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EFFECT OF LOAD AND SPEED ON WEAR PROPERTIES OF Al 7075-FLY ASH COMPOSITE MATERIAL

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***Abstract*:** In the present paper we experimentally investigate the effects of load and sliding speed on the friction coefficient and wear properties of pin of Al 7075-Fly Ash composite material on Pin on Disc apparatus. Composites are most successful materials used for recent works in the industry. Metal composites possess significantly improved properties including hardness and wear resistance compared to alloys or any other metal. Hence composites with fly ash with Al 7075 as reinforcement are optimizes the different physical and mechanical properties which widely used in the automotive and space craft applications.

Keywords: Al 7075, Fly Ash, Coefficient of Friction, Wear Rate, Load, Sliding Speed, Scanning Electron Microscope

I. INTRODUCTION

The particulate reinforced aluminium composites are gaining importance now the days because of their low cost with advantages like isotropic properties and the possibility of secondary processing facilitating fabrication of secondary components. Cast aluminium matrix particle reinforced composites have higher specific strength, specific modulus, hardness and good wear resistance as compared to unreinforced alloys.

In the present work, fly-ash which mainly consists of refractory oxides like silica, alumina, and iron oxides is used as reinforcing phase. Composite was produced with 10gm to 40gm fly-ash as reinforcing phase. In this work we investigate the effects of normal load and sliding speed on the coefficient of friction and wear properties of Al 7075-Fly Ash composite material on Pin on Disc apparatus against a mild steel disc. After that we also made the microstructure study of the wear pin on the Scanning Electron Microscope apparatus which shows the condition of surface of all composite pins to judge the wear effects. These aspects have been discussed by many researchers:

K.V. Mahendrai[1] in their paper on Fabrication of Al-4.5% Cu alloy with fly ash metal matrix composites and its characterization studied Metal matrix composites (MMCs) are engineered materials, formed by the combination of two or more dissimilar materials (at least one of which is a metal) to obtain enhanced properties. In the present investigation, an Al-4.5% Cu alloy was used as the matrix and fly ash as the filler material. The composite was produced using conventional foundry techniques. The fly ash was added in 5%, 10%, and 15 wt. % to the molten metal. The composite was tested for fluidity, hardness, density, mechanical properties, impact strength, dry sliding wear, slurry erosive wear, and corrosion. Microstructure examination was done using a scanning electron microscope to obtain the distribution of fly ash in the aluminium matrix. The results shows an increase in hardness, tensile strength and wear resistance properties with increasing fly ash content. P. Shanmughasundaram[2] studied the Development of lightweight materials has provided the automotive industry with numerous possibilities for vehicle weight reduction. Progress in this area depends on the development of materials, processing techniques, surface and heat treatments Aluminium matrix ceramic reinforcement composites have attracted increasing attention due to their combined properties such as high specific strength, high stiffness, low thermal expansion coefficient and superior dimensional stability at elevated temperatures as compared to the monolithic materials. An attempt has also been made to investigate its microstructure, mechanical, wear and corrosion behavior of composites. Deepak Singla[3] studied that Metal composites possess significantly improved properties including high tensile strength, toughness, hardness, low density and good wear resistance compared to alloys or any other metal. There has been an increasing interest in composites containing low density and low cost reinforcements. Among various reinforced materials used, fly ash is one of the most inexpensive and low density reinforcement available in large quantities as waste product during combustion of coal in thermal power plants as well as in the brick factory and rice mill.

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II. EXPERIMENTAL WORK

A. Sliding Wear

A cylindrical pin of size 10mm diameter and 40mm length were prepared for all compositions of Al 7075-Fly Ash composite material and after that tested on the Pin on Disc apparatus which connects directly with computer. Table 2.1 shows the composition of Al 7075-Fly Ash composite material. Figure 2.1&2.2 shows the Pin on Disc wear testing machine and the specimen of all compositions respectively. Before testing the surface of the all specimens was polished with the help of 1000 grit paper. All the wear tests were carried out at the room temperature having relative humidity 60% for. The rotating disc was made of mild steel. These tests were carried out at different speeds and normal load conditions. Here we varied the load at 30N, 50N, 70N and speed at 600rpm, 800rpm,1000 rpm for 5 minutes. Wear rate can be calculated by the formula:

$$WR = (w_1 - w_2)/2\pi rnt$$

Table 2.1: Composition Used For Metal Matrix Composite

No. of Samples	Aluminium(7075) (gm)	Magnesium (gm)	Fly Ash (gm)	Total Weight (gm)
S1	500	10	40	550
S2	500	20	30	550
S3	500	30	20	550
S4	500	40	10	550

Figure 2.1: Pin on Disc Wear Testing Machine

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Figure 2.2: Specimen for Wear Test

B. Microstructure Analysis

Scanning Electron Microscope(SEM) was used to analyze the wear surface profile to decide the wear mechanism of all compositions. First of all, for proper testing on SEM these specimens were manually polished by an etchant. Figure 2.3 shows the picture of JEOL JSM-6610LV SEM machine.

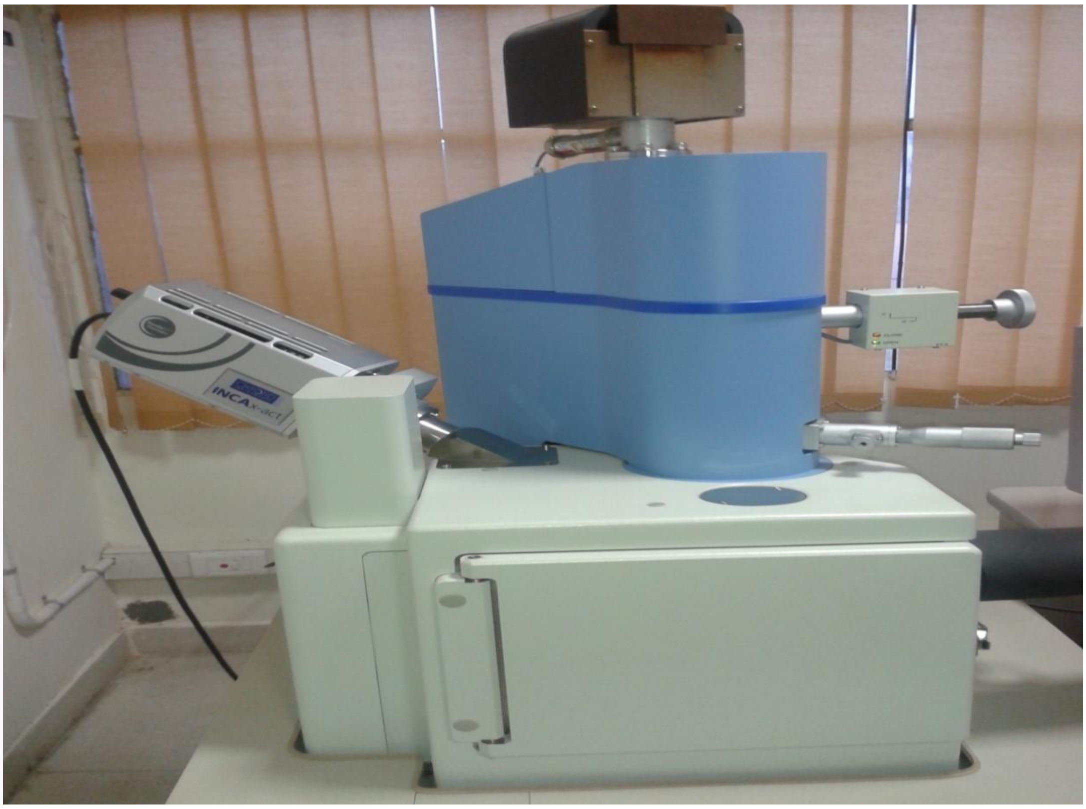

Figure 2.3: JEOL JSM-6610LV Scanning Electron Microscope

III. Results & Discussion

A. Sliding Wear and Coefficient of Friction (COF)

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LOAD	30 N			50 N			70 N		
SPEED (rpm)	600	800	1000	600	800	1000	600	800	1000
Coefficient Of Friction(μ)	0.390	0.495	0.416	0.372	0.315	0.261	0.242	0.122	0.086
Wear rate $*10^{-8}$(gm/mm)	21.24	14.45	16.95	28.69	31.50	36.99	39.56	63.62	69.002

Table 3.1: Experimental values of COF and Wear Rate for Sample1

Table 3.2: Experimental values of COF and Wear Rate for Sample2

LOAD	30 N			50 N			70 N		
SPEED (rpm)	600	800	1000	600	800	1000	600	800	1000
Coefficient Of Friction(μ)	0.615	0.896	0.693	0.604	0.589	0.446	0.325	0.225	0.178
Wear rate $*10^{-8}$(gm/mm)	6.10	1.06	4.60	17.71	18.99	25.06	25.70	41.85	56.09

In the present work, we were examined the coefficient of friction and wear rate of composite pins as a function of fly ash content at various load and sliding speed conditions against the high carbon alloy steel(EN-31) disc. Various experimental data of COF and wear rate are tabulated in the form of table (3.1-3.4) and also the table 3.5 for hardness of Al 7075- Fly Ash composites [3]. These tables show the COF and rate of wear of composite pins at different load and speed conditions. Wear resistance of the Al 7075-Fly Ash composites is increased as of fly ash content increased.

Figure (3.1&3.2) shows the graph between COF and wear rate Vs fly ash content respectively at load conditions of 30N and at various sliding speed as on 600rpm, 800rpm & 1000 rpm. From figure 3.1, we observed that as of we increases the fly ash content the value of COF improves but up to the some incorporation of reinforcing material after that it decreases. In this fig. we observed COF at diff. speeds 600,800 & 1000 rpm. As the sliding speed increases initially from 600rpm to 800rpm the value of COF for various values of fly ash content also increases in great extent due to of oxide layer and mechanical mixing layer (MML). As the sliding speed increases, the surface of mild steel reacts to form ferrous oxide along with aluminium oxide

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Table 3.3: Experimental values of COF and Wear Rate for Sample3

LOAD	30 N			50 N			70 N		
SPEED (rpm)	600	800	1000	600	800	1000	600	800	1000
Coefficient Of Friction(μ)	0.441	0.493	0.463	0.427	0.303	0.272	0.253	0.194	0.163
Wear rate $*10^{-8}$(gm/mm)	16.78	14.17	15.49	26.70	31.80	34.93	37.10	53.22	57.69

Table 3.4: Experimental values of COF and Wear Rate for Sample4

LOAD	30 N			50 N			70 N		
SPEED (rpm)	600	800	1000	600	800	1000	600	800	1000
Coefficient Of Friction(μ)	0.287	0.357	0.312	0.257	0.245	0.132	0.229	0.180	0.129
Wear rate $*10^{-8}$(gm/mm)	27.90	22.74	25.80	37.20	39.45	53.34	41.40	54.84	63.05

Table 3.5: Experimental Data for Hardness of Al 7075-Fly Ash Composites

Samples	S1	S2	S3	S4
Hardness(HRB)	70	77	75	68

and MML b/w the composite pin and mild steel disc was formed. It is obvious that the work hardening of the Al occurs during the sliding action and the formation of oxide layer on the surface of the pin enhances the wear resistance. But from 800rpm to 1000 rpm the value of COF decreases due to the thermal softening effect b/w pin and disc which smash out the oxide layer. Acc. to the behavior of the COF as of it increases initially and after that go down, the wear rate first decreases and then suddenly increases as shown in fig. 3.2.

Figure (3.3&3.4) shows the graph between COF and wear rate Vs fly ash content respectively at load conditions of 50N and at various sliding speed as on 600rpm, 800rpm & 1000 rpm. In this case as we increases the sliding speed the COF go down and wear rate increases due to the thermal softening effect of the Al which lowers the interfacial bond b/w the Al and fly ash and also the protective oxide layer smashed out during the sliding action at higher speed and high load conditions as shown

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in fig. 3.4. The same results are tabulated when graphs b/w COF and wear rate Vs fly ash plotted at load conditions of 70N due to the same effect of thermal softening of Al which lowers the bond b/w Al and ash content as shown in figure (3.5&3.6).

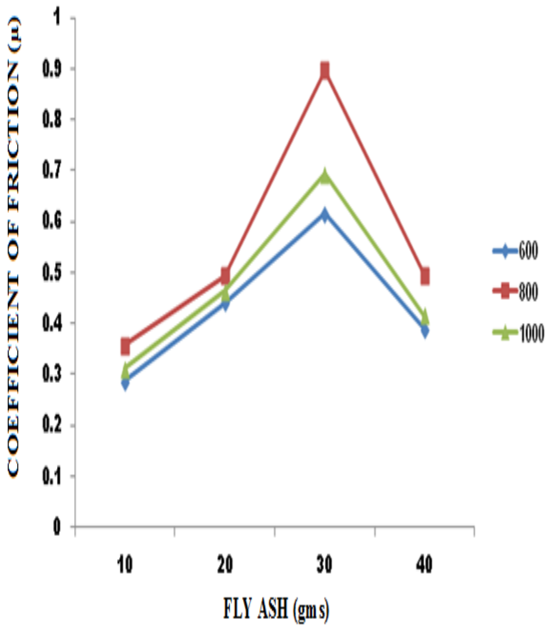

Figure 3.1: COF Vs FLY ASH at 30N

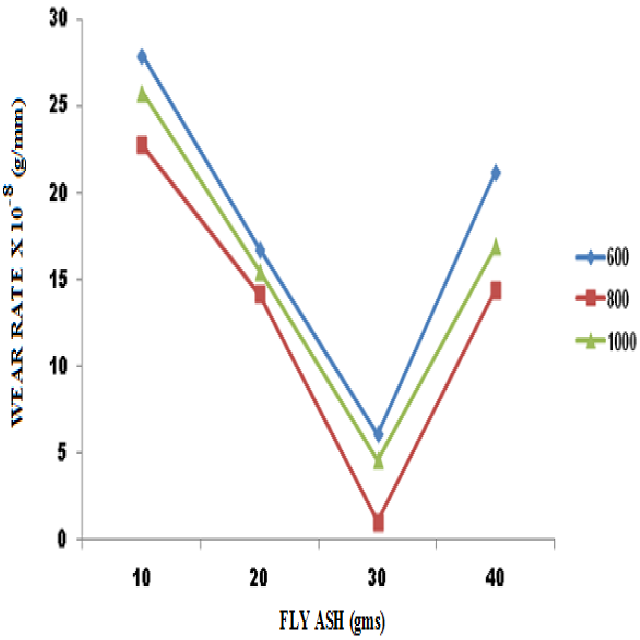

Figure 3.2: WEAR RATE Vs FLY ASH at 30N

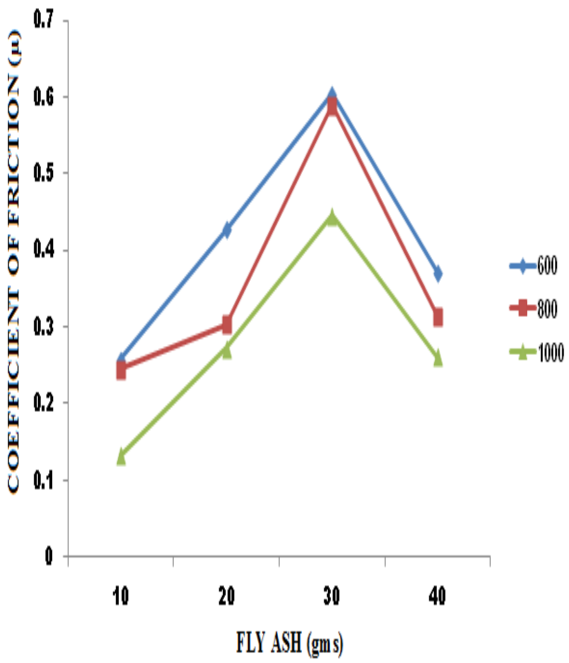

Figure 3.3: COF Vs FLY ASH at 50N

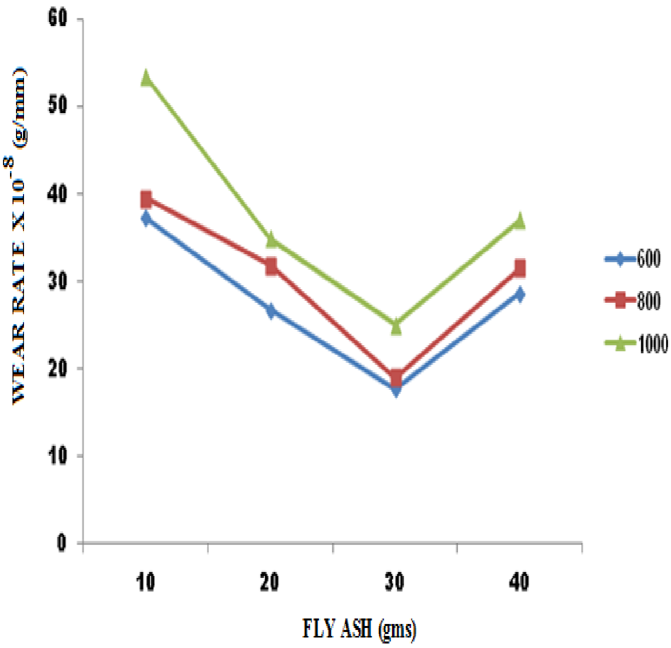

Figure 3.4: WEAR RATE Vs FLY ASH at 50N

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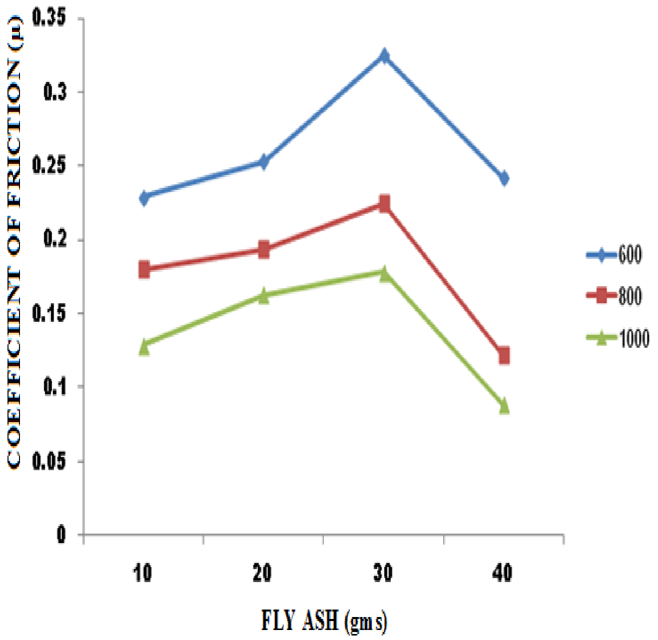

Figure 3.5: COF Vs FLY ASH at 70N

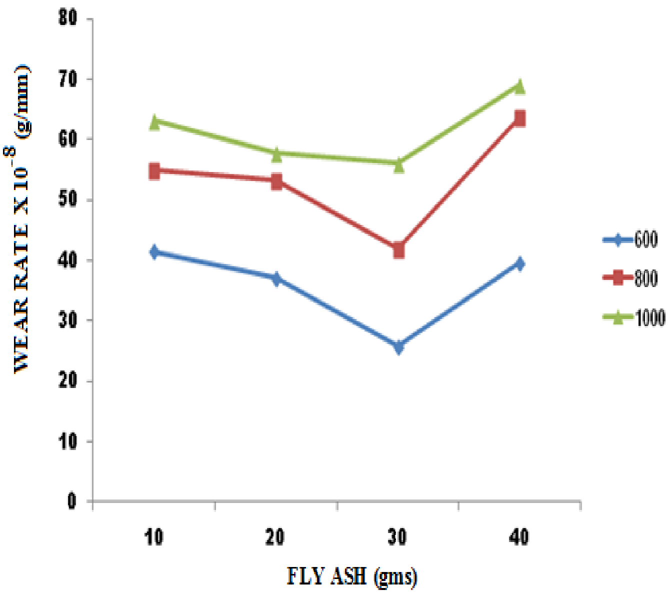

Figure 3.6: WEAR RATE Vs FLY ASH at 70N

The obtained results are in line with the other researchers [2]. By superimposing the fig. 3.2, fig.3.4 & fig.3.6, it can be observed that the wear rate of the Al 7075- Fly Ash composites increases as the load increases from 30N to 70N and also the trend in wear resistance can be found to be increasing with increase of ash content in the composites. This increase in wear resistance of the composite is due to the reason of the reinforcement material fly ash which is much harder than the matrix material Al. This increase in wear resistance can also be attributed to a better interfacial bonding b/w Al and fly ash particles thus helps in preventing the damages caused due to the sliding action. Incorporation of 30gm fly ash to the Al matrix was very effective in reducing the wear loss due to the strong interfacial bond which transferring the load from Al matrix to the ash content as these are harder in nature. As the ash content increases beyond 30gm wear rate increases as load and sliding speed increases. This may be due to clustering of fly ash particles and poor interfacial bonding b/w Al and fly ash particles.

B. Microstructure Analysis of Wear Test Specimen

Figure 3.7 shows the worn surfaces of Al 7075-Fly Ash composites for all samples after conducting of wear test at conditions 70N and 1000rpm. Fig. shows the extent of wear on the surface of composites in the form of grooves and scratches. Figure.3.7(a), (b), (c)&(d) shows the microstructure of composite, as the fly ash content increases, the grooves along the sliding direction were smaller. This is due to the properties of fly ash as of ash content increases hardness of composite material also increases but up to some extent. This occurs up to the 30gm of fly ash and after that the hardness moreover all mechanical and physical properties goes down. Initially grooves and scratches were diminish as the ash content increases up to 30gm but after it again increased. Since Al composite is much softer than the steel disc, steel penetrates inside the composite matrix producing cuts and large amount of material loss. Hence ability to resist the wear rate improves as of ash content increases.

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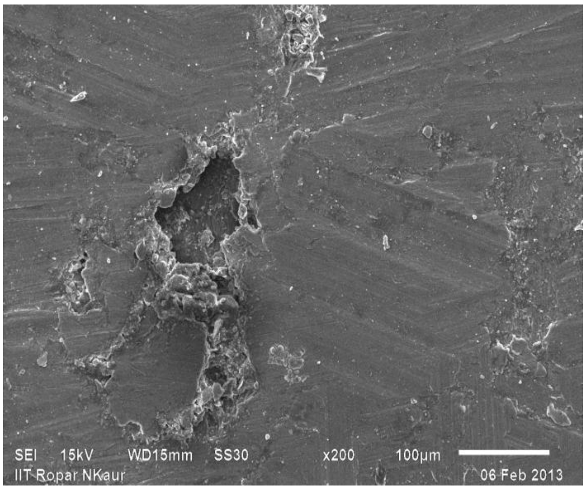
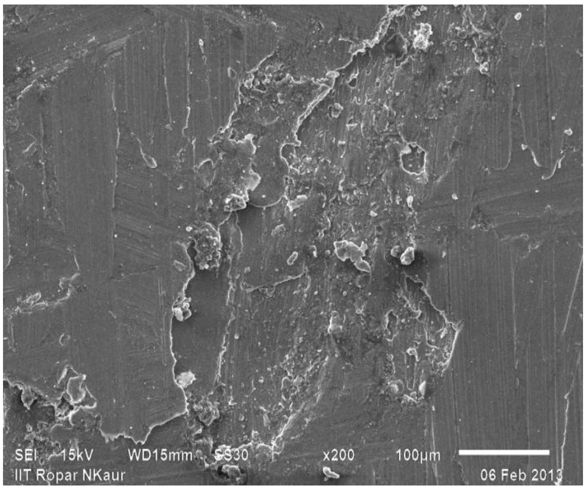
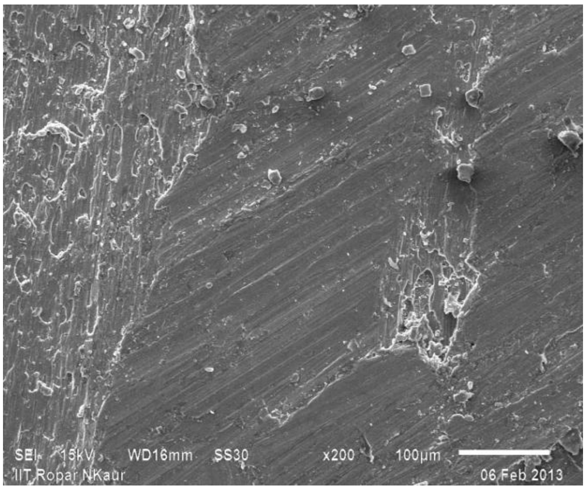


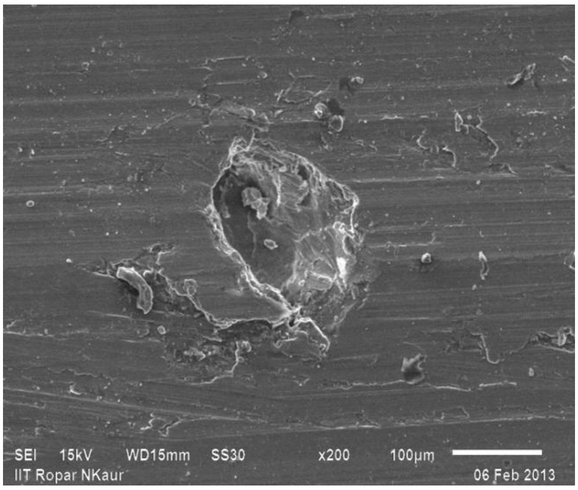
3.7(a)FA-10gm



3.7(b)FA-20gm



3.7(c)FA-30gm



3.7(d)FA-40gm

Figure 3.7:Worn surfaces of Al 7075-Fly Ash Composites on different range of Fly Ash (a),(b),(c) &(d) at 70N and 1000rpm

IV. CONCLUSIONS

Here we successfully examined the wear and friction properties of Al 7075-Fly Ash Composites by using Pin on Disc wear testing machine. We have drawn various conclusions from the data of coefficient of friction and wear rate:

a) As we increase the load and speed, the wear rate of composites increases and coefficient of friction decreases.
b) Result shows that the coefficient of friction increases as the fly ash content increases and improves the ability to resist the wear. This is due to the favorable effect of fly ash particles which increases the hardness of composite material up to some range.
c) However the addition of 30gm fly ash particles in the Al 7075 was very effective to improve its ability to resist the material loss.

From the above results we find the Sample2 having a good coefficient of friction and ability to resist a wear for a long time. So that these composites could be used in those sectors where good mechanical and physical properties are required as like in automobile and space industries.

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BIOGRAPHY

Myself Deepak Singla graduated in 2010 with 75% (hon's) and pursuing my master degree in manufacturing science with 72% from Kurukshetra University. Presently I am working on my thesis under the guidance of Dr. S.R. Mediratta(DG). My research interest is in the material science and mechanical vibration. I have already published one research paper in International Journal of Innovative Research in Science, Engineering and Technology.