

# The Effect of Extrusion on Microstructure, Mechanical and Wear Properties of AL7068 MMCs

<sup>1\*</sup>Sirajuddin, <sup>2</sup>Ashraf Ali, <sup>3</sup>Basavaraja, <sup>4</sup>D Ananth Kumar, <sup>5</sup>Deepak, <sup>6</sup>N Mohan

<sup>1, 2,3,4,5</sup>.UG Students, Department of Mechanical Engineering, Nitte Meenakshi Institute of Technology, Bangalore,560064, India

<sup>6</sup>Professor Department of Industrial Engineering & Management, Dr.Ambedkar Institute of Technology, Bangalore, 560056, India

**ABSTRACT:** Metal matrix composite (MMC) has dramatically improved properties including high mechanical strength mechanical modulus, damping ability and strong wear resistance compared to unreinforced alloys. Composites containing low density and low cost replacements have become increasingly of interest. Among the numerous discontinuous dispersoids used, SiC is one of the largest available in expensive low density reinforcement which is cost efficient. Therefore, composites with SiC as reinforcement in small engine applications are expected to resolve the cost barrier for wide spread use in automotive. In the present test, A7068 matrix alloy was strengthened with specific Wt percent of SiC (3 percent and 5 percent) for its microstructure, mechanical & wear properties. MMCs and later were measured before and after extrusion with as-cast alloy. The A7068 MMCs microstructure shows a moderately even dispersal of SiC in matrix A7068. The composite's longevity, stiffness, and tear properties increased with SiC's weight percentage increasing. Extruded MMCs from Al7068 demonstrated superior performance, i.e. stiffness, strain and wear properties relative to MMCs previous to extrusion. The present research illustrates the prominent characteristics of SiC's casting methodology and classification enhanced Al7068 MMCs.

**KEYWORDS:** A7068 alloy, SiC, Microstructure, Hardness, Compression and Wear.

## I.INTRODUCTION

Metal matrix composite is a composite material which contains at least two constituent metal components. Additionally, two of the other components can be another metal or some other material, such as a ceramic or natural compound. The composite generally has finest characteristics than any of the individual components. MMCs are made by dispersing a reinforcing material into a (usually ductile) metal matrix. The surface of the reinforcement can be shielded to stop a chemical reaction with the matrix. The matrix is the single crystal monolithic or mono crystalline substance into which the reinforcement is embedded and is fully continuous. Unlike two materials sandwiched together, this capacity that there is a path across the matrix to every stage in the substance. The reinforcing element is incorporated in the matrix. The reinforcing typically no longer performs a basic protective function that strengthens the substance but is utilized in addition to sharing physical residences such as wear and corrosion resistant to improved fatigue presence co-efficient friction or thermal conductivity and in turn its weight small. The strengthening can be either continuous or discontinuous. They can be designed to improve wear resistance and better ambient temperature, improved thermal and mechanical fatigue and creep tolerance than those of monolithic alloys, such as high physical strength and stiffness. Discontinuous MMCs may be isotropic, but are severely impaired by the existence of weak and almost non deformable reinforcements such as particulate whiskers or strong fibres, such as Al / SiC or Al<sub>2</sub>O<sub>3</sub> composites, and can be employed with normal metal processing techniques such as extrusion there are some improved properties for MMCs provided underneath. Owing to the highest basic electrical rigidity and wear resistance in addition to the manufacturer temperature.

## II.OBJECTIVES

- ❖ Materialation of Al7068/SiC composites by Stir Casting Method.

- ❖ Extruding the Al7068/SiC composites at a ratio of 1:4.32.
- ❖ Microstructure characterization of the composites using Optical microscope and SEM.
- ❖ Evaluation of mechanical properties of the composites.
- ❖ Evaluation of Tribological properties of the composites
- ❖ Comparing the results of mechanical and tribological properties of as cast alloy with composites.
- ❖ Drawing conclusion based on the obtained results.

### III.LITERATURE SURVEY

**Rama Rao et al [1].**Examined the aluminum alloy boron carbide composites were materialized with specific particulate weight fraction (2.5, 5 and 7.5 per cent) using liquid metallurgy methods. Phase identification was performed on boron carbide via the evaluation of x-ray diffraction analysis microstructure with SEM; a composite was characterized by hardness and compression testing. The impact effects shows render the boron car-bide larger. The composites number declined while the stiffness rose. Whereas the compressive power of the composites used to be improved with the percentage of boron carbide in the composites being enlarge.

**Balasivanandha prabu et al [2].**Investigated the best method to boil and time to heat. Material aluminum alloy silicon carbide MMC composite with unnecessary silicon content, with 10 percent SiC through the use of stirring velocities and stir in periods. The produced composite microstructure was once studied by means of an optical microscope and scanning electron microscope. The tests with respected pace and stirring time affected the composite's microstructure and toughness. They also look at why the particle team was more at lower stirring velocity with decrease stirring time. Increasing the time and pace of stirring resulted in better distribution of particles. The mechanical analysis of results also showed that stirring velocity and stirring time influence the composite's toughness. The appraised standard toughness was once done with 10min stirring at 600 rpm. But the properties deteriorated again over the stir rate. This will learn how to establish the trend between processing parameters including stirring velocity and stirring time with microstructure and composite hardness.

**Karunamoorthy et al [3].**Analyzed that FEA models based on 2D microstructure were developed to learn about MMC's mechanical behaviour. The mannequin takes into account the consequences of randomness and clustering. From the model, the results of particle clustering on stress, strain response and failure behavior were studied. Residential optimization was performed from MMC microstructure evaluation due to the fact that the properties depend on the arrangement of the particles in the microstructure. To model the micro-structure for finite element analysis (FEA), the image of micro-buildings converted from the raster into vector form than it converted push to faze IGES and mesh in ANSYS 7 FEA mannequin.The failure for particle clustered and non-clustered micro-structures such as Particle Interface decohesion and fracture the estimates.

**Sozhamanna et al [4].**Analyzed that the usage of gasoline pressure penetration solution may be synthesized with A356 fly ash cenosphere composites over a wide variety of reinforcement scale fraction from 20 to 65 percent. The densities of Al356 fly ash cenosphere composites, developed under a variety of experimental conditions, are within the range of 1250-2180 kg / m<sup>3</sup> corresponding to the cenosphere fraction in the range 20-65 percent.

**Rao and Sivaram et al [5].**Elaborately reviewed the ring compression check for extraordinary interface conditions and lubricants like graphite, zinc stearate, grease, and laptop oil. The reductions in peak and temperature have no giant impact on the friction elements and are possibly to rely on 25 the tool material mixture and the surface conditions. They concluded that some of the calibrations would yield friction factor increased than team spirit and may also pose concern in these being used, specifically for the contrast of go with the flow stress.

Material of AL7068 MMCs are fabricated by using stir casting then afterwards extrusion is done on alloy and composites then after the micro characterization, mechanical properties and tribological studies are evaluated based upon the results obtained the conclusion is given.

#### IV.METHODOLOGY

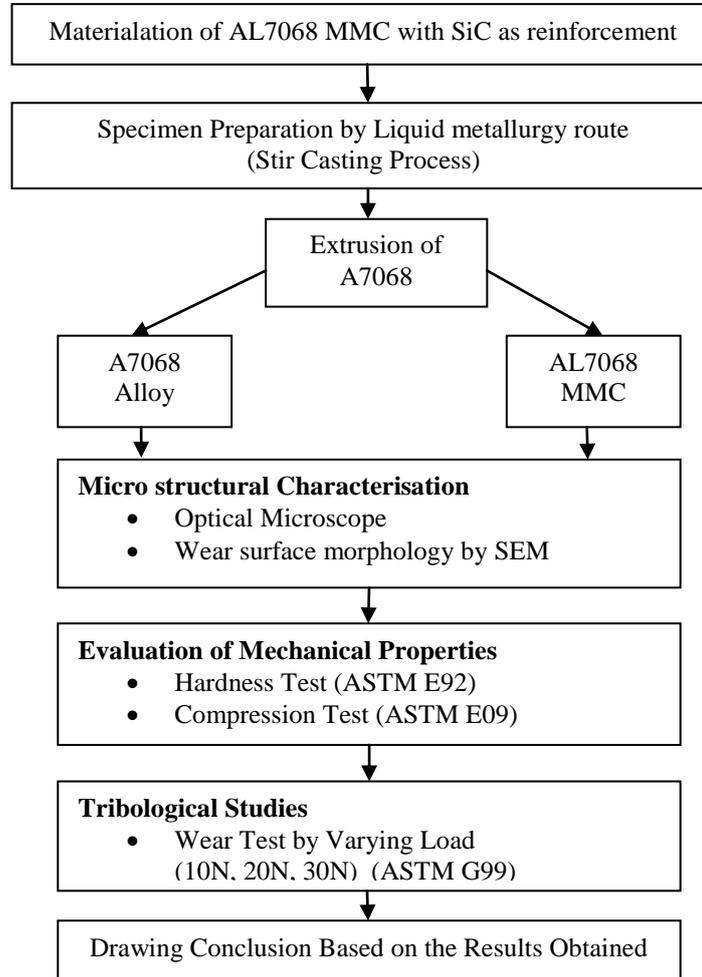


Figure 1: Flow Chart of Experimental Work

#### V.EXPERIMENTAL SETUP

This method has the primary advantage of very small development costs for MMCs. It is placed in a graphite crucible of an Induction furnace and heated to a temperature of 720<sup>0</sup>c .Mean while a mixture of SiC of varying combinations & fixed amount of graphite is placed in a muffle furnace for a period of 2-3 hrs at a temperature of 150-200<sup>0</sup>c. Since solid-phase production takes a longer period than the solid-phase materialization solution. Throughout this method, the crucial factor is to establish sufficient wetting between the particulate reinforcement and the molten metal, which from in homogeneity in the reinforcement.

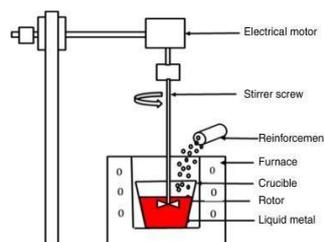
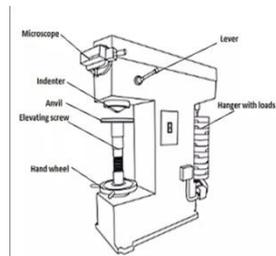


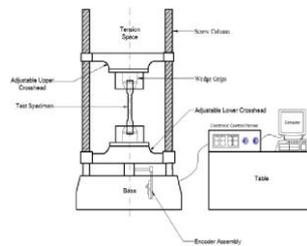
Figure 2: Stir Casting Setup

The Vickers hardness test is used in the context of the micro hardness test load range to assess the hardness of a material. However, the hardness test is also used to test thin layers such as coatings or to solve the problems of fragile and cracking materials.



**Figure 3: Vicker Hardness Tester**

The compression test is used to assess the behaviour of a material when measuring variables such as tension, strain and deformation are undergoing a compressive load.

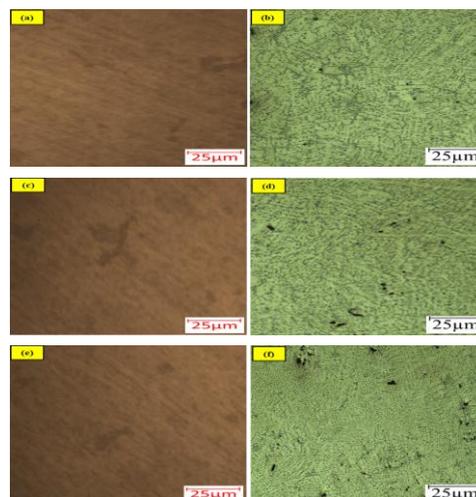


**Figure 4: Universal Testing Machine**

Wear test is carried out to predict the performance of wear and to examine the wear mechanisms. The two main reason as per material point of view test is performed to evaluate the property of a wear and to adequate for a specific wear application and to study the corrosion of a material.

## VI.RESULTS & DISCUSSION

### 1. Micro structural Characterization of A7068 alloy and its composites before and after extrusion using Optical microscope



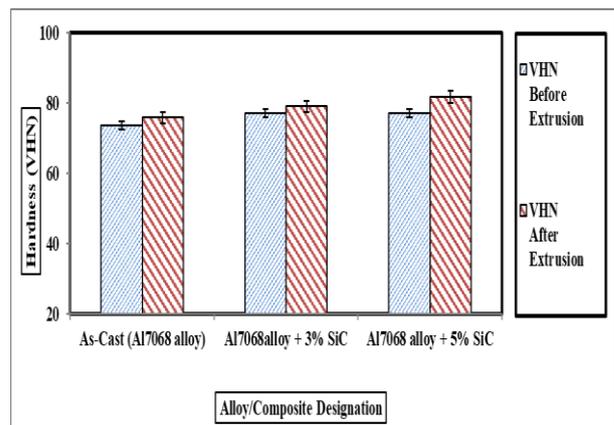
**Figure 5: Microstructure Characterization of A7068 alloy and its composites before and after extrusion using Optical Microscope, Where (a) A7068 alloy before extrusion, (b) A7068 alloy after extrusion ,(c) Al7068 alloy + 3% SiC before extrusion, (d) Al7068 alloy + 3% SiC after extrusion, (e) Al7068 alloy + 5% SiC before extrusion, (f) Al7068 alloy + 5% SiC after extrusion**

Figure 5: Microstructure Characterization of A7068 alloy and its composites before and after extrusion using Optical Microscope. From 1(a-b) shows the optical micrograph of A7068 alloy before and after extrusion. From Figure 1(b) we can see equated fine grains which is due to extrusion process. From 1(c-f) shows the optical micrograph of A7068 alloy reinforced with 3% and 5% SiC before and after extrusion. From the micrographs we can see the even dispersal of SiC in the A7068 matrix..

**2. Hardness test results of A7068 alloy and its composites before and after extrusion.**

**Table 2.1: Hardness test values of A7068 alloy and its Composites**

S/No	Alloy/Composite	Designation	Hardness VHN (Before Extrusion)	Hardness VHN (After Extrusion)
1	As-Cast (Al7068 alloy)	A7068	73.5	75.7
2	Al7068 alloy + 3% SiC	3S	76.9	78.9
3	Al7068 alloy + 5% SiC	5S	77.0	81.6



**Figure 6: Hardness test values of A7068 alloy and its Composites before and after extrusion**

Figure 6: shows the Hardness test values of A7068 alloy and its composites before and after extrusion. From the figure we can see that there is a slight increase in hardness values after extrusion. The percentage increase in hardness values of A7068 alloy after extrusion was found to be 2.99 %. Similarly, the percentage increase in hardness values of Al7068 alloy reinforced with 3% SiC and 5% SiC was found to be 2.60 % and 5.97 % respectively after extrusion. The increase in hardness values was due even dispersal of ceramic reinforcement and equated matrix grain structure leading to improvement in hardness in the matrix.

**3. Compression test results of A7068 alloy and its composites before and after extrusion**

**Table 3.1: Compression test values of A7068 alloy and its composites before and after extrusion.**

S/No	Alloy/Composite	Designation	UCS (Mpa) (Before Extrusion)	UCS (Mpa) (After Extrusion)
1	As-Cast (Al7068 alloy)	A7068	106	119
2	Al7068 alloy + 3% SiC	3S	118	129
3	Al7068 alloy + 5% SiC	5S	125	137

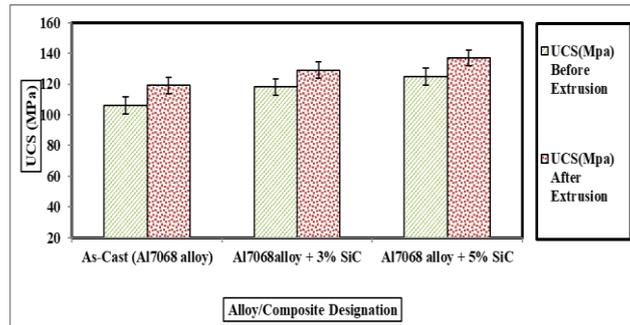


Figure 7: Compression test values of A7068 alloy and its composites before and after extrusion

Figure 7: shows the compression test values of A7068 alloy and its composites before and after extrusion. From the figure we can see that there is a slight increase in UCS values after extrusion. The percentage increase in UCS values of A7068 alloy after extrusion was found to be 12.26 %. Similarly, the percentage increase in hardness values of Al7068 alloy reinforced with 3% SiC and 5% SiC was found to be 9.32 % and 9.6 % respectively after extrusion. The increase in UCS values was due to the addition of hard ceramic reinforcement in the matrix and grain refinement caused by the addition of reinforcement and extrusion process.

4. Wear test results of A7068 alloy and its composites before and after extrusion

Table 4.1: Wear rate test values of A7068 alloy and its Composites before Extrusion

Wear rate of A7068 & its MMCs before Extrusion					
S/No	Load(N)	10	20	30	
1	As-Cast (Al7068 alloy)	1.6682	1.6715	1.6758	
2	Al7068 alloy + 3 % SiC	1.6515	1.6548	1.6554	
3	Al7068 alloy + 5 % SiC	1.6423	1.6435	1.6441	

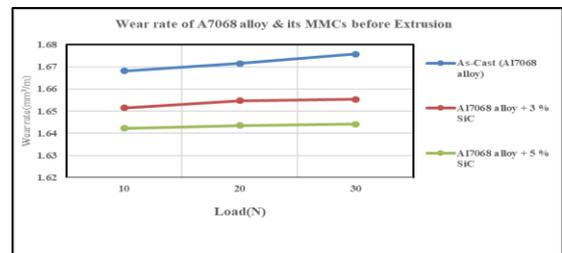
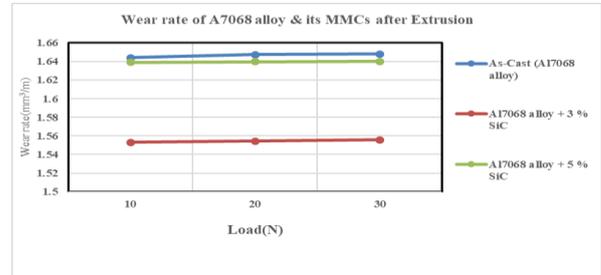


Figure 8: Wear rate test values of A7068 alloy and its Composites before extrusion

From Figure 8: we can see that as the load increases the wear rate increases. Highest wear rate is for A7068 alloy i.e.  $1.6682 \times 10^{-3} \text{ mm}^3/\text{m}$  for 10N and  $1.6758 \times 10^{-3} \text{ mm}^3/\text{m}$  for 30N respectively. Least wear rate is found for Al7068 alloy + 5 % SiC i.e.  $1.6423 \times 10^{-3} \text{ mm}^3/\text{m}$  for 10N and  $1.6441 \times 10^{-3} \text{ mm}^3/\text{m}$  for 30N respectively.

**Table 4.2: Wear rate test values of A7068 alloy and its Composites after Extrusion**

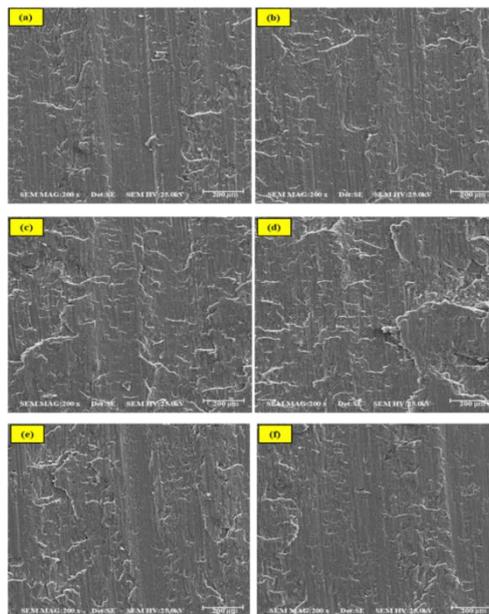
Wear rate of A7068 & its MMCs after Extrusion					
S/No	Load(N)	10	20	30	
1	As-Cast (Al7068 alloy)	1.6441	1.6473	1.6481	
2	Al7068 alloy + 3 % SiC	1.5531	1.5543	1.5558	
3	Al7068 alloy + 5 % SiC	1.6391	1.6397	1.6402	



**Figure 9: Wear rate test values of A7068 alloy and its Composites after extrusion**

From figure 9: 12 % SiC i.e.  $1.6391 \times 10^{-3} \text{ mm}^3/\text{m}$  for 10N and  $1.6402 \times 10^{-3} \text{ mm}^3/\text{m}$  for 30N respectively. SiC particles act as load bearing and protect matrix from wearing out. Extrusion leads to formation of fine equated grains in the A7068 matrix which further helps in reduction of wear rate [6]. Figure 9 we can see that as the load increases the wear rate increases. Highest wear rate is for A7068 alloy i.e.  $1.6441 \times 10^{-3} \text{ mm}^3/\text{m}$  for 10N and  $1.6481 \times 10^{-3} \text{ mm}^3/\text{m}$  for 30N respectively. Least wear rate is found for Al7068 alloy + 5 % SiC i.e.  $1.6391 \times 10^{-3} \text{ mm}^3/\text{m}$  for 10N and  $1.6402 \times 10^{-3} \text{ mm}^3/\text{m}$  for 30N respectively. SiC particles act as load bearing and protect matrix from wearing out. Extrusion leads to formation of fine equated grains in the A7068 matrix which further helps in reduction of wear rate.

**4.2.1 Wear Surface Morphology of A7068 alloy and its composites at a load of 30N before and after extrusion**



**Figure 10: Wear Surface Morphology of A7068 alloy and its composites at a load of 30N before and after extrusion , Where (a) A7068 alloy before extrusion, (b) A7068 alloy after extrusion ,(c) Al7068 alloy + 3% SiC before extrusion, (d) Al7068 alloy + 3% SiC after extrusion, (e) Al7068 alloy + 5% SiC before extrusion, (f) Al7068 alloy + 5% SiC after extrusion.**

Figure 10: shows the wear surface morphology of A7068 alloy and its composites at a load of 30N before and after extrusion .From the figure 6 we can see that wear surface morphology of A7068 alloy and its composites before extrusion has a rough surface and more surface delamination. Also, we can see that there is a greater extent of plastic deformation on the surfaces. Whereas wear surface morphology of A7068 alloy and its composites after extrusion has a relatively smoother surface with less surface delamination and lesser extent of plastic deformation.

## VII. CONCLUSION

From the tests conducted in order to determine the mechanical properties of SiC reinforced Al7068 composites of different weight fractions of the reinforcement, it was found that:

(i) The Optical Micrographs of polished specimens, the following was observed:

- The dispersal of SiC is found to be uniform in A7068 matrix
- The SiC Particles has caused good wetting with the A7068 matrix which further leads in the improvements of the mechanical and wear properties.

(ii) Silicon Carbide particles as a reinforcement helped in increasing the hardness (VHN) of A7068 from 73.5 (VHN) as per the following:

- 3% Silicon Carbide – 76.9 (VHN ) (4.62 % increase)
- 5% Silicon Carbide – 77.0 (VHN) (4.76 % increase)

(iii) Silicon Carbide particles as a reinforcement helped in increasing the hardness (VHN) of extruded Al7068 from 75.7 (VHN) as per the following:

- 3% Silicon Carbide – 78.9 (VHN) (4.22 % increase)
- 5 % Silicon Carbide – 81.6 (VHN) (5.90 % increase)

(iv) Silicon Carbide particles as a reinforcement helped in increasing the UCS (Mpa) of A7068 from 106 Mpa as per the following:

- 3% Silicon Carbide – 118 Mpa (11.32 % increase)
- 5% Silicon Carbide – 125 Mpa (17.92 % increase)

(v) Silicon Carbide particles as a reinforcement helped in increasing the UCS (Mpa) of extruded Al7068 from 119 Mpa as per the following:

- 3% Silicon Carbide – 129 Mpa (8.40 % increase)
- 5 % Silicon Carbide – 137 Mpa (15.12 % increase)

(vi) Wear surface morphology of A7068 alloy and its composites before extrusion shows rough surface with more grooves and ridges compared to wear surface morphology of A7068 alloy and its composites after extrusion.

## REFERENCES

- [1]S.Rama Rao. G. Padmanabhan, Fabrication and me chemical properties of aluminium-boron carbide composites, international journal of materials and biomaterials applications 2(2012) 15-18.
- [2]S. Balasivanandha prabu, I. Karunamoorthy Microstructure- based finite element analysis of failure prediction in particle-reinforced metal-matrix composite, journal of materials processing technology 207(2008)53-62.
- [3]P.k. Rohatgi , j.k. Kim, N.gupta, Simonalaraj, A.Daoud Compressive characteristics of A356/fly ash cenosphere composites synthesized by pressure infiltration technique, science direct 37(2006) 430 437.
- [4] Mahendra boopathi, k.p. arulshri N. Iyandurai, Evaluation of mechanical properties of aluminium alloy 2024 reinforced with silicon carbide and fly ash metal matrix composites, American journal of applied sciences, 10(2013), 219-229.



- [5] Venkat prasat, N.Radha, r. Subramanian, Tribological behaviour of aluminium/alumina/graphite hybrid metal matrix composite using taguchi's techniques, journal of minerals and materials characterization and engineering 10(2011) 427-443.
- [6] G.g. Sozhamanna. S.Balasivanandha prabu, Paskaramoorthy. Failures analysis of particle reinforced metal matrix composites by microstructure based models, materials and design, 31(2010) 3785-3790.
- [7] S. O. Adeosun O.P. GbenedoroSekunow O.I. Effect Of die entry angle on extrusion responses of aluminium 6063 Alloy International Journal of Engineering and Technology Volume 4 No.2, February, 2014.
- [8] V.V. Ganesh, N. Chawla, Effect of particle orientation anisotropy on the tensile behaviour of metal matrix composites: experiments and microstructure-based simulation, Mater. Sci. Eng. A391 (2005) 342–353
- [9] R. K. Goswami, R. Sikand, A. Dhar, O. P. Grover, U. C. Jindal, and A. K. Gupta “Extrusion characteristics of aluminium alloy/SiC metal matrix composites”. Materials Science and Technology, 1999, Vol. 15, pp443-449.
- [10] L. Avinash, T. Ramprabhu, and S. Bontha, “The Effect on the dry sliding wear behavior of gravity cast A357 reinforced with dual size silicon carbide particles,” in *Applied Mechanics and Materials*, 2016, vol. 829, pp. 83–89.
- [11] KR Suresh, S Mahendran, MS Krupashankara, L Avinash” Influence of powder composition & morphology on Green density for powder metallurgy processes” International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, Issue 1, January 2015, pp 18629-18634