Experimental Analysis of Compressive Stress-Strain Rates and Mechanical Properties of Al 6061 and Al 6061-Sic

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Abstract - The project deals with the study and analysis of mechanical properties and compressive stress-strain deformation of (Al 606l and Al 6061/SiC particle reinforced into a cylindrical component. The experimental component is a cylindrical specimen with two different dimensions. The analysis takes place at a dominant temperature deformation for different compressive stress loads while temperature dominate (room temp). The result show in Al 6061 and Al 6061/SiCcylinder is considers to the different compression strain rates.The experimental component is make powder based metallurgy for combination of content weight%, 80% Al 6061 and 20% SiC reinforcement a cylindrical component is two different radius (15mm,20mm) and height of cylinder specimen (50mm,40mm). Such as step by step apply the five different stress load on test cylinder specimen for evaluate and analysis the different strain rates and different mechanical properties (SEM, Hardness, Elongation) by using finite element analysis method (FEM) and comparison of mechanical properties.

Keywords: Al 6061 MMC, Reinforcements particles, sand casting, compression test, Hardness.

I. INTRODUCTION

A composite material is defined as a combination of two or more materials that results in better properties than those of the individual components used alone. In contrast to each MMC material retains its separate chemical, physical, and mechanical properties. The two constituents are reinforcement a matrix. The main advantages of composite materials are their high strength, stiffness, and combined with low density, when compared with bulk materials allowing for a weight reduction in the finished part. The reinforcing phase provides the strength and stiffness. In most cases, the reinforcement is harder, stronger, and stiffer than the matrix. The reinforcement is usually a fiber or a particulate, while reinforcement to be much weaker and less stiff than continuous fiber composites, but they are usually much less expensive. Particulate reinforced composites usually contain less reinforcement (up to 40 to 50 volume percentage) due to processing difficulties and brittleness. The engineering field is always on the search for new materials with superior mechanical properties combined with ease of design, manufacturing, reproducibility and ability to vary the composition to attain a range of desired properties. Metal matrix composites have drawn immense interest for various applications in aerospace, automobile equipment and other high stressed component, lower cost, easy of fabrication and high dimensional stability [1].

II. MATERIALS USED

2.1 Metal Matrix

The group of heat-treatable alloys uses a combination of magnesium and silicon (magnesium Silicide) to render it heat-treatable. These alloys find their greatest strength, combined with good corrosion resistance, ease of formability and excellent ability to be anodized. Typical alloys in this group include 6061, 6063 and 6082 used for building Structure, land transport applications. The prepared Chemical composition of Al 6061MMC powder metallurgy and their composite were carried out as per ASTM standards.

2.2 Reinforcement Materials

The role of the reinforced particles in a composite material is fundamentally one of improve the mechanical properties of the neat resin system. All of the different particulates used in composites have different properties and so affect the mechanical properties of the composite in different ways. The reinforcement used in the experimentalinvestigation are:

2.2.1 Silicon Carbide (SiC)

Silicon carbide is the only chemical carbon and silicon. It was originally produced by a high temperature electro- chemical reaction of sand and carbon.Silicon carbide is an excellent abrasive and made into grinding wheels. The material has been developed into a high quality technical grade ceramics.The chemical composition of SiCis tabulated in Table 2.

Table 2- Composition of SiC

Compounds	Silicon	Fe	Al	Ca	Cr	Na	Mn	Ni
Weight %	99.7	0.02	0.06	0.01	0.007	0.008	0.02	0.006

III. EXPERIMENTAL SETUP

The material used in this study is commercial Al 6061 and Al 6061/SiCof composite that is fabricated by powder metallurgy method. The chemical composition of the preparation received specimen %80 Al alloy and %20 reinforcement's particles. The compression specimen is of cylindrical different geometry, 30 mm diameter and 50 mm in height and height reduction of specimen 40 mm diameter and 40mm height , cut and machined from the cylinder in such a way that the compression axis is along the rolling direction. After polishing the specimens down with 1200 grit emery paper, the surface of both ends is sprayed.The liquid metallurgy technique (stir cast) with optimum care was taken and standard procedure was followed to obtain the cast cylindrical specimen. The particles were preheated before being introduced into the vortex and stirring of the molten composite were accomplished for 10 minutes at 500 rpm starrier speed. Pouring temperatures adopted were 700°C. The different cylinders of specimen cast composites of Al 6061 and Al6061/SiCwere obtained. The fabrications of experimental cylindrical specimen are fig.1and 2

Fig.-1 Sand casting Al 6061and Al 6061/SiC cylindrical specimen

Fig.-2 Fabrications of Al6061 and Al606/SiC different different cylindrical

IV. RESULT AND DISCUSSION

4.1 Compression Test

All tests were conducted in accordance with American Society for Testing & Material standards. The compression tests are carried out at constant static load rates of 100 to 1000 KN at each load 30 sec impact on different cylindrical testing specimen. Tests are performed in a TUN 1000 UTM machine. The specimen is mounted and compressed between highly polished tungsten-carbide flat dies, the surfaces of the dies being parallel to within 0.005 mm. The specimens are deformed between the flat dies, All the specimens were deformed to different true stress rates. The deformed specimens are shown in fig-3.

Fig 2. Before test specimen

Fig 4.Tested the deform specimen

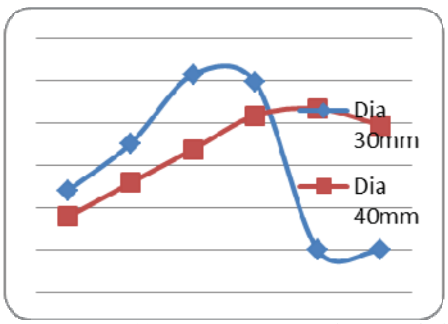
The Compression tests were conducted on a UTM in accordance with ASTM Standard at room temperature. In this test the compression loads were gradually increased and the corresponding strain was measured until the specimenfailed. The load-stroke data obtained from the compression tests are converted into true stress-true strain curves, using standard equations for true-stress and true-strain calculations. To study the effect of flow stress strain rate on flow strain stress rate sensitivity is calculated is given by the equations as" (1), (2)".

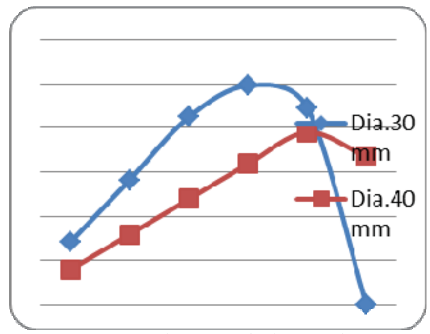
$$\sigma = P/A ==> P/\pi/4\times (D^2) \quad \text{--------} \qquad (1)$$

$$\varepsilon = \sigma/E \quad \text{-------------} \qquad (2)$$

The resultant graphical is arrangement of x-axis plotted by true stresses and y-axis plotted by applied load.

4.2 Compression test true Stress Vstrue strain curve of Al 6061and Al 6061/SiC





(a) True stress-true strain curve of Al 6061 (b) True stress-true strain curve of Al 6061-SiC

4.3 Elongations of different cylindrical specimen

The graph of the experimental elongation of the composites according to the combinations of Al 6061 and then SiC, their different dimensions of specimen. It isexperimentally observed that the elongation of composites is gradually decreased than that diameter of MMC reinforced particle of specimen. Elongation of specimen is observed as 80% wt. MMC and with combination of reinforced range is 20% wt. which elongation of reinforced (Al 6061/SiC) specimen is lower than compare with (Al 6061) elongations of cylindrical specimen.

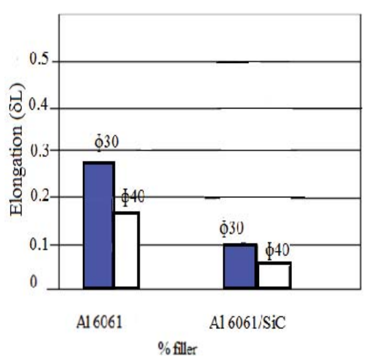


Fig.-5 Elongations of Al 6061 and Al 6061/SiC

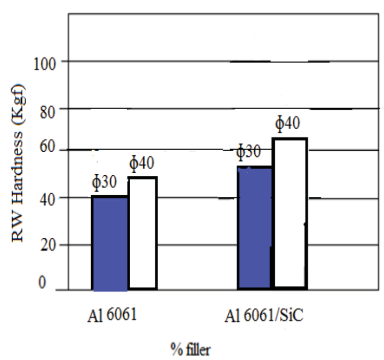


Fig 6.Flow chart for hardness of Al6061 Vs Al6061/SiC

4.3 Micro Hardness Test

The RWH micro-hardness of cast Al 6061 and Al 6061/ SiC bases matrix and their composites. They are evaluated using diamond indenter at an applied load of 100 Kgf is presented in figure 7. From the figure, it can be observed that the hardness of the Al 6061/ SiC is greater than that Al 6061 of cast matrix alloy. The composites containing higher filler content exhibits higher hardness.

Fig.7 RWH Hardness test of Al 6061 and Al 6061/SiC

Table-2. Rackwell hardness for differnet specimen sensitivity values

Specifications of Specimen	Al 6061	Al6061-SiC
30mm diameter	40	54
40 mm diameter	50	65

A load of 100Kgf was applied on the specimen for 30 seconds by using 1/16'' ball indenter and the indentation diameter was measured using a micrometre microscope. The mean values of least five measurements on perpendicular conducted on different areas of each (Al 6061 and Al 6061/ SiC) cylindrical specimen.

4.4 SEM analysis

General elemental analysis of aluminum composites were obtained with scanning electron microscopy and microstructures were investigated at high magnification levels as well The Al 6061 and Al 6061/SiCcylindrical specimen (30 mm diameter) are general analysis performed by scanning electron microscopy. SEM photographs are important to reveal the precipitates that may form after the heat treatment. Since the precipitates are very small and it is very hard to observe with optical microscopy, the only reliable way to observe them is scanning electron microscopy. Their size can be predicted from SEM photographs range are 50µm.

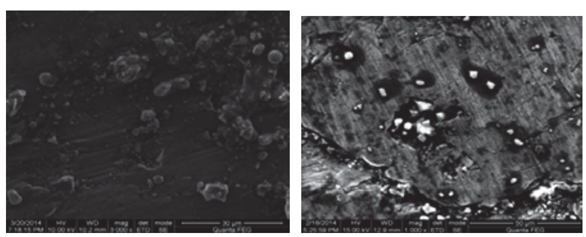


Fig.8 SEM Microphotograph of Al 6061 and Al 6061/SiC

4.5 Compression stress-strain analysis by using ANSYS

ANSYS work bench is used for the compressive stress-strain analysis with determine of deform of ultimate stress. The results are compared between the Al6061 and Al 6061/SiC) of particle reinforcement with unreinforced alloy. The Analysis of Al6061 and Al 6061/SiC different cylindrical specimen and different deformed stage for compressive stress. While specimen consider to different diameter are (30mm, 40mm) of cylindrical.

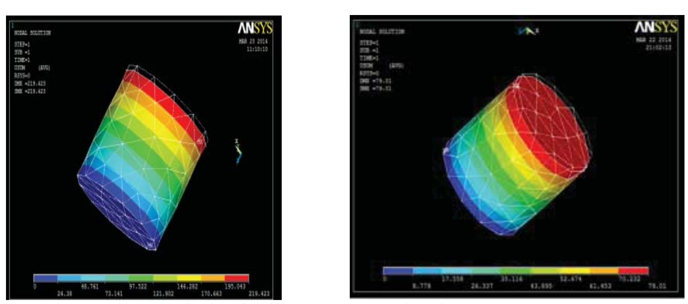


Fig.9 Analysis of different stress-strain Al 6061

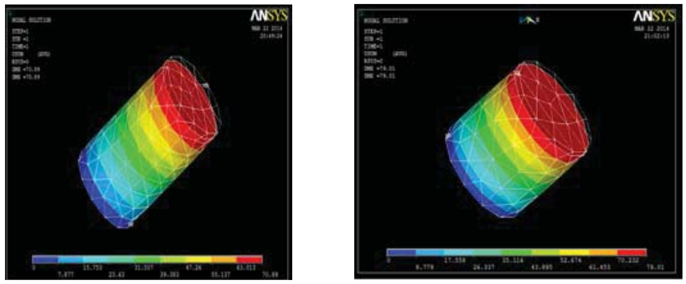


Fig.10 Analysis of different stress-strain Al 6061/SiC

V. CONCLUSION

The study has conducted an experimental test and analysis of investigation to the effects of the different strain rate on the static impact response and micro structural examination of Al 6061 cylindrical specimen at different strain rates from 1.06x10-3 and then Al 6061/SiCstrain rates 0.32 x10-3 the cylindrical specimen geometry in the range of radius (15mm, 20mm) and height of cylinder specimen (50mm, 40mm). The deformation characteristics of Al 6061, Al 6061/SiCalloy by means of the compression test have been determined different applied load range and impact of interval 30 seconds of strain rates. The testing cylindrical specimen for evaluate and analysis the different strain rates and different mechanical properties (SEM Microstructural, Hardness, Elongation) and analysis of deform stage by using finite element analysis method (ANSYS) and comparison of mechanical properties Al 6061/SiC and without reinforcement particles mixture (Al 6061) specimen properties.

REFERENCES

[1] M. A. ABD EL –RAHMAN, W.W.MARZOUK, M.N. EL- SHICH AND M.A.ABD EL- AZEM, (MJET) Vol. 31, No 2, July 2012, Mechanical Behaviour OfAluminum Powder Metallurgy – Ceramic Fibres Composites.
[2] M. ARULSELVAN, G. GANESAN, (IJRTE) ISSN: 2277-3878, Volume-2, Issue-4, Sep 2013, "A Study on Compression Test on Ti-6Al-4V in various Strain rates and Various Temperatures".
[3] A.CHENNAKESAVA REDDY, ESSA ZITOUN (2010), Vol. 3, ISSN: 0974- 6846 Matrix Al-alloys for Silicon carbide particle reinforced metal matrix composites.
[4] DONG JOO KIM, SHERIF EL-TAWIL, AND ANTOINE E. NAAMAN, Vol.32, No.1, 2010, High Strain Rate Material Testing Using Elastic Strain Energy.
[5] DUNG D. LUONG, OLIVER M. STRBIK III, VINCENT H. HAMMOND, NIKHIL GUPTA, AND KYU CHO, Journal of Alloys and Compounds 550 (2013) 412–422, Development of high performance lightweight aluminum alloy/SiC hollow sphere syntactic foams and compressive characterization at quasi-static and high strain rates.
[6] M. GUDEN, I.W. HALL, Materials Science and Engineering A232 (1997), High strain-rate compression testing of a short-fiber reinforced aluminum composite.
[7] JEEVAN.V, C.S.P RAO And N.SELVARAJ,(IJMET), Vol.3.Issue 3, Dec-2012, "Compaction, Sintering and Mechanical Properties of Al-SiC_pComposites".
[8] JING CAI, YUEJIAN CHEN, VITALI F. NESTERENKO, MARC.A MEYERS, Materials science Engineering (2008), Effects if strain rate on the compressive mechanical properties of aluminium alloy materials composite filled with discontinuous carbon fibres.
[9] JOARDAR H, 1DAS N.S, SUTRADHAR G, SINGH.S, IJASE Vol. 2, Issue 4, 2013, " Barreling of solid composite (Lm6/Sic) Cylinders under uni axial compressive load.
[10] KHIN SANDAR TUN, WAI LEONG EUGENE WONG, QUY BAU NGUYEN AND MANOJ GUPTA, Materials 2013,Tensile and Compressive Responses of Ceramic and Metallic.
[11] QUAN Guo-zheng, LIU Ke-wei, ZHOU Jie, CHEN Bi, Trans. Nonferrous Met. Soc. China 19(2009), Dynamic softening behaviors of 7075 aluminum alloy.
[12] RAJESH PUROHIT, R. S. RANA AND C. S. VERMA, (IJERA) ISSN: 2248-9622, Vol. 2, Issue 3, May-Jun 2012, Fabrication Of Al-Sicp Composites through Powder Metallurgy Process And Testing Of Properties.
[13] S. RAMA RAO, G. PADMANABHAN, International Journal of Materials and Biomaterials Applications 2012, Fabrication and mechanical properties of aluminium-boron carbide composites.
[14] RAMESH.A, J. N. PRAKASH, A. S. SHIVA SHANKARE Journals from JMMCE, Vol. 8, No.2, pp 93-106, 2009, Comparison ofthe Mechanical Properties of AL6061/Albiteand Al6061/Graphite Metal Matrix Composites.
[15] WASIU AJIBOLA AYOOLA, SAMSON OLUROPO ADEOSUN, OLUJIDE SAMUEL SANNI, AKINLABI OYETUNJI, Journal of Engineering Science and Technology Vol. 7, No. 1 (2012), Effect Of Casting Mould On Mechanical Properties Of 6063 Aluminum Alloy.