O	0.64

2.3. Rice Husk Ash

Rice Husk Ash (RHA) are the hard protecting coverings of grains of rice used as an reinforcing element for the fabrication of Al alloy based MMCs. Rice husk is an agricultural residue abundantly available in rice producing countries. Husk Produced is around 20% of total rice production. Silica is the major constituent of rice husk ash and the following tables gives typical composition of rice husk and rice husk ash. With such a large ash content and silica content in the ash it becomes economical to extract silica from the ash, which has wide market and also takes care of ash disposal. The chemical composition of Fly Ash is given in Table-3.

Table-3: Chemical Composition of Rice Husk Ash

Composition	Wt %
SiO2	93.42
Al2O3	0.238
Fe2O3	0.167
CaO	0.823
MgO	0.53

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Na2O	0.25
K2O	1.94
LOI	2.632

3. METHODS USED FOR FABRICATION:

3.1. STIR CASTING METHOD

Two MMCs were manufactured by stir casting process. First MMCs is manufactured by taking LM6 alloy as matrix and Rice Husk Ash as reinforcement and second MMCs is manufactured with same matrix element and Fly Ash as reinforcement. First, Al-Si alloy matrix material was melted in resistance heated furnace in a graphite crucible and liquid metal heated at 7000C. Next RHA, FA are preheated to 4000C were added into molten aluminium materials by means of argons gas flow with rate of 20g/min. The stir casting set-up is shown in the figure No.1.

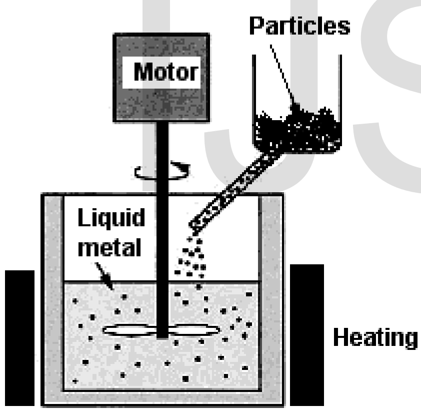

Fig. 1: Stir casting Set-up

3.2. HOT FORGING OF COMPOSITE

Samples for forging are made by machining the 32 mm diameter and 260 mm longer castings. After machining, 30 mm diameter and 80mm height samples of LM6 alloy and composite obtained for forging with different percentages of Fly Ash and Rice Husk Ash. The cast LM6 and LM6 reinforced by FA and RHA composites were subjected to hot forging using 100T Universal testing machine.

Table-4: Forging parameters

1	Type of forging	Press forging
2	Initial Billet Temperature	510oC
3	Final Billet Temperature	440oC
4	Die Type	Flat die
5	Deformation Ratio	4:1
6	Initial Billet Height	80 mm
7	Final Billet Height	20mm
8	Strain	0.72

4. RESULTS AND DISCUSSIONS

4.1 DENSITY MEASUREMENT

Density is the physical property of composite that reflects the characteristics. The proportions of the matrix and reinforcement in a composite are expressed either as the volume fraction or the weight fraction. The following figure shows the variation of density with the addition of different reinforcements in the LM6 Al alloy. The values of density are represented in table-5.

Table-5: Density of different Alloys and MMCs.

	Cast (Before Forging) (In g/cm3)	After Forging (In g/cm3)
LM6 alloy	2.611	2.713
LM6-RHA	2.571	2.672
LM6-FA	2.376	2.443

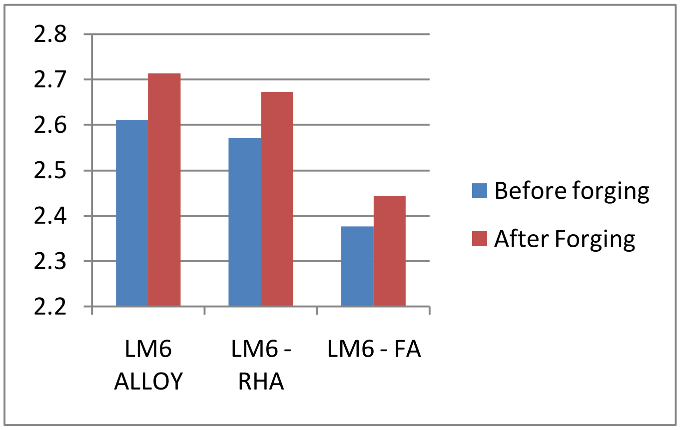

Fig. 2: Variation of density before and after forging

4.2. HARDNESS MEASUREMENT

Hardness test was carried out using Brinnell cum Rockwell hardness tester. The samples were prepared and polished to provide a scratch free test surface. Tungsten Carbide ball indenter of 20mm with 3mm tip was used for Brinnell Hardness Test (shown in Figure No. 2).

Fig. 3: Brinnell Hardness testing machine

Table-6: Hardness of different Alloys and MMCs.

	Cast (Before Forging) (BHN)	After Forging (BHN)
LM6 alloy	53.38	57.84
LM6-RHA	68.94	73.22
LM6-FA	76.25	79.76

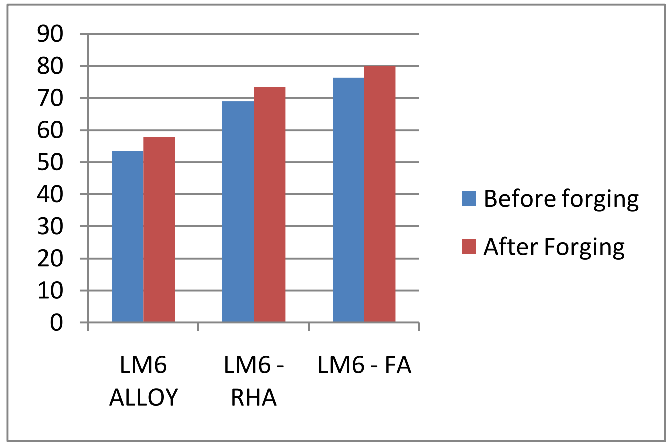

Fig. 4: Variation of Hardness before and after Forging

4.3. TRIBOLOGICAL PROPERTIES (Wear Test)

A pin-on-disc test apparatus was used to investigate the dry sliding wear characteristics of the composites. The disc used is En-32 steel hardened to 62 HRC, 75 mm track diameter and 8 mm thick. The initial weight of the samples was measured using a single pan electronic weighing machine with an accuracy of 0.01 g. During the test, the pin is pressed against the rotating disc. The wear test was conducted by applied a load of 30 N with a constant speed of 254 rpm at room temperature. Following figure shows the wear of LM6 alloy and the two MMCs. Table No. 7 & 8 shows the wear of LM6 Alloy and MMCs before and after forging.

Table- 7: Wear of LM6 Alloy and MMCs before Forging

	TRACK	LOAD	RPM	INITIAL WEIGHT (in gm)	FINAL WEIGHT (in gm)	LOSS OF WT. (in gm)
LM6 ALLOY	75	30	254	3.710	3.692	0.018
LM6 – RHA	75	30	254	3.832	3.817	0.015
LM6 – FA	75	30	254	3.881	3.869	0.012

Table- 8: Wear of LM6 Alloy and MMCs after Forging

	TRACK	LOAD	RPM	INITIAL WEIGHT (in gm)	FINAL WEIGHT (in gm)	LOSS OF WT. (in gm)
LM6 ALLOY	75	30	254	3.784	3.768	0.016
LM6 – RHA	75	30	254	3.590	3.577	0.013
LM6 – FA	75	30	254	3.732	3.721	0.011

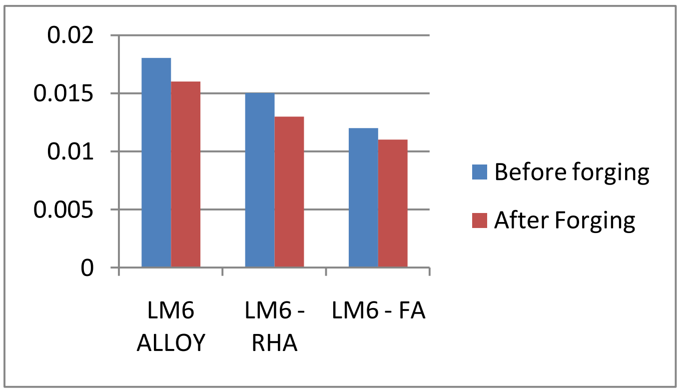

Fig. 5: Variation of wear rate before and after Forging

5. CONCLUSION

From the above results and discussion the following conclusions are made:

1. The fabrication of Al-Si alloy along with fly ash and rice husk ash were successful.
2. The weight calculations revealed that, although both the matrices were supplied with 15wt% of fly ash and rice husk ash respectively, even after several trials, 13wt% of fly ash was accepted whereas 11wt% of rice husk ash was accepted in their respective matrices.
3. The stir casting method used for the preparation of composites is easy, efficient and most economical method. It also helps in the uniform distribution of reinforced particles (Fly ash and RHA) with the matrix metal..
4. Before forging the density of the MMC, reinforced with fly Ash was found 7.5% and 9% less than MMC reinforced with rice husk and virgin Al-Si Alloy respectively and after forging it was found 8.7% and 9.9%.
5. The hardness of the RHA composite increases from 68.94 to 73.22 BHN and that of FA composite increases from 76.25 to 79.76 BHN.
6. Before forging metal matrix composites, reinforced with fly ash shows 38 % and 26% batter tribological property than MMC reinforced with rice husk and virgin Al-Si Alloy respectively.
7. After forging metal matrix composites, reinforced with fly ash shows 31% and 15% batter tribological property than MMC reinforced with rice husk and virgin Al-Si Alloy respectively.
8. The incorporation of the Fly Ash particles in the Al-Si alloy (LM6) matrix as a reinforcement increases the wear resistance of the material.
9. From the above experiment it was concluded that the Fly Ash reinforced composites shows better mechanical and tribological properties compared to Rice Husk Ash composite due to the presence of more alumina in Fly Ash particles.

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