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Deformation, Finite Element Studies on Solid Cylinder of AA 2024/Sic/Fly Ash Hybrid Composites

Miss. K. Sarika[1], Miss. P. Satya Lakshmi[2], Mr. US Ramakanth[3]
[1]PG Student, [2, 3]Assistant Professor, Visakha Technical Campus,Narava, Visakhapatnam, Andhra Pradesh, India

***Abstract:** In this work presents the deformation actions of AA 2024, AA2024/Sic/Fly Ash, and aluminium matrix composites were found. Newly formed AA2024/Sic/Fly Ash hybrid composites are the grouping of the different hybrid materials. Cold upsetting tests were carried out on as cast and homogenized hybrid composite accommodations.*

The strength coefficients k and strain hardening exponents' n are calculated for these composites, it shows the ductility and brittleness nature of the materials. A 3D model of the solid samples was deformed in compression between two plane platens to predict the metallic flow at room heat. The circumferential stress constituent σθ increasingly becomes tensile with constant deformation. On the other hand the axial stress, σz increased in the very initial steps of deformation but started becoming less compressive directly as barrelling improves. A 3D model of the Samples was designed and Finite element analysis is performed on the solid samples using different metal matrix composites to determine axial, circumferential and hydrostatic stresses. Analysis is performed in Ansys. A good arrangement was shown between FEA and analytical solutions.

Keywords: Studies of A2024 Alloy/Fly-Ash/Sic Hybrid Composites

I. INTRODUCTION

Aluminium matrix composites (AMCs) have gained wide acceptance in the past three decades due to their high specific strength and stiffness and superior wear resistance [1-3]. Usage of ceramic particle - reinforced metal matrix composites (MMCs) is steadily increasing due to advantages like isotropic properties and possibility of secondary processing, facilitating fabrication of secondary components. Increase in density and hardness with increase in amount of silica sand of A206 aluminium alloy containing silica sand particles [4]. M Kok [5] examined AA 2024 aluminium alloy metal matrix composites (MMCs) reinforced with three different sizes and weight fractions of Al_2O_3 particles up to 30 wt. % were fabricated by a vortex method and subsequent applied pressure. The effects of Al_2O_3 particle content and size of particle on the mechanical properties of the composites such as hardness and tensile strength were investigated. SEM observations revealed that the dispersion of the coarser sizes of particles was more uniform while finer particles led to agglomeration of the particles and porosity. The results show that the hardness and the tensile strength of the composites increased with decreasing size and increasing weight fraction of particles. J Babu Rao et al [6], AA 2024 aluminium alloy MMCs reinforced with flyash powders were fabricated up 10% successfully. Dry sliding wear behaviour of silicon particles reinforced aluminium matrix composites results showed that silicon particle- reinforced composites exhibited reduced wear loss than the unreinforced alloy specimens [7]. Quartz ($SiO_{2(}$p)) reinforced chilled MMC for automotive applications [8] concluded that the mechanical properties of the chilled composites were superior to those of the matrix alloy. Strength and hardness increase with increase in dispersoid content and this may be possibly because of the occurrence of a more uniform distribution of SiO_2 particles within the matrix.

A. AA 2024 Introduction

2024 aluminium alloy is an aluminium alloy, with copper as the primary alloying element. It is used in applications requiring high strength to weight ratio, as well as good fatigue resistance. It is weldable only through friction welding, and has average machinability. Due to poor corrosion resistance, it is often clad with aluminium or Al-1Zn for protection, although this may reduce the fatigue strength. In older systems of terminology, 2XXX series alloys were known as duralumin, and this alloy was named 24ST.Al.2024 is commonly extruded, and also available in alclad sheet and plate forms. It is not commonly forged

Table 1 Chemical composition of prepared AA 2024 alloy (in wt. %).

Cu	Mg	Si	Zn	Fe	Cr	Al
4.38	1.52	0.4	0.13	0.02	0.12	Balance

II. LITERATURE REVIEW

Many investigators have investigated the behaviour of solid cylindrical specimens during cold offset forging due to its huge technical relevance in metal forming process. A comprehensive review of the same has been published by Johnson and Mellor [9]. Another important aspect of axis-symmetric compression from the viewpoint of testing the manufacturing properties of metal is its estimation of forming limits up to plastic instability and subsequently fractures as explained by Shaw and Avery [10]. In upsetting process, the presence of frictional constrains between the work-piece and the material has pertinent effect on the plastic deformation of the former. When a solid specimen (cylinder/square billets/rectangular billets) undergoes axial compression between the bottom and punch plate, the work-piece which is in contact with the plate surfaces undergoes heterogeneous deformation which results in the phenomenon of “barrelling” of the specimen.

The friction cannot be eliminated completely during upset forging and it is necessary to go for a correction factor for the bulging process during the designing of a die. Kulkarni and Kalpakjian [11] examined the arc of barrel, led to an assumption that it may be circular or parabolic in cross section.

A. Casting Process

The present review is on the method employed in stir casting shown Fig 1. The variation in the type of mixing the particulates into the metal matrix has also been dealt with in the paper.

Figure 1.Stirring using Graphite Blade

B. Analytical Calculations

The plastic behavior of L/D ratio 1.0 and 1.5 samples made of AA 2024 & AA 2024/SiC/FA materials were analyzed using the theory of plasticity. The engineering stress-strain curve does not give a true indication of the deformation characteristics of a material because it is based entirely on the original dimensions of the specimen and these dimensions change continuously during the test. In metalworking processes the work piece undergoes appreciable change in cross sectional area. Thus measures of stress and strain which are based on the instantaneous dimensions are needed. True stress and true strains were calculated with the help of the Load – displacement data; which was generated during the cold upsetting of alloy and composites. The calculated true stress and true strains were fit into well established Hollomon power law given by:

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$\sigma = K\,\varepsilon^{n}$

Where σ =Effective Stress

K= Stregenthe Coeffcient

ε= Effective Strain and n Strain Hardening exponent

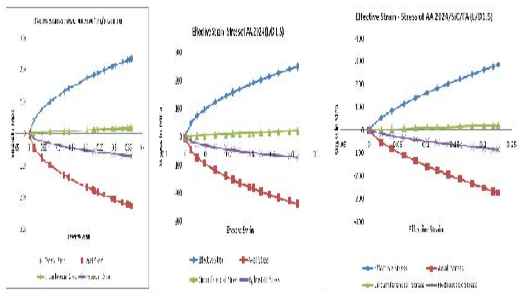

Fig 2 Various Stress – Strains for AA 2024 (L/D 1.0),AA 2024 (L/D 1.5) & AA 2024/Sic/FA (L/D 1.5)

C. *Plastic Analysis Results*

Using experimental data different stress are determined for AA 2024 & AA 2024/SiC/FA material for length to height ratio 1.0 and 1.5 for analyzing of the plastic behaviour of the material. The axial, circumferential and Hydrostatic stress are shown in Fig2.The K and n values are increased with increasing of reinforcement content in the AA 2024 material. K and n values are increased the material having get good elastic properties. Compare to AA 2024, the AA 2024/SiC/FA material having good elastic properties.

D. *Finite Element Simulation*

Finite element analysis of deformation behavior of cold upsetting process was carried out for cylindrical specimens with aspect ratios of 1.0 and 1.5 for AA 2024 and AA 2024/SiC/Fly Ash specimens respectively. Since computers with high computational speed are now available in the market at relatively cheaper cost, the time of computation is not a major constraint for solving the problems of small sized 3-D models. Further, the tetrahedral elements can easily be accommodated in any shape . This reduces the number of iterations and steps to be solved. Owing to these facts the present problem was solved using 3-D model. The analysis can also be extended to non axisymmetric problems using a full 3-D model. In the present analysis, quarter portion of 3-D and full model was considered with symmetric boundary conditions

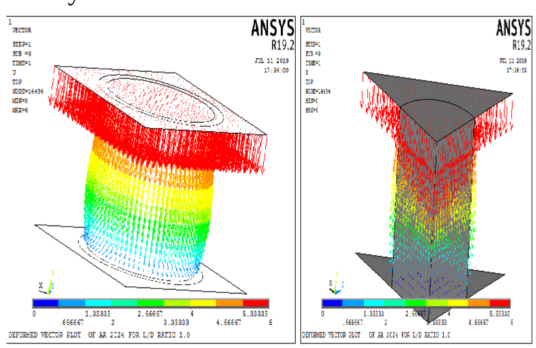

Fig 3. Finite element Model of L/D 1.0 &1.5

III. RESULTS AND DISCUSSIONS

From the Tables 2 & 3 reports that K strgenth coefficient and n strain hardening exponent values of AA 2024 and AA 2024/SIC/FA materials of L/D ratio 1.0 & 1.5. The material is AA 2024/SIC/FA having good elastic properties compare to AA 2024 material for L/D ratio 1.0. The material AA 2024 is brittle in nature because the K and n values are low, if those values are low the material is brittle in nature in the after elastic limit, these confirm by the many researches.

Compare to L/D ratio 1.5 the L/D ratio 1.0 is good because the K and n values are positively obtained in this project work. The pistons and springs today they are taken L/D ratio 1.0 for Alluminium alloys. The new invention material AA 2024/SIC/FA is excellent material properties than a traditional AA 2024.

Table 2 K & n Values FOR L/D RATIO 1.0

TYPE OF MATERIAL	K	n
AA 2024	407.48	0.535
AA 2024/SiC/FLY ASH	1127	0.738

Table 3 K & n Values FOR L/D RATIO 1.5

TYPE OF MATERIAL	K	n
AA 2024	354.60	0.528
AA 2024/SiC/FLY ASH	808.35	0.702

A. FEA Calculations

A 3D model of the Standard cylindrical samples of 12 mm X 12 mm Φ (H/D=1.0) and 12 mm X 18 mm Φ (H/ D=1.5) were designed and modelled in 3D modelling software CATIA successfully. Finite element analysis is performed on the Standard cylindrical samples using the four different metal matrix composites successfully. Different stress like axial ,circumferential and hydrostatic stress performed for the all the metal matrix composites materials, these plots are shown in chapter-5 and shown in below . Results obtained by finite element analysis closely matched with the analytical values and hence the model is validated.

ANSYS 19.2 software was used to analyzing the plastic behaviour of the material. The length and diameter of the specimen was taken as 12mm by 12mm and 3D model was designed in ANSYS. The specimen material was AA 2024, the material data was taken from the experimental results (E=3381 MPa, poison ratio 0.33 and density 2.78g/cc). The bottom and upper plates was designed and assigned as a steel material (E=210 GPa, poison ratio 0.3 and density 7.85g/cc). The contact pair was created between top and bottom plates of the specimen. The convergencey requirement was satisfied as shown in below. A 3D finite element was used (solid 10 node element).

Using experimental data different stress are determined for AA 2024 material for length to height ratio 1.0 for analyzing of the plastic behaviour of the material . The hydro static stress far to the effective strain line, it indicates the material is brittle in nature between the elastic limit to failure limit. The table 6.3 shows that comparison of analytical and ANSYS results of various stress of AA 2024 material. The ANSYS non linear plastic analysis carried out for the maximum deformed shape of the specimen set to 6mm, it was given in the boundary condition aspect view, where as in the experiment the material was broken at 8.36mm, the corresponding stress were found. For this reason a minor percentage of error was found in ANSYS and experimental results. In the ANSYS the true stress and true strain data was given in the material model aspect view.

ANSYS 19.2 software was used to analyzing the plastic behaviour of the material. The length and diameter of the specimen was taken as 12mm by 12mm and 3D model was designed in ANSYS. The specimen material was **AA 2024/SiC/FA**, the material data was taken from the experimental results (E=10277 MPa, poison ratio 0.33 and density 2.769g/cc).The bottom and upper plates was designed and assigned as a steel material (E=210 GPa, poison ratio 0.3 and density 7.85g/cc). The contact pair was created between top and bottom plates of the specimen. The convergencey requirement was satisfied as shown in below. A 3D finite element was used (solid 10 node element).

Using experimental data different stress are determined for AA 2024/SiC/FA material for length to height ratio 1.0 for analyzing of the plastic behaviour of the material. The axial, ciecumferncial and Hydrostatic stress are shown in the Table 6.4.

IV. CONCLUSIONS

The following conclusion can be reached based on the present investigation.

A. AA 2024 alloy prepared in the laboratory was in tune with the commercial alloy.
B. Metal-metal composites of AA 2024 reinforced with Sic and fly ash alloy particulate have been successfully fabricated.
C. Resultant composites were produced by direct hot extrusion.
D. Composite with 12 X 12 mm size reinforcements have shown improved Mechanical Properties Interns Of Density And Ductility.

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