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Study On Deformation Properties: Influence Of Granite And Fly Ash Particles In AZ91E Matrix Composites Fabricated By Stir Casting Technique

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Abstract

A complete experimental investigation on workability behaviour of the AZ91E-Granite-Fly Ash has been carried out during cold upsetting. The preforms are made by taking the magnesium alloy AZ91E and filling the Granite and fly ash reinforcement particles at different wight percentages (0,5 and 10) using a stir casting method. The casting preforms are machined using conventional lathe machine and different aspect ratios (H/D 1.0 & 1.5) of solid samples are prepared. These samples are tested on UTM and found mechanical compressive propertieslikeMax Compressive Strength (MPa), Max Compressive Strain and Youngs Modulus (MPa).The K and n values are increased for the composites compare to the base material AZ91E. For aspect ratios 1.0 and 1.5 samples of 10wt.% of MMC having good plastic flow compare to the other material samples. The true stress-strain curves are having low values compare to the engineering stress strain curves because the instantaneous area gives the correct nature of the material behaviour. Mostly the base metal AZ91E and composite are brittle nature only in the compression test gives the actual metal flow analysis compare to the tension test. The axial, compressive and hydro static stress are found using standard analytical equations and same results are validated in ANSYS software, the analytical and ANSYS results are matched very closely. The strength co efficient and strain hardening exponent tell the plastic behaviour of the fabricated performs

***Keywords**: AZ91E, UTM, Reinforcements, ANSYS, Plastic behavior*

1. INTRODUCTION

Magnesium is the lightest of all minerals. Magnesium is used for a wide variety of applications, including fireworks, metal, chemical, electrical and chemical applications. Magnesium and magnesium alloys are mainly used in the automotive and aviation industries in various structural properties due to their tensile strength (160-365 MPa), elastic modulus (45 GPa) and two-thirds aluminum low density (1740 kg / m3).Magnesium alloys have high strength-to-weight ratios (tensile strength / density) similar to other structural minerals [1].

Magnesium alloy compounds (AZ91D) reinforced with silicon carbide particles with different volume ratio are manufactured by a two-stage pressure casting process. The results showed that the mechanical properties of the compounds increased with increasing SiC particles and decreased with increasing particle size [2-4].Magnesium-based metal matrix compounds reinforced with varying content of boron carbide (B4C) particles were prepared using the casting method. The mechanical properties of cast compounds such as tensile strength and total hardness have been studied. Magnesium compounds showed rigidity, yield strength and final tensile strength compared to uninformed Mg [5].Al-Zinc / fly ash /SiC-supported compounds are manufactured by the vortex method using a casting path. The incorporation of fly ash the tensile properties, such as tensile and yield strength are improved. Reinforcement mechanisms to improve the properties of wear and corrosions are discussed[6-8].

This document refers to the experimental study of the use of vegetable oil as a cutting fluid in the manufacture of EN 353 steel ingots to reduce the cutting temperature under different lubrication conditions, that is, dry, flood and minimum lubrication conditions for quantity. Metallic models for the automotive industry, the prototype test and research laboratories are described in detail. Finally, this review provides an overview of the future automotive industry through metallic models [9-10].Carbon nanotubes (CNTs) are made from a pressurized method of reinforced metal matrix AZ91 compounds (MMC). Corrosion characteristics were determined and the possibility of applying automatic transmission and engine parts was investigated [11].

The compression characteristics of AA7075 metal matrix composite using a traditional analytical method and finite element method was found. The circumferential stress is always in compression for all the cases for lower aspect ratio the circumferential and hydro static stress are high compare to higher aspect ratio of base and reinforced composites [12-13].Samples of cylindrical aluminum and copper alloys between flat trays under lubrication and dry conditions were moved to 1.0 and 1.5 with initial inverse ratios to estimate the metal flow. Friction factors were determined using ring pressure tests [14].

Complete experimental research has been conducted on the performance behavior of Al-SiC during cold upsetting.The present study was conducted to evaluate the effect of particle size on the addition of silicon carbide in the formation of P / M of Al-SiC compound on operation studies. [15].

2. EXPERMENTAL WORK - PREFORMS FABRICATED BY STIR CASTING METHOD

Primary formations are made using the Stir casting method, using cast iron dye, inert gas, electric stirrer, and crusuble made of graphite. Granite and Fly Ash particles are taken as equal weight percentages with respect to the base material AZ91E as shown in the table 1.1and hybrid composites are made.The melting temperature of AZ91E is about400 to 750 ° C.

The fly ash and Granite powders are poured into the graphite crusuble and spin at a constant speed for at least 5 minutes, and it is rotated with an electric stirrer. The molten metal is poured into the cast iron dye, then the necessary samples are made as shown in Figure 1.1.

Table 1.1 Compositions of Hybrid Composite

S.No	Composition of reinforcements	Granite wt. %	Fly ash (FA) wt.%
1	AZ91E	0	0
2	AZ91E + 2.5% Granite + 2.5% F ash	2.5	2.5
3	AZ91E + 5% Granite + 5% Fly as	5	5

Fig 1.1 stir casting and Casted Cylindrical samples

3. EXPERMENTAL WORK - DEFORMATION TEST ON UTM

Models like solid cross setions of aspect ratio H/D 1.0 & 1.5 are made according to the standard dimensions of pressed shapes are made with the help of a traditional lathe machine.As shown in Figure 1.2 of the axial stress analysis, the aspect ratio (from height to diameter) is 1.0 and 1.5. A compression test was performed on a universal test machine. The test was performed until shear failure of the free surface of the sample or 50% deformation of the sample. UTM produces load shift data for AZ91E,5 and 10 weight percentage of MMCs of H / D ratio 1.0 and 1.5.

Fig 1.2 Machined Samples of aspect ratio 1.0 & 1.5 & Tested on UTM

ANALYTICAL METHOD

The tri-stress are found for the plastic analysis of base and composites of MMCs using the follwing formulas are given in below.

True strain in axial direction $\epsilon_Z = \ln\left(\frac{Hi}{H0}\right)$

The true stress and true strain data were well fitted into the Hollow Man power law of equation for determination of deformed properties of the material as given in below.

$$\sigma f = K \epsilon^n$$

Where K is strength coefficient and n are strain hardening exponent.

The Hydro static Stress $\sigma_H = \frac{\sigma_z + \sigma_\theta + \sigma_r}{3}$

Where $\sigma_z, \sigma_\theta, and\ \sigma_r$ are axial, hoop and radial stress respectively in the orthogonal axis on compression test.

Axial Stress $\sigma_z = \sigma f[\{1 - (\frac{1+2\alpha}{2+\alpha}) + (\frac{1+2\alpha}{2+\alpha})\}^2]^{-1/2}$, here α is the slope between axial strain and circumferential strain and σf is the flow stress of the material.

The hoop stress $\sigma_\theta = \sigma_z [(\frac{1+2\alpha}{2+\alpha})]$ and the radial stress are zero on the free surface of the material.

4. FINITE ELEMENT SIMULATION OF COLD UPSETTING PROCESS

Upsetting is most broadly utilized metal framing marvels for assembling of various machine segments. According to viewpoint proportions the samples are desined in ANSYS APDL, the investigation was performed with the assistance of solid 18 element and contanct elements 182 and 183. A closed contant pair was created and show in Fig 1.3. The material properties of top and base passes on of the UTM machine was thought to be steel(E=210Gpa,μ=0.3) and the samples are AZ91E and their composites.

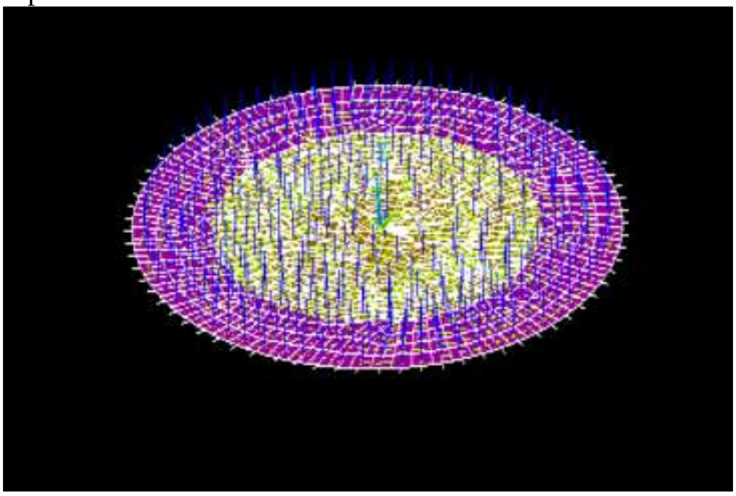

Fig 1.3 closed contant pair was created in ANSYS

RESULTS AND DISCUSSIONS

ASPECT RATIO H/D 1.0 OF BASE , 5 AND 10 WT.% OF MMC RESULTS IN ANALYTICAL METHOD.

Using traditional therory of plasticity equations to found the strains in height and diametre direction due to the application of load was acted on the samples of H/D 1.0 and 1.5 for the 5 and 10 WT.% of MMCs. The diameter is increased with decreasing of height of the specimen under compression test as shown in the Fig1.4 and Fig 1.4 showed the grid representation ieVarying height and diameter of the solid cylinder of composites.

The Fig 1.5 showed that the effective strains are taken in X-axis and various calculated stress are taken in Y-axis, the axial stress are increasing with increasing of deformation whereas the circumferential stress are decrease in nature. For solid cylinder aspect ratio 1.0 of 10% wt. of MMC brittle in nature. Compare to 5MMC the 10MMC is little bit far to effective strain line hence it was ductile in nature compare to 5MMC.

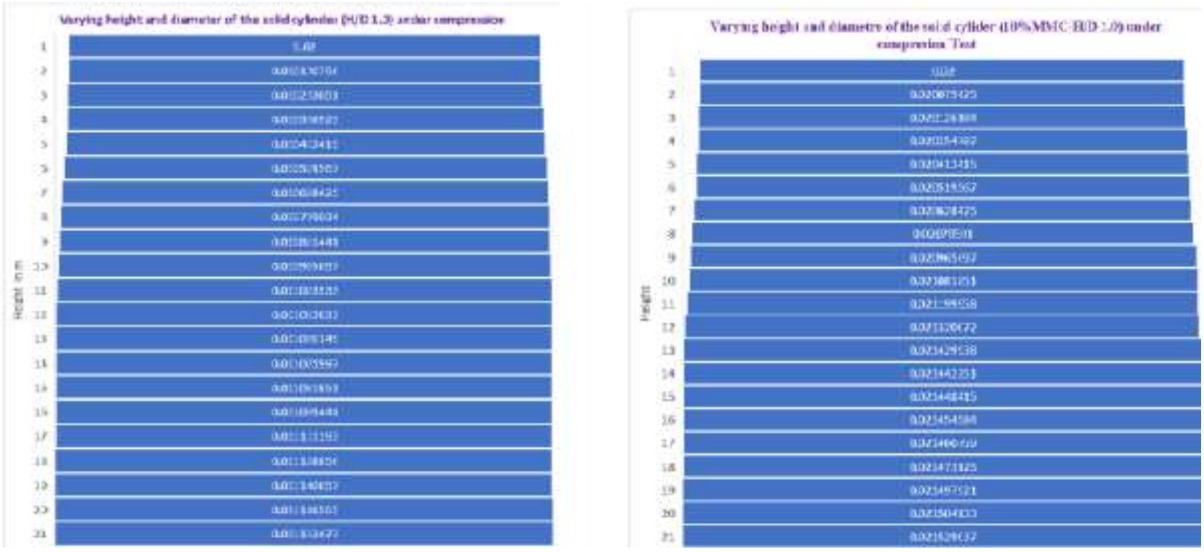

Fig 1.4 Varying height and diameter of the solid cylinder under compression-5& 10 MMC-H/D 1.0

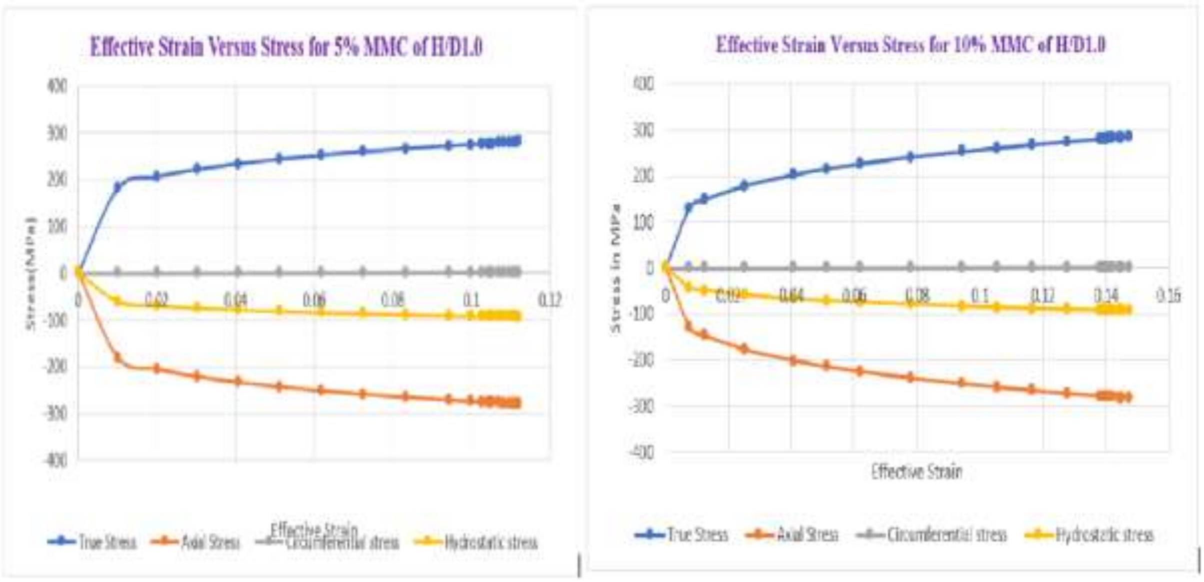

Fig 1.5 Effective Strain Versus Stress for 5 and 10 % MMC of H/D1.0

ASPECT RATIO H/D 1.5 OF BASE, 5 AND 10 WT.% OF MMC RESULTS IN ANALYTICAL METHOD

Aspect ratio H/D 1.5 of base, 5 and 10 WT.% of MMC results are found and discussed below. Fig 1.6and 1.7 represents the varying height to diametre and different stress effcet with respect to the effective strains. Clearly show the plastic nature of the base and the composites due to the incresing nature of the circumferencial stress. The material was well elongated for 5wt.% of MMCs for aspect ratios 1.0 and 1.5 compare to the other composition and base material. The 5wt.% of MMCs having good ductile in nature compare to the base material. For solid cylinder aspect ratio 1.0 and 1.5 of 5% wt. of MMC brittle in nature.

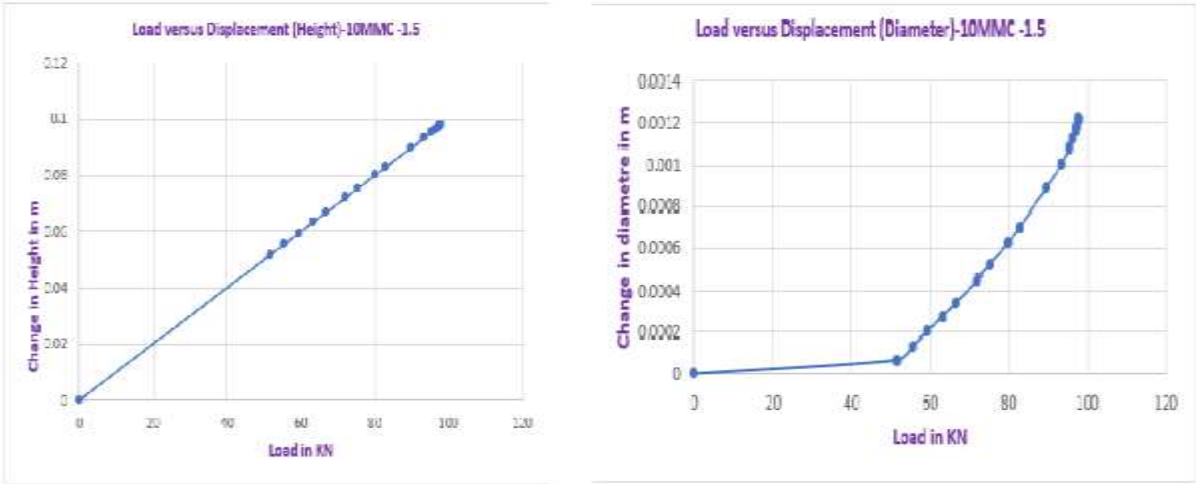

Fig 1.6 Load versus Displacement (Height)-Load versus Displacement (Diameter) of 10MMC -1.

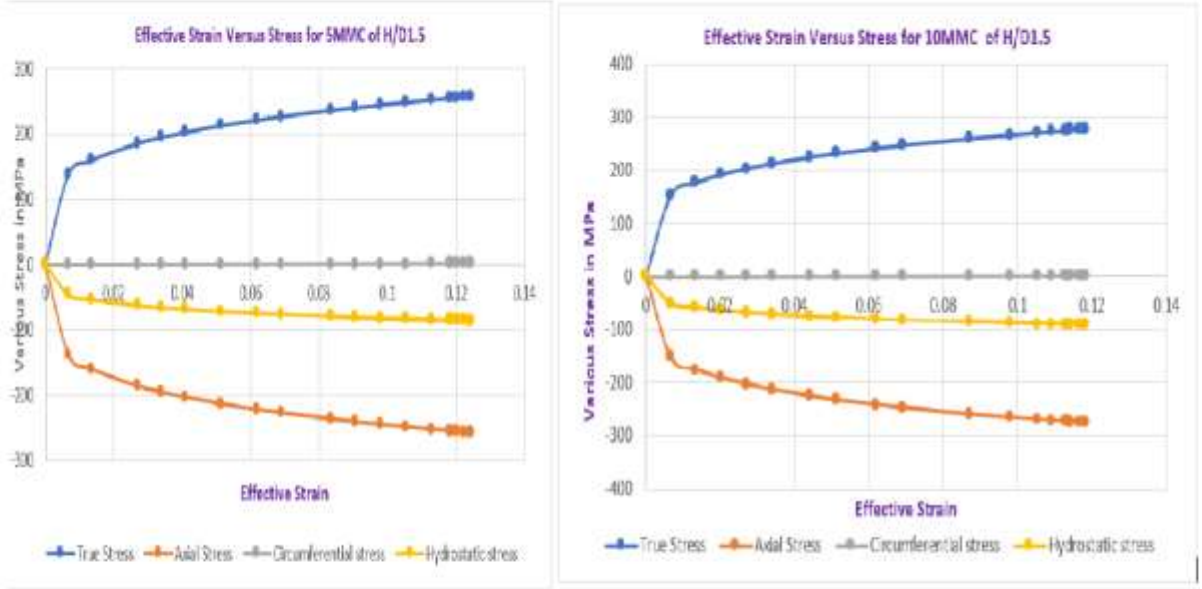

Fig 1.7 Effective Strain Versus Stress for 5 and 10 MMC of H/D1.5

ANSYS RESULTS FOR H/D 1.0 AND 1.5

Finite element simulation (FEM) of the forged specimens by lagrangian finite element model of the cold upset forging process under unlubricated condition is developed using Ansys software. Rigid-flexible contact technique was used for upsetting process. The rigid tools of top and bottom dies need not meshed. The cylindrical samples are meshed with solid 185 element. The sample materials are AZ91E and their composites in which linear elastic and non-linear plastic properties are assigned. The Fig 1.8 to Fig 1.13 showed the Deformed -Un deformed, axial, circumferential and hydro static stress of H/D 1.0 and 1.5 for base and 5 and 10 wt. percentage of MMCs were found in finite element analysis software ANSYS.

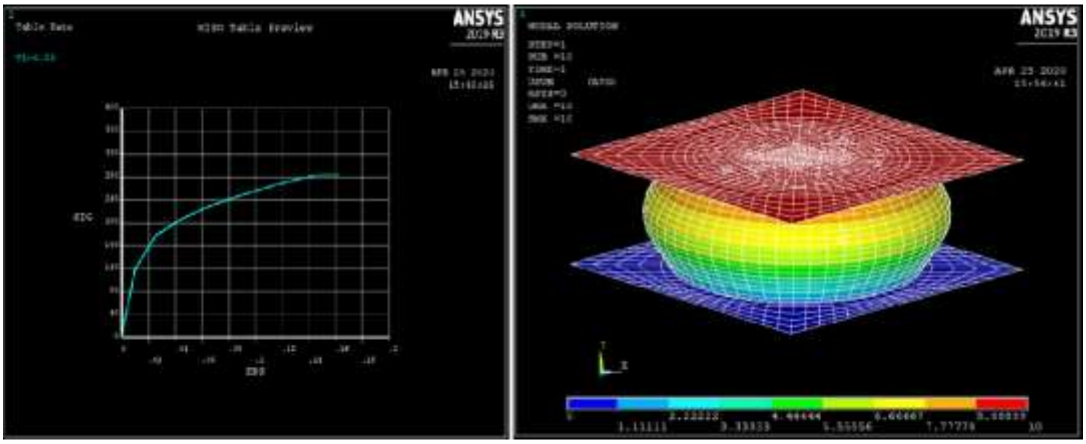

Fig1.8 True stress - strain curve and max displacement of base AZ91 E for H/D ratio 1.0

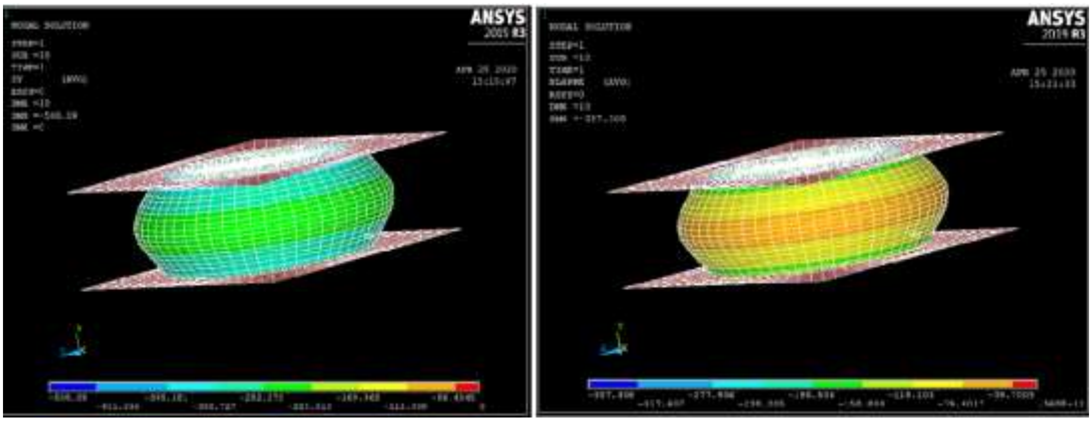

Fig 1.9 Axial and Hydro Static Stress of base 5MMC for H/D ratio 1.0

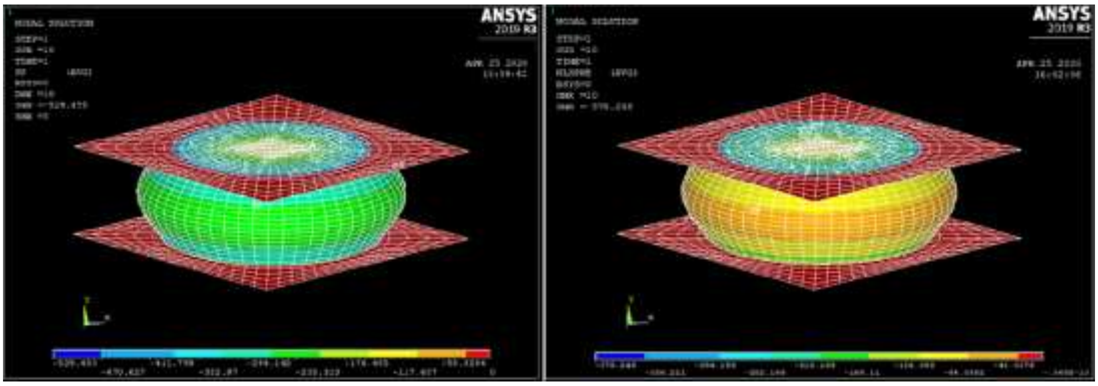

Fig 1.10 Axial and hydro static Stress of 10MMC for H/D ratio 1.0

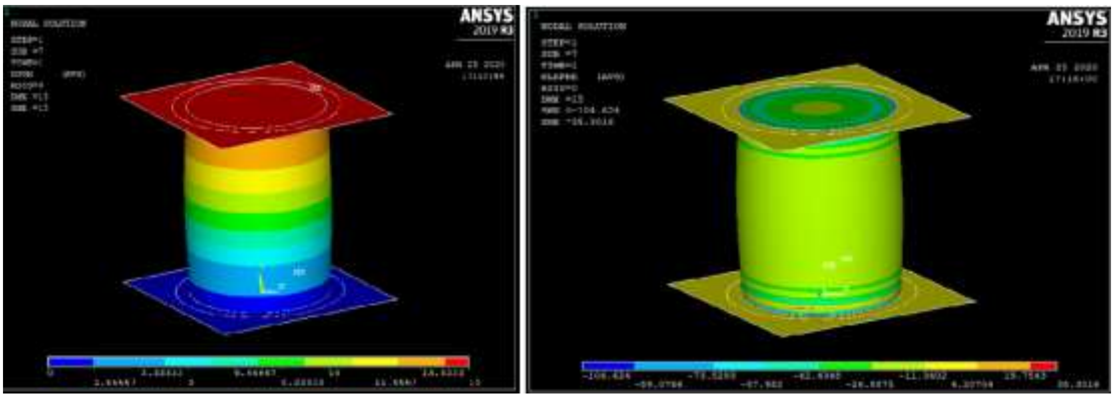

Fig 1.11 Maximum Displacement and Hydro static Stress of AZ91 E for H/D ratio 1.5

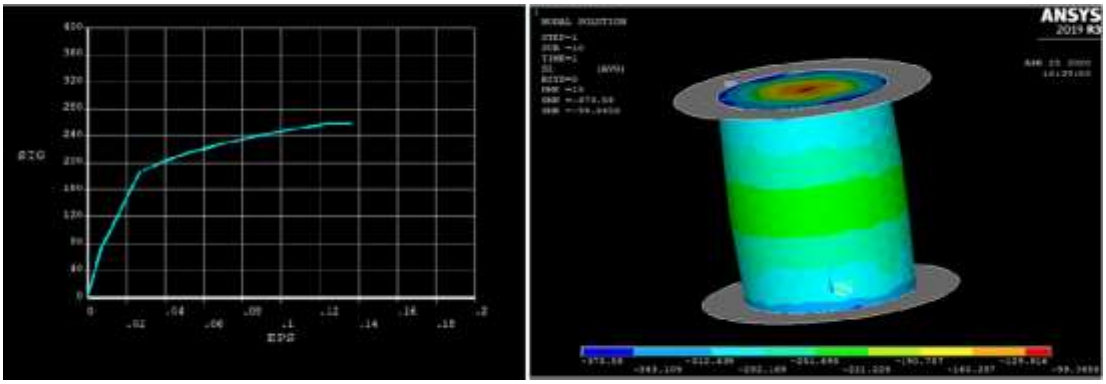

Fig 1.12 True Stress -Strain Curve and Axial Stress of 5MMC for H/D ratio 1.5

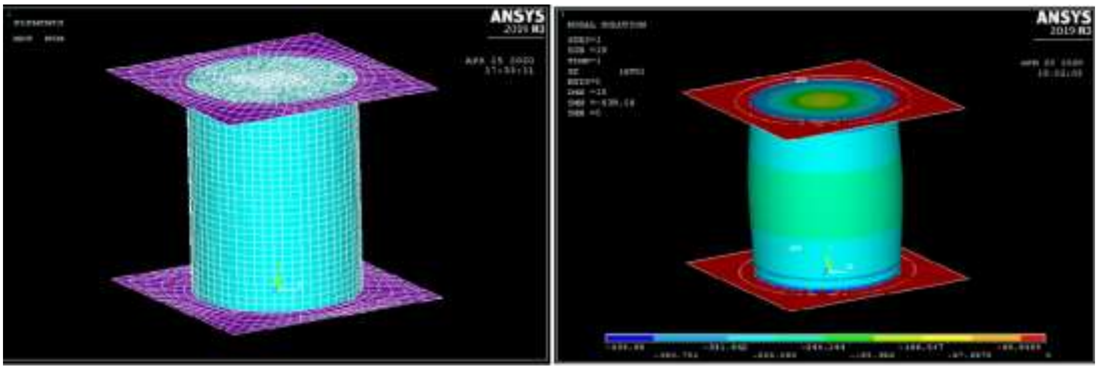

Fig 1.13 Un-deformed and Axial Stress of 10 MMC for H/D ratio 1.5

EFFECT OF K AND N VALUES

Table 1.2 Effect of K and n values

Type of Material	K (H/D 1.0)	n(H/D1.0)
AZ91E	320.15	0.1512
AZ91E + 2.5% Granite + 2.5% Fly ash	416.71	0.1811
AZ91E + 5% Granite + 5% Fly ash	472.86	0.2662

Table 1.3 Effect of K and n values

Type of Material	K (H/D 1.5)	n(H/D1.5)
AZ91E	300.42	0.1428
AZ91E + 2.5% Granite + 2.5% Fly ash	404.27	0.215
AZ91E + 5% Granite + 5% Fly ash	431.12	0.2079

Table 1.2 and 1.3 shows the K and n values of AZ91E, 5wt. and 10wt.% of MMCs. The K and n values are increased for the composites compare to the base material AZ91E. For aspect ratios 1.0 and 1.5 samples of 10wt.% of MMC having good plastic flow compare to the other material samples. Fig 1.20 and Fig 1.21 are the stress strain curves of base and composite materials of different aspect ratios. The true stress- strain curves are having low values compare to the engineering stress strain curves because the instantaneous area gives the correct nature of the material behaviour. Mostly the base metal AZ91E and composite are brittle nature only in the compression test gives the actual metal flow analysis compare to the tension test.

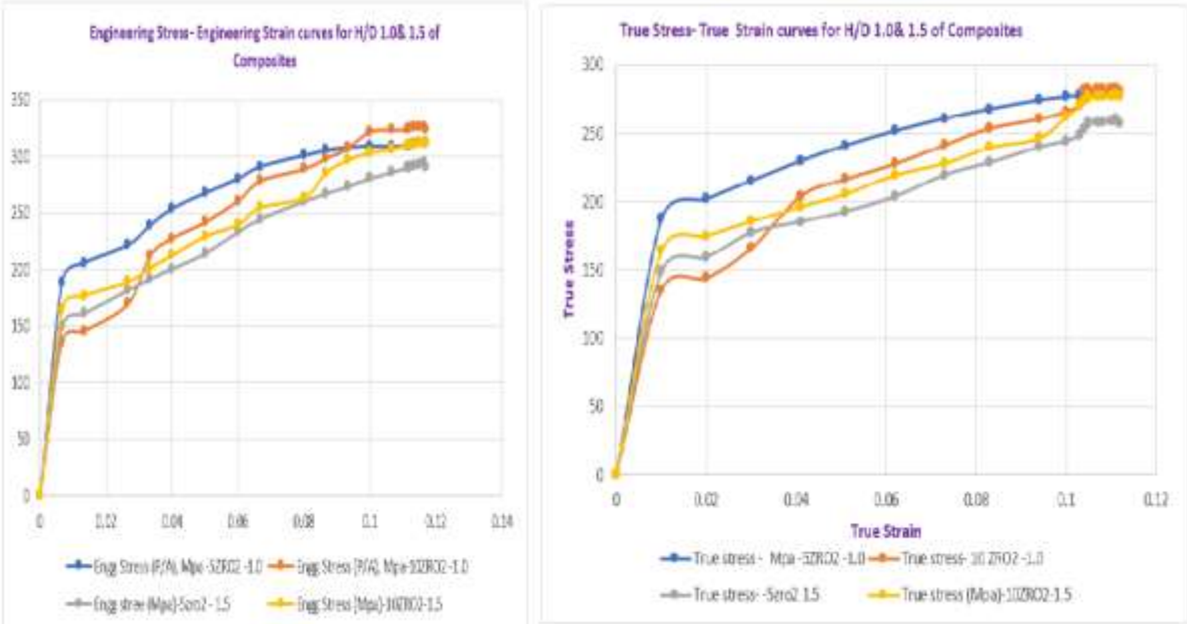

Fig 1.14 Engineering Stress- Engineering Strain and True Stress- True Strain curves for H/D 1.0& 1.5 of Composites

5. CONCLUSIONS

The Upsetting preforms are fabricated successfully by stir casting Technique.
The experimental work was done with the help of UTM (instron) for all the aspect ratios and different MMCs.
The axial, hoop and hydro static stress are determined for the estimation of plastic behaviour of the metal using traditional equations.
The ANSYS software was used to determine the stress for analysing the plastic flow of the material and the results are validated and are very close victim to each other.
Results obtained by finite element analysis closely related to experiment results.The values are thus validated by the FEM model.

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