FABRICATION AND FINITE ELEMENT ANALYSIS OF AL 2024 REINFORCED WITH SIC -FLY ASH HYBRID METAL MATRIX COMPOSITES FOR AUTOMOTIVE APPLICATIONS.

Zahoor Ahmed Shariff[1], A. Abdul Munaf[2], Hurmathulla Khan[3]
[1] Lecture, Boduthakurufaanu Magu, Malé, Maldives
zahoor.ahamed@villacollege.edu.mv
[2] Associate Professor, Rajalakshmi Institute of Technology, Chennai, Tamil nadu, India
munaf.rafan@gmail.com
[3] Assistant Professor
H.M.S Institute of Technology, Tumkur, Karnataka, India
hurmath1980@gmail.com

Abstract:
In Materials Science Improvement of crossover metal matrix composites becomes difficult in research enthusiasm. With this view, the current innovation focusses on improvements in Aluminum-SiC-flyash hybrid metal matrix composites.If the metal matrix consist two reinforcement materials then it is referred as a hybrid metal matrix composite. In this innovation mechanical features of Aluminum 2024are evaluated, here this aluminum 2024 is the mixture of fly ash SiC and its combination.Here with two phases stir casting methodology, composites of Al-SiC-flyash were fruitfully fabricated. For the miniaturized scale fundamental evaluation scanning electron microscopy is used with this microscopy fundamental portrayal was finished over the composite of metal matrix. By intentionally performing illustrated experimental attempts mechanical features of metal matrix composites can be discovered and the mechanical assets such as quality of yield, hardness, elasticity and prolongation test. The manifestations were meant with stir casting and definitive level strategy was utilized for the production of composites of aluminum metal system.For SiC (2, 4, 6, 8Wt %) variety of reinforcement is accomplished and 8Wt% is for settling fly ash and 1.5Wt% is for Mg consistent with aluminum.For structural estimation composites of aluminum alloy (Al-SiC-flyash) is considered as piston with this to stand up the experimental outcomes finite componentinvestigation is done.Hence Aluminum metal framework composite consolidates fortification quality with the grid durability to achieve attractive feature combination not available in any single traditional material.

Keywords:Silicon Carbide (SiC),Aluminium alloy (Al2024), Mechanical assets,Fly ash.

INTRODUCTION

Aluminum alloys are broadly utilized in aviation applications and industries of automobile because of their incredible mechanical assets, minimum coefficient of warm extension, minimum thickness, wear and good corrosion resistance as compared with conventional alloys and metals.According to the innovation perspective this is most beneficiary in several uses in different fields because of its Good mechanical assets and minimum production cost of composites. When the SiC and reinforcement'sflyashmixed with the base alloy to create the composite it increases the base alloy density. In addition, estimated density values and theoretical density values of these composites are matched. Later, Miyajima et.al. [1] Submitted that the density of Al2024-SiC molecule composites is more prominent than that of Al2024-SiC whisker supported composites for a similar measure of volume division. Ceramic elements consist maximum density with the density maximization. Later as volume fraction is getting higher with this composites density is also getting higher along with this evaluated and theoretical density values of these composites are matched with one another. Furthermore, the mentioned conversation can provide evidence for the ceramic elements that these consist of maximum density. With liquid metallurgy methodology is also referred as stir casting route, the Al7075-$Al_2O_3$and Al6061-SiC particulate reinforced composites were developed.With two techniques such as rule of mixtures and weight to volume ratio composite specimens and cast alloy were analyzed [2]. Among the reinforcements variations, the minimum aspect proportioncomponent reinforcements are very important in imparting material hardnesswith it gets dispersed (Fiber reinforced MMC hardness< whisker reinforced MMC < particle dispersed MMC) [1]. To impart maximum hardness Al_2O_3,aluminide and SiC are commonly considered to utilize and these SiC, $Al_2O_3$and aluminide are theparticulate reinforcements.With Cu [5] and Ni [4] reinforcements coating provides the better quality interface features and therefore provides a hardness development.Hardness to weight proportion gets increased if TiC spread in matrix of A1. In addition, it includes thermodynamic stability to the composites [6-7]. Importance of hard ceramic elements in maximizing AlMMCs bulk hardness discussed in [10-13].With maximizing the volume fraction elements composite hardness is getting developed which is explained in [12]. [15-16] credited this expansion in hardness to the diminished molecule size and expanded explicit surface of the support for a given volume division. Deuis et.al. inferred that the increment in the hardness of the composites containing hard earthenware particles relies upon the size of support as well as on the construction of the composite and great interface holding [16]. The micro- hardness is an immediate, straightforward and simple strategy for estimating the interface holding strength among the reinforcement and matrix [17]. From the application perspective, the mechanical assets of the composites are vital. The changed standards of combination proposed by a few analysts [18] are compelling in analyzing modular lower and upper bound values and strength assets of the composites. When Al-MMCs are operated along the gradient of reinforcing elements and also by adding a good strategy of preparing an optimized mixture of surface and bulk mechanical elements are completed. [19]. Even though there is no accurate connection among mechanical assets of composites reinforcement kinds, nature of reinforcement layer and volume fraction [14], gradual decrease in the reinforcement element size[20] is considered be very significant in developing the composites strength. Composites features are controlled by the properties and structure of reinforcements. Strong interface can be created by maximizing in composites strength and elastic modulus this spreads and sends the load to the reinforcement from the matrix. [18]. Later, by pre heating up the reinforcements proper spreading of elements in the matrix and developing the strength if interface can be finished [17]. By reducing the reinforcement [19-20]size in the composite and by maximizing the percentage of volume of ceramic stage the strength of Al_2O_3 , SiC, TiC [9], and TiB2 particulate reinforced Al-MMCs is noticed. To have maximum elastic modulus, fatigue and tensile strength upon monolithic alloy particle reinforced Al-MMCs are appeared in common.After the process of heating composites yield strength is maximized in the alloys of A1 and its composites. To shape the materials in simple these materials are kept in some heating process with some conditions before the operation of fabrication, To give developed mechanical assets after the process of fabrication these materials are get heated up with some peak conditions[18].

2.1 Experimental Details

Selection of Material:

Matrix material (Al2024)

Al2024 with copper is referred as primary alloying component and A12024 is generally considered as an aluminum alloy.At the good fatigueresistance and maximum strength to weight ratio applications this is utilized in such uses.It consists less corrosion resistance, fatigue strength and average machinability.With the friction welding this gets wieldable.

Table 1. Chemical composition of matrix material (Al2024)

Elements	Cu	Zn	Mg	Si	Fe	Mn	Ni	Cr	Sn	Ti	Al
% by wt	4.4	0.25	1.8	0.5	0.5	0.9	1.5	0.1	0.1	0.15	94.7

Reinforcing material (SiC)

To develop the composite features, in the form of fibers, whiskers or particulate SiC can be utilized as reinforcement.With the wear resistance and corrosion composite strength can be completely improved by SiC if it gets embed in metal matrix composites.Minimum thermal expansion coefficient, maximum modulus of elasticity and highest wear resistance and yield strength can be improved by 20%Aluminum MMCs reinforced with SiC particles compared to corresponding system of un-reinforced matrix alloy.

Table 2. Chemical composition of Silicon Carbide (SiC)

Elements	Si	C
% by wt	0.46	0.53

Reinforcing material (flyash)

Commonly fly ash is obtained by burning bituminous, old anthracite and harder. In which lower than 7% lime (CaO) present. Cementing agent like hydrated lime, Portland cement, quicklime alumina and glassy silica of fly ash needs any of above cementing agent for Possessing pozzolanic properties, and gets combined with the water for reaction and givescementitious elements. In another way geopolymer is obtained by combining fly ash with a chemical activator like sodium silicate (water glass).

Table 3. Chemical composition of Fly ash (Weight Percentage)

Al_2O_3	SiO_2	Fe_2O_3	CaO	Loss of Ignition
20-40	5-35	10-40	1-12	0-15

Stir casting procedure for Al2024/SiC MMCs

Below figure. 1 shows stir casting process, during operation of SiC elements upheld aluminum system composites, to eliminate the volatile substances and to keep 750^{O} C temperature to melt, here the components are heated up for 2 h at 600-800 degree Celsius. Additionally, by heating up the SiCelementswhich causes artificial oxidation of the particle surface which creates the SiO_2 layer. Elements gets wet with the help of this SiO_2 layer. The process of melting and furnace with charged Al2024 billets this is continued till it reaches the 750^{O} C of temperature (which is greater than the temperature limit of liquid). Cooling has been taken to the melt to 600^{O} C to a semi-solid state (the temperature which is lower than the liquid temperature). Slurry mixing taken for 20 minutes this slurry consist melt along with fly ash and silicon carbide. To monitor the furnace temperature readings an external temperature probe was used. Slurry composition gets heated up again to the temperature of above the level of liquid temperature level which maintains temperature of about 750^{O}C 10^{O}C after the manual stirring, mechanical stirring was considered. 1.5% of pure Mg was combined with complete composites, to maximize the wettability.With the average stirring rate of 400 rpm is taken, and this operation of stirring is done for 10 minutes. At the 720^{O} C of pouring temperature Casting was done on the prepared sand moulds. To this we select commercial aluminum with 900gm quantity and particular quantity of flyash, SiC mixtures in the form of powder.

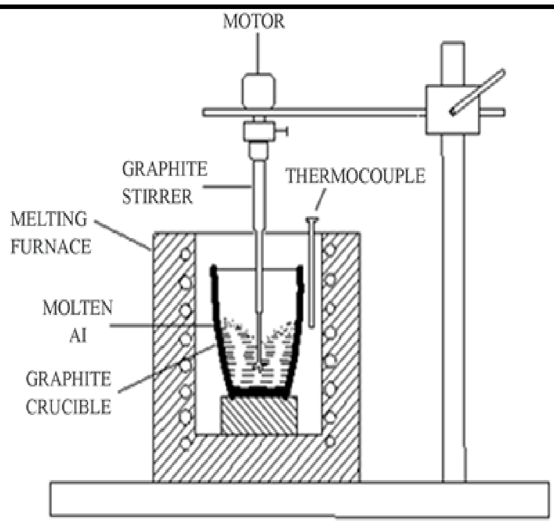

Fig 1.Stir casting

RESULTS AND DISCUSSIONS

MICROSCOPIC EXAMINATION

The physical features of composites dependent on the size of reinforcement particle, shape, microstructure and spreading in alloy and the by utilizing the SEM and to examine the spreading style of flyash in the matrix developed samples are evaluated or tested. In the complete operation of the composites microstructure acts as significant part in it. The appearance of combination of SiC- fly ash at different level of concentration shown in figures. 2,3,4,5,6 depicts equal quantity of particles association is found in the aluminum micrographs. Overall the casting maximum particles are appeared here. Mechanical and physical features of composites gets influenced highly by the distribution of particles. Including the SiC, magnesium and fly ash to the melt volume percentage of reinforcement gets maximized which is represented in the shown result.

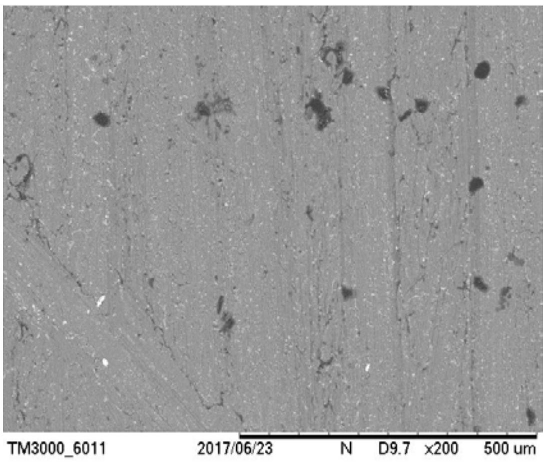

Fig 2. Microstructure of Al 2024

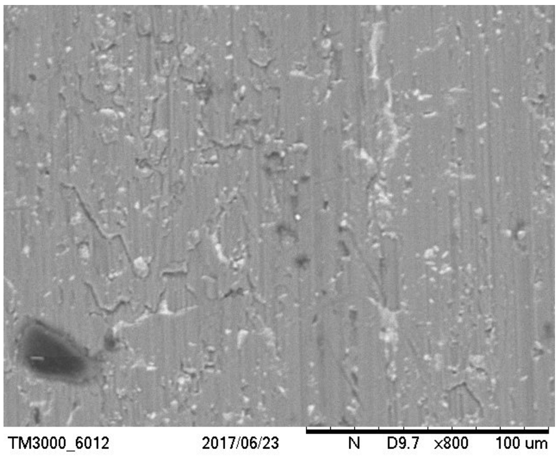

Fig 3. Microstructure of Al 2024 with 2% weight SiC and flyash (4-25 micron)

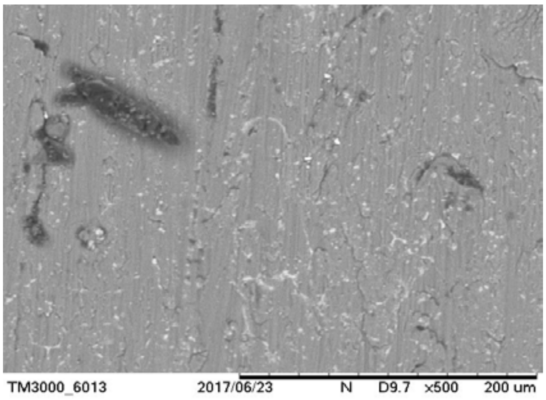

Fig 4. Microstructure of Al 2024 with 4% weight SiC and flyash (25-40 micron)

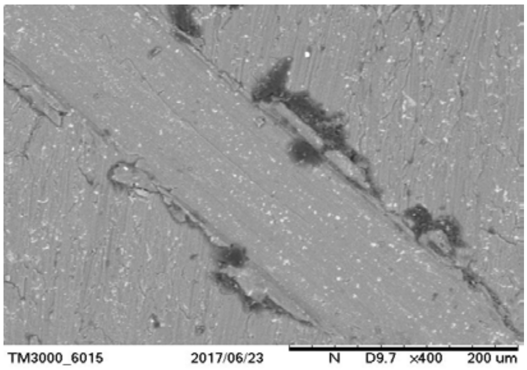

Fig 5. Microstructure of Al 2024 with 6% weight SiC and flyash (40-55 micron)

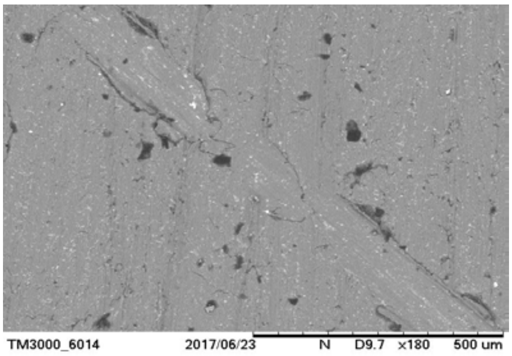

Fig 6. Microstructure of Al 2024 with 8% weight SiC and flyash (55-65 micron)

ULTIMATE TENSILE STRENGTH (UTS)

Figure. 7. Represents the experimental tensile strength graph of the composites as per the fly ash,SiC and their mixtures. As compared to the unreinforced Al composites tensile strength is greater which is shown in results. 70.12 $N/mm^2$is the unreinforced Al Tensile strength and for the Al/(4%SiC+8%fly ash) composite value is maximized to 133 N/mm^2, which means 47% development upon the unreinforced Al matrix.

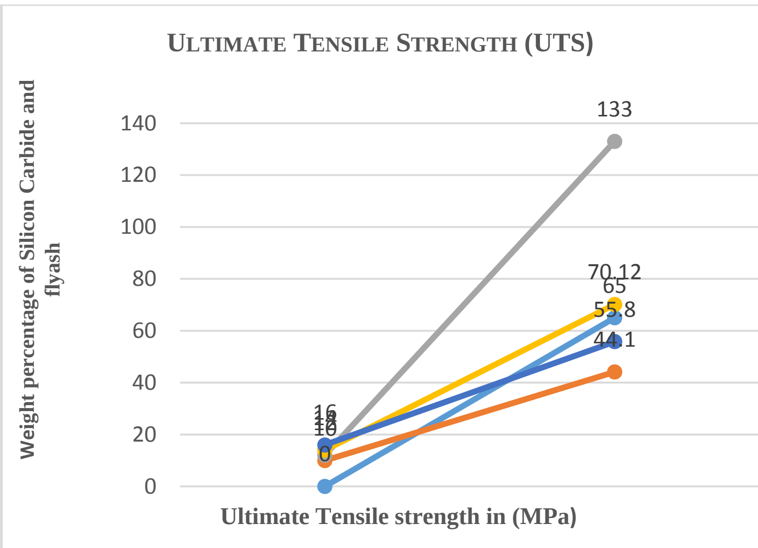

Fig. 7: Ultimate Tensile Strength (UTS)

ELONGATION

As per the fly ash, SiC and its mixtures composites experimental elaboration graph is shown in Figure 8.For the unreinforced aluminium composites elongation gets minimized with its obtained and it is observed carefully through experiments. 2% of unreinforced Al Elongation is observed,1.5% isfor Al/(6%SiC+8%fly ash), 25% of composite is obtained with unreinforced Al matrix reduction.

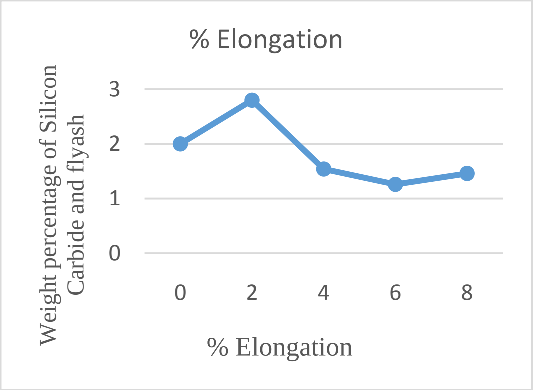

Fig.8.% ELONGATION

HARDNESS STUDIES

As per the fly ash, SiC and its mixture experimental composites hardness graph is represented in Figure 9. By observing in the graph it shows that weight fraction of fly ash, SiC, and its combination is directly proportional to hardness, as the hardness increase the weight fraction gets increased accordingly. At Al/(4%SiC+8%fly ash) we get highest hardness, due to this when it is given to strain it causes deformation. We can obtain continuous improvements in hardness and AI matrix deformation by incorporation this withparticles of fly ash. Compared to aluminum maximum hardness is obtained in the mixture of fly ash particles and SiC

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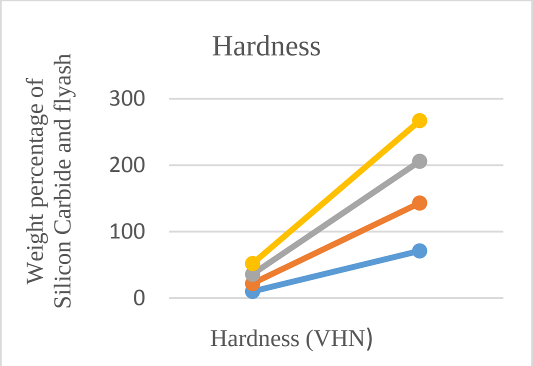

Fig.9HARDNESS STUDIES

FINITE ELEMENT ANALYSIS

Modelling In Catia V5R20

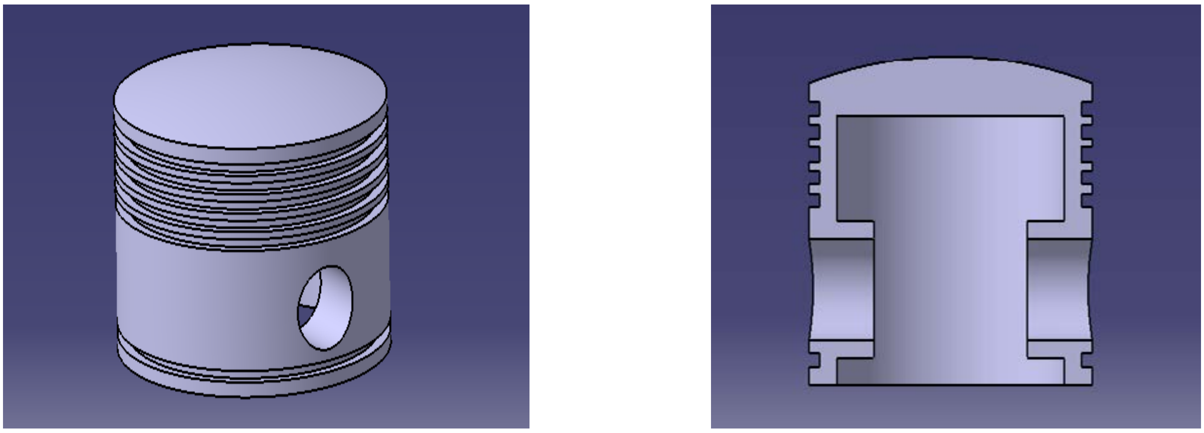

Fig. 10Modelling In Catia V5R20

In CATIA V5R20 the model is designed shown in figure 10, after that it gets convert to STP file and then import to HYPERMESH 12as shown in figure 11. As per the following phases considering the estimation.Select the Aluminum alloy Material and provide it to imported model. With the software complete detail about the aluminum alloy material are predefined. To examine the model through FEM model meshing is compulsory. Mesh shape and size are analyzed, by considering triangle shape for mesh represented as (TetraMesh) and the element with size 15.

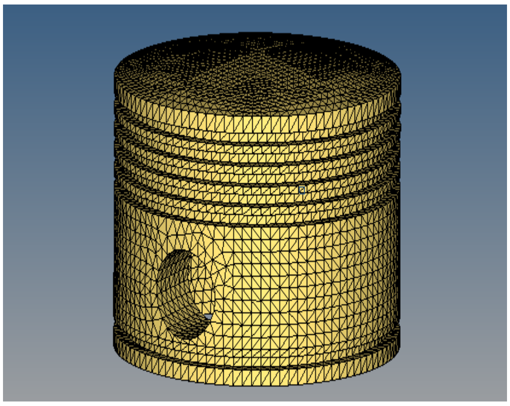

Fig. 11FE model of piston

MATERIAL ENTITIES OF ALUMINIUM ALLOY:

Table 4. Material entities of aluminium alloy

Poissons Ratio	0.17
Youngs Modulus	70 GPa
Yield Stress	210 MPa
Density	2.6898 e^{-3} g/mm^3

BOUNDARY CONDITION:

Loading Condition: BMEP = 5 Mpa

Figure 12 shows,5 MPa of magnitude pressure is provided over piston head top layer this is considered for static structural examination. For aluminum alloy 5 MPa of gas combustion pressure is considered.

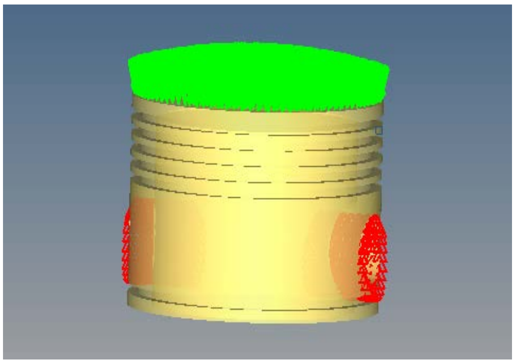

Fig. 12 Loading Condition: BMEP = 5 Mpa

RESULTS AND DISCUSSION:

By importing model to ABQAUS 6.14 obtaining the results. Below which represents the obtained results for the structural deformation and for Von-Mises stress. 147 MPa is the value obtained for stress and 0.1092 mm is the value obtained for structural deformation show in figures 13 & 14.

VON-MISES STRESS

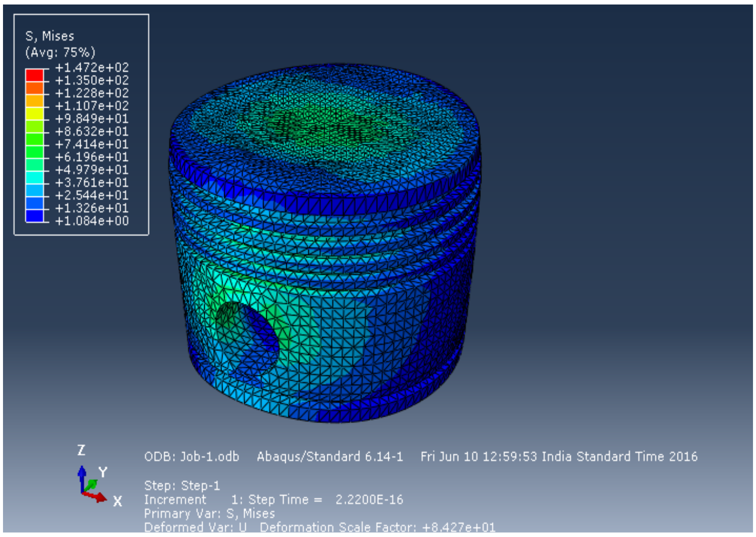

Fig. 13 : Von-Mises Stress Plot

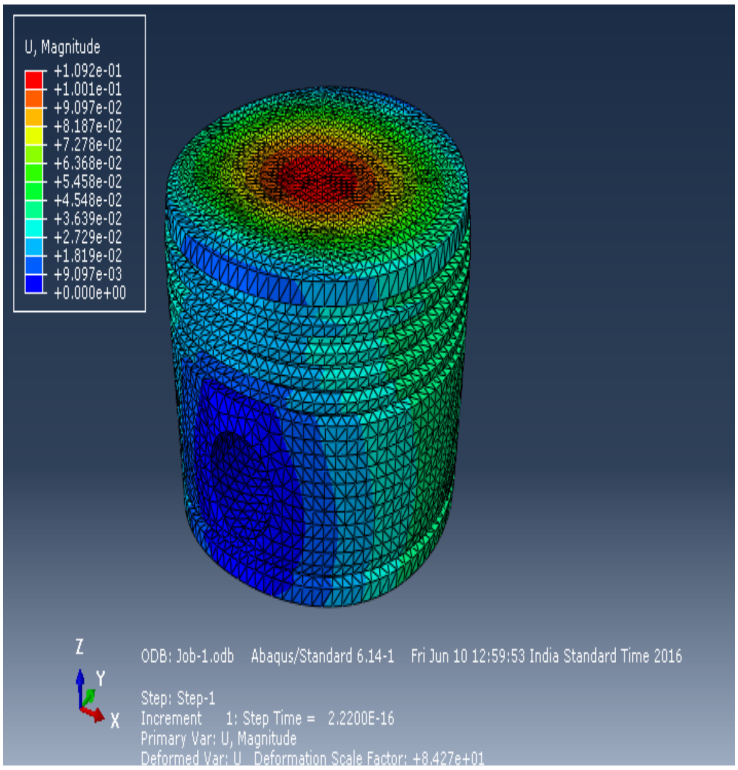

Fig 14: Displacement Plot

Conclusion

Increasing in the Hardness and reduction in the composites density is observed honestly. Accordingly it is observed that stretching of crossover metal system composites and reduction in the unreinforced aluminum in comparison and also rigidity expansion.

The Aluminum-SiC-flyash composites basically differentiated in most of the properties estimated. Aluminum with the reinforcement extent of SiC (4%)- flyash (8%) was difficult as compare to other created composites.

Composites density diminished by expanding the reinforcement content. Thus, it was discovered that, Al-SiC-fly ash composites can be utilized in uses where generally weight decreases are appropriate.

For the test materials hardness, yield strength andTensile strength were evaluated. There is improvement we can get in hardness, yield strength and tensile strength by increasingreinforcement area fraction in matrix.

Including fly ash and SiC with maximum quantity elaboration rate of the hybrid MMCs is reduced continuously.

Both flay ash and SiC elements are equally distributed in the matrix of aluminum and this is revealed by Optical micrographs.

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