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Compression Strength and Tensile Fracture Analysis of Aluminium Matrix Composites Made Via Stir Casting Method

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Abstract: ***In the research work, preparation of Al-Si-Mg alloy based composites (AMCs) which have been effectively made via economical casting method. AA6351/SiC AMCs included with diverse mass concentration (0, 4, 8, 12, 16 and 20 wt.%) were fabricated via by stir casting method. The effect of hard and brittle SiC particle on the flexural strength (FS), ultimate tensile strength (UTS) and ultimate compression strength (UCS) of the proposed AMCs were assessed. The proposed AMCs and basic alloy were portrayed through scanning electron microscope machine. The examined outcomes exhibit that the mechanical characteristics of the proposed AMCs are boosted by enhancing the SiCp content. SEM photograph illustrates the nearly homogeneous dispersion of SiCp content all over the AA6351 matrix.***

Index Terms: ***Tensile strength, fracture morphology, SEM analysis, flexural strength.***

I. INTRODUCTION

1.1 Nonferrous alloy based composites

In the past few eras, the most number of research and development works has been concentrated on aluminium (Al), magnesium (Mg), Titanium (Ti) and its alloy. Mg is lighter weight, but is extremely reactive to oxygen. In the recent days, aluminium alloy has attracted attention of many researchers, technologists and designers as a promising structural material in different industries like aircraft and automobile. Various metals and alloys have been employed as matrix materials [1-5]. Aluminium and its alloys play a critical role in the manufacturing of MMCs. Aluminium is the most attractive non-ferrous material, particularly employed in the automobile and aerospace industry where weight of structural component is important. The purpose of incorporating reinforcements to aluminium and its alloy are to enhance stiffness, strength, corrosion and wear resistance but, this is achieved at the expense of other attributes. Mechanical property enrichment is not simply a function of volume percentage, size, shape and spatial dispersion of the reinforcement, but likewise it depends upon how well the externally applied load is changed over and transferred to the reinforcement. AMCs are non-magnetic, it is light weight and has outstanding compressive strength. It has possesses superior fatigue and corrosive resistance, creep and abrasive resistance. It delivers extraordinary performance at elevated temperature. They reveal outstanding thermal conductivity, superior shear strength and non-flammability [6-11].

1.2 Manufacturing routes

Ceramic (or) ash particles reinforced metal matrix composites are presently produced using a extensive type of well-known methods as well as specific some patented techniques. Semi solid state slurry casting, liquid state stir casting, exothermic casting, chill casting, squeeze casting, centrifugal casting and solid state powder metallurgy method are the conventional process utilized to manufacture the composites. Amid those fabrication process, melt stirring process is highly fastest, more appropriated, simple, flexible and low-priced method [12-20].

1.3 Reinforcements

In the recent days, non-ferrous alloy based composites is reinforced with brittle and very hard ceramic phases like TiN, AlN, TiO_2, B_4C, SiC, Al_2O_3, TiC, ZrB_2, SiO_2 and TiB_2 to get various preferred properties [21-24].

In the past few decades, brittle form of hard ceramic phases included metallic materials based composites have a enormous quantity of benefits in marine, transportation, aerospace, vehicle structural and military applications such as piston and drive shaft. In this work, the AA6351 matrix phase was included with a various wt% of Si carbide (SiC) to fabricate the AMCs and assess the mechanical characteristics with basic matrix material.

II. MATERIALS AND FABRICATION PROCESS

AA6351 (Al-Si-Mg) alloy was picked as a basic matrix material and the hard ceramic SiC phases are used as the reinforcement material. The SEM micrograph of SiCp is depicted in Figure 1. AA6351 aluminum material has been melted in the Gr material based crucible inside an heating furnace and SiCp were incorporated in several mass concentration like Al6351+0% SiCp,

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Al6351+4% SiCp, Al6351+8% SiCp, Al6351+12% SiCp, Al6351+16% SiCp and Al6351+20% SiCp. Preheating furnace shown in Figure 2. The assessed quantity of SiC particles were incorporated to the molten Al alloy. Melting furnace setup shown in Figure 3.

The casting hotness of the liquid melt was kept at eight hundred and fifty degree celsius. The Al-SiCp liquid melt was mixed frequently at 400 rev/min. After execution of the process, the Al-SiCp melt was poured into mould (300^0C). Proposed AMCs and basic and primary material were exposed to compression test, flexural test and tensile test. The push type compression test (ASTM E9 standard) and pull type tensile test (ASTM E8 standard) was performed on the basic matrix phase and proposed AMCs employing the UTM machine.

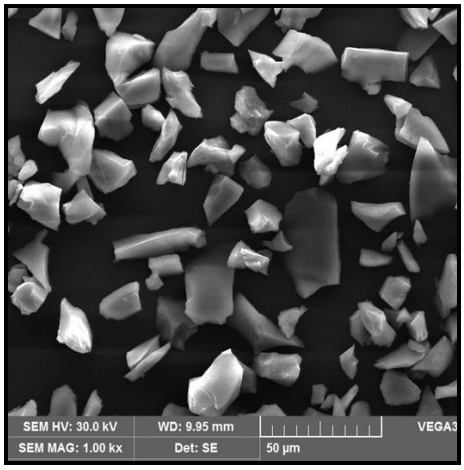

Figure 1. SEM micrograph of SiCp content

Figure 2. Preheated furnace

Figure 3. Melting furnace setup

3. RESULT AND DISCUSSIONS

3.1 Microstructural analysis of AA6351/SiC composites

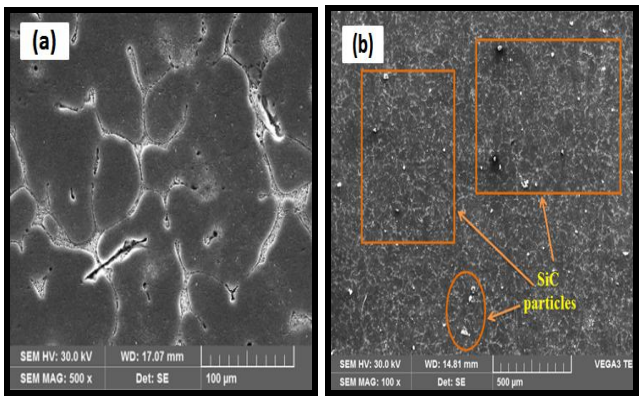

Figure 4. SEM micrographs of (a) AA6351 alloy and (b) AA6351/20% SiC

Figure 4. shows the SEM photographs of the Al-MMCs. SEM microstructural examination display the almost unvarying scattering of SiCp and also reveal the fine and pure interface between the Al alloy and the brittle form of secondary phases. It should enhance the mechanical characteristics of the final Al-MMCs. [12, 13].

3.2 Fracture examination of Al-MMCs

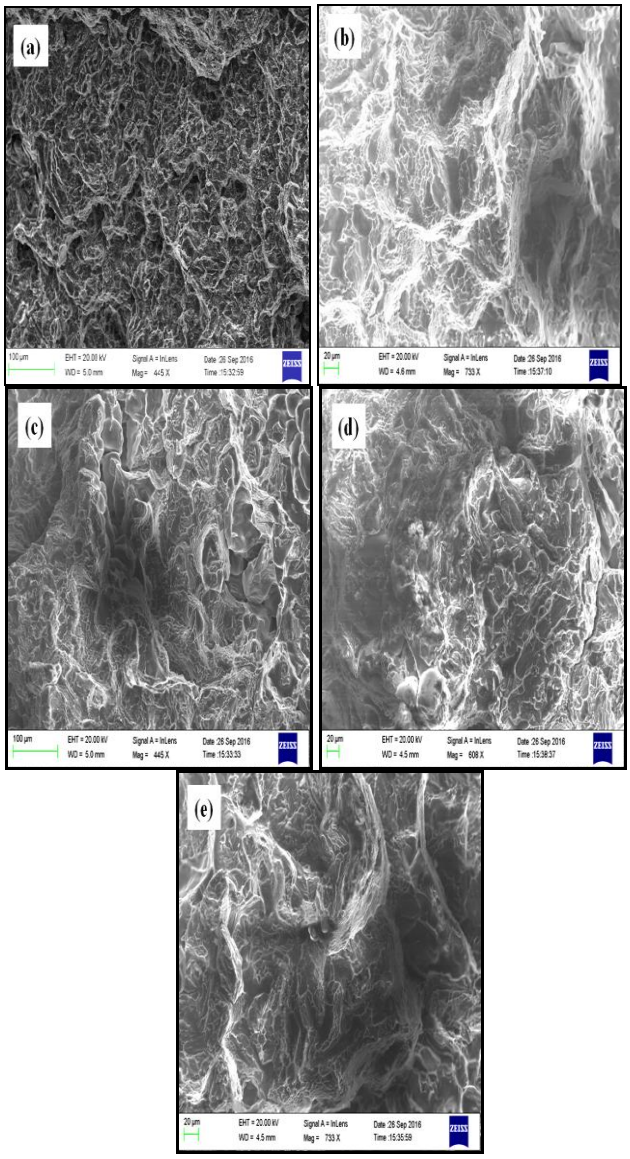

Figure 5. SEM fractographs of Al-MMCs (a) AA6351 alloy, (b) AA6351/4% SiC, (c) AA6351/8% SiC, (d) AA6351/16% SiC and (e) AA6351/20% SiC

Figure 5. displays the tensile fractograph of the AA6351/SiC AMCs. Figure 5(a). displays brittle type of failure at unreinforced matrix alloy. Figure 5(b-e). reveals the addition of SiC particles significantly reduces the quantum of dimples. it can be mainly due to the grain refinement by the SiC particulates. The homogeneous presence of hard SiCp in the matrix alloy the mode of failure linearly transferred from ductile form of failure to merged mode of fracture (ductile and brittle). Some amount of SiCp are detected on the fracture surface representing superior interfacial closeness between the ductile Al material and the brittle SiCp material.

3.3 Strength of the Al-MMCs

Figure 6. displays the yield and tensile strength (UTS) of Al-MMCs. The YS and UTS strength of the AMCs augments progressively with the rise in hard ceramic phase. The homogeneous presence of brittle SiCp phases in the Al-MMCs which serve as an obstruction to the movement of dislocation direct to bonus augmentation in UTS [9, 10]. Besides, the clean and sharp interface into the basic alloy and the SiC particles, extraordinarily transfers the gradual force from the Al material to the SiCp. Thus the YS and UTS of the Al-MMCs is augmented. Table 1. displays the mechanical properties of AA6351/SiC AMCs.

Table 1. Mechanical properties of AA6351/SiC AMCs.

AMCS	UTS (MPa)	YS (MPa)	CS (MPa)	FS (MPa)
AA6351	133	109	179	258
AA6351/4% SIC	169	126	186	277
AA6351/8% SIC	191	141	207	307
AA6351/12% SIC	203	163	223	339
AA6351/16% SIC	215	177	241	365
AA6351/20% SIC	227	194	253	392

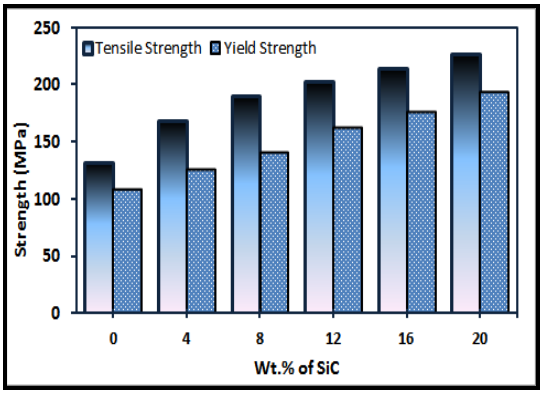

Figure 6. UTS and YS of the Al-MMCs

3.4 Compression strength of the Al-MMCs

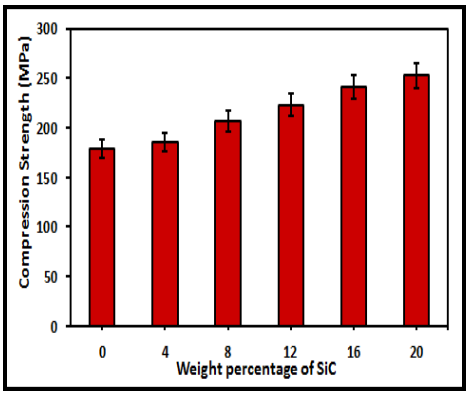

Figure 7. UCS of the Al-MMCs

The impact of SiCp on the UCS of Al-MMCs is revealed in Figure 7. The compression strength was detected to augment with the rise of SiCp phase content and it is remarkably greater than the strength of the non-reinforced basic material. The presence of hard SiC particle in the matrix serves as a barrier for the dislocation movement. This barrier directs to enhance the UCS of the AA6351/SiC Al-MMCs.

Therefore, the UCS reaches peak values at twenty mass fraction of SiC particle in the AA6351 alloy. 3.5 Flexural strength of the Al-MMCs

Figure 8. shows the impact of SiCp phase on the flexural strength (FS) of the AMCs. The FS has been found to augment with the rise in SiCp content. It might be accredited to the boosted dislocation density instigated by CTE (coefficient-thermal expansion) mismatch between Al primary material and the SiC secondary phase, which directs to enhanced the FS of the proposed Al-MMCs.

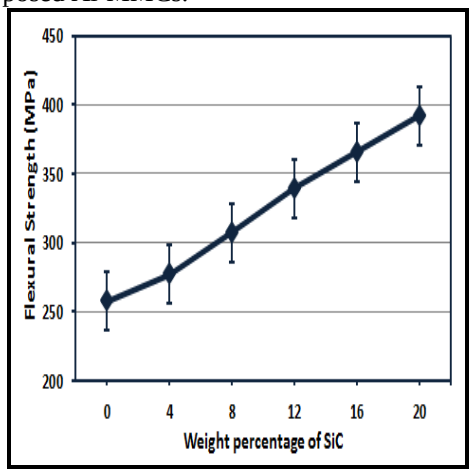

Figure 8. Flexural strength of the Al-MMCs

II. CONCLUSION

The prime goal of this study is for estimating the microstructural and mechanical characteristics of ceramic phases included with 6351Al AMCs were prepared via stir casting method.

- SEM characteristics authorized the almost uniform dispersion of SiCp in Al ductile material.
- The UCS, YS, UTS and FS of the Al-MMCs have drastically enhanced by the occurrence of hard SiCp.
- AA6351/SiC composites attains a peak hardness of 89 HRB at 20 wt.% SiC.
- The mechanical characteristics of the AMC is developed at the 20 mass concentration of SiCp content.

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