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Experimental and FEA evaluation of AA2014/TIC composites

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Abstract: ***AA2014/titanium carbide composites (Al-MMCs) included with diverse mass fraction of TiC (0, 4 and 8 wt.%) were made through stir casting method. This present work, examines the tensile behavior of the fabricated specimen and finite element modeling based tensile specimen. Experimental tensile specimens are examined through ultimate testing machine (UTM). The modeling of the tensile specimen has been developed in ANSYS 12.0 for finite element analysis, which are the most standard CAE tools. Tensile load values are calculated by experimental method and that load values are given as input to the FEA analysis. The finite element outcomes employing ANSYS APDL software exhibiting stresses and deflections were confirmed with experimental upshots and analytical outcomes.***

Index Terms: ***ANSYS, Composite, Modeling, Tensile properties.***

I. INTRODUCTION

Aluminium and its alloys play a key role in the fabrication of Al-MMCs. Aluminium is the greatest attractive non-ferrous material, predominantly employed in the automotive, airplanes, structural and aircraft company where weight of structural component is important. The purpose of including reinforcements to aluminum and its alloy are to develop stiffness, strength, corrosion and wear resistance but, this is attained at the expense of other attributes [1-5]. Al matrix composites (Al-MMCs) are broadly employed in several industries because of its extraordinary specific strength and weightless [6-8]. The mechanical properties of Al-MMCs are prepared via different form of processes like vacuum casting, pressure die process, stir casting, chill casting, powder metallurgy and centrifugal casting. Amid those casting methods, the stir casting process is extremely simple, greatly flexible, very simple, more convenient and very cheap process when compared to other producing methods [9-14].

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Finite element analysis (FEA) is a method, which can predict the maximum & minimum stress values and deformation values on a structure. Finite element modeling splits the structure into a grid of elements, which form a model of the real structure. All the elements is a simple shape (like rectangle, triangle or square) for which the FEA has information to write the governing equations in the form of a stiffness matrix. ANSYS is a fine and accurated mechanical software is a comprehensive FEA analysis tool for thermal, fluid, structural analysis, comprising linear and dynamic analyses [15].

II. SPECIMEN PREPARATION

2.1 Experiment Method

For each casting, about 1200 gram of Al 2014 was primarly heated and melted in the crucible to a temperature of 900 degree celcius. The reinforcing particles TiC of 4 wt% and 8 wt% were preheated to 500oC. The TiCp were then added in the Al material plainly melts through vortex. The tensile samples were made through EDM machining according to ASTM E08 standard. Figure 1. schematic diagram of tensile specimen.

2.2 FEA Method

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].

2.3 Reinforcements

The standard dog bone shape tensile samples were made through designing according to ASTM E08 standard. To achieve tensile samples with thick of 12 mm and a gauge length of 40 mm were tested in a UTM machine. Figure 2. displays the FEA model tensile specimen. ANSYS APDL is a typical reason FE modeling package. In this work, FEA model is carried out using ANSYS 12.0 APDL software. The sample is meshed with the Quad 4node 182 element which has 3 DOFs. The FE model of the tensile sample obtained with 9000 elements and 11466 nodes.

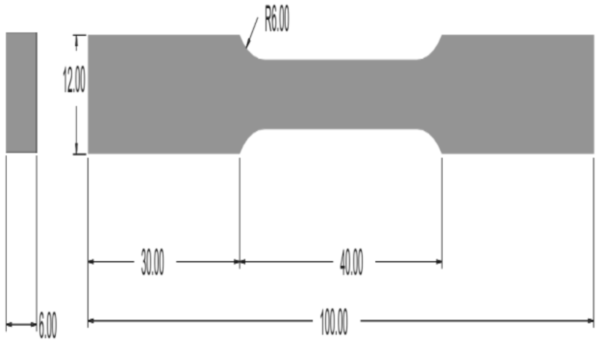

Figure 1. Schematic diagram of tensile specimen as per ASTM E8

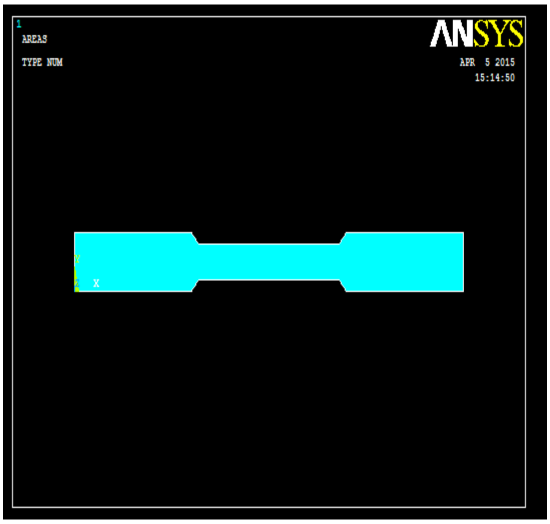

Figure 2. FEA model tensile specimen as per ASTM Standard

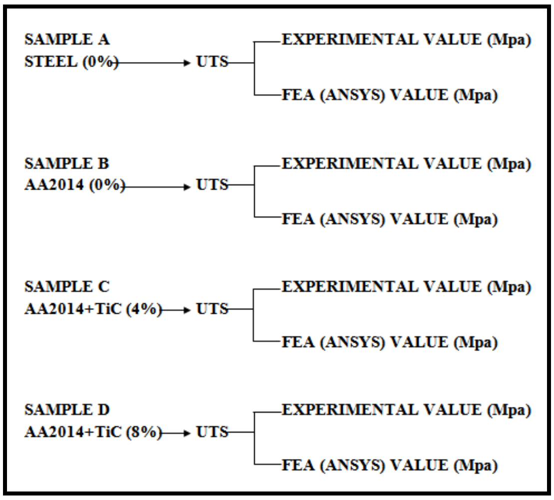

Figure 3. Schematic representation of experimental plan

III. RESULTS AND DISCUSSIONS

3.1 Comparison of tensile behavior on steel and composite materials

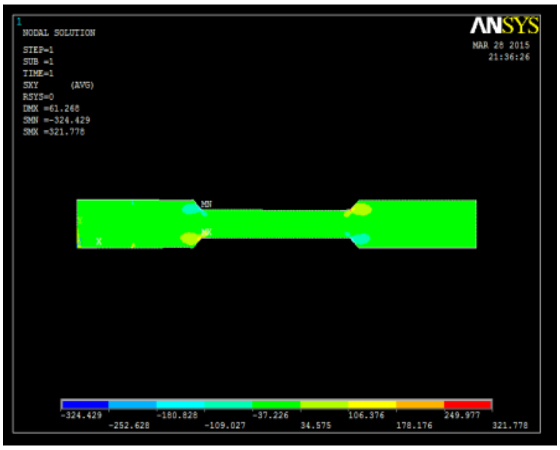

Figure 4(a). Steel

Figure 3. displays the schematic representation of experimental plan. Specimen were fabricated as per ASTM standard with varying weight percentage of aluminium composite and steel specimen are as shown in figure 4(a-d).

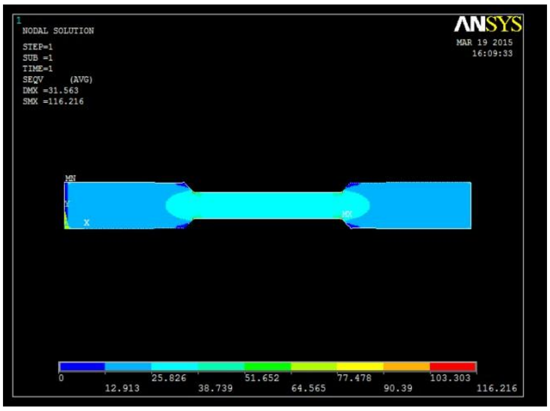

Figure 4(b). AL2014+0%TiC

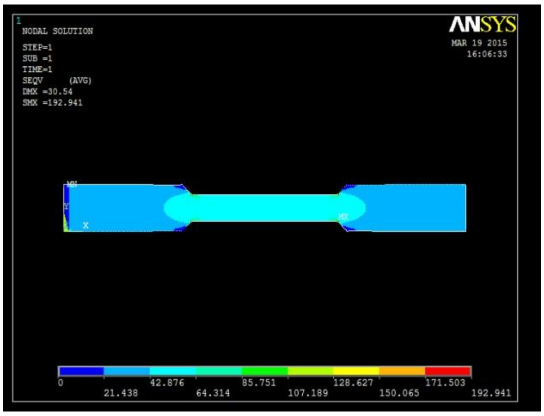

Figure 4(c). AL2014+4% TiC

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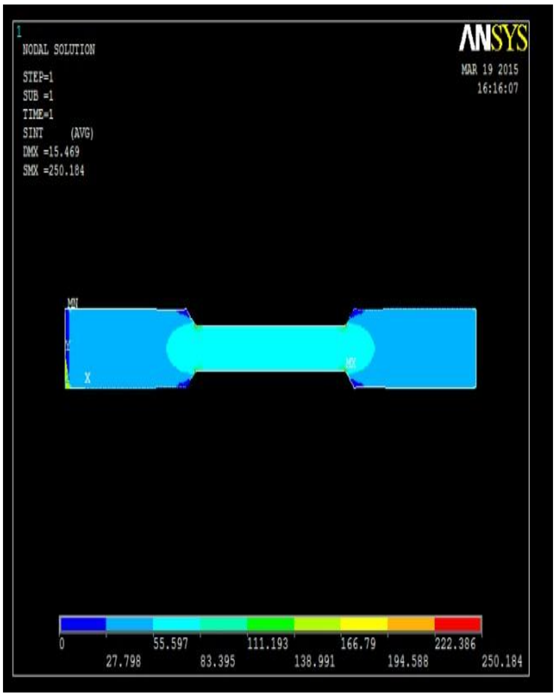

Figure 4(d). AL2014+8% TiC

3.2 Experimental results

Figure 5. displays the before and after fractured tensile specimen. The sample is fixed in the computer based UTM and the movable jaw is adjusted for the gauge length of 25 mm.

The tensile load is progressively applied till the sample is broken at the range of 5.73 KN to 11.42 kN. The experimental tensile strength obtained for from this analysis at the values of 112.09 MPa to 245.71 MPa. The AA2014/8%TiC composites revealed the higher tensile value compared to the plain Al material.

Moreover, the tensile strength values of the steel is superior than the UTS of the Al-MMCs, but the developed composite materials having good wear resistance, superior strength and light weight for low density.

Therefore developed composite materials are extensively replace the conventional materials. Experimental and FEA tensile behavior of the Al-MMCs and steel specimen values are shown in Table 1.

Figure 5. Before and after fractured tensile test specimen

Table 1. Tensile strength of experiment and FEA results

S.NO	SAMPLES	BREAKING LOAD (KN)	EXPERIMENTAL TENSILE STRENGTH (MPa)	FEA TENSILE STRENGTH (MPa)
1.	STEEL	15.52	316.09	321.778
2.	AA2014	5.73	112.09	116.216
3.	AA2014+4%TiC	8.87	185.11	192.941
4.	AA2014+8%TiC	11.42	245.71	250.184

3.3 FEA tensile results

In this study exhibits the UTS value of the aluminium composite material and steel. The tensile strength value is to be analyzed by using ANSYS (APDL12.0). Sample one end is arrested (All DOF) and other end is loaded. Assessing is completed when the load reaches a higher value of 5.73 to 11.42 kN for different specimens. The FEA tensile strength obtained for from this analysis at the values of 116.216 MPa to 250.184 MPa. The AA2014+8%TiC Al-MMCs discovered the higher tensile value compared to the base alloy.

3.4 Qualified evaluation of experimental and FEA results

The UTS of the specimen is compared with the experimental and FEA results. The disparity in the three values is detected to be 4.0 to 8.0%. The experimental and FEA comparative values are display in Table 2.

Table 2. Difference between the experimental and FEA results

S.NO	SAMPLES	EXPERIMENTAL TENSILE STRENGTH (MPa)	FEA TENSILE STRENGTH (MPa)	ERROR
1.	AA2014	112.09	116.216	4.12%
2.	AA2014+4%TiC	185.11	192.941	7.83%
3.	AA2014+8%TiC	245.71	250.184	4.47%

IV. CONCLUSION

Al-Zn-Mg-Cu (Al 2014) alloy included with 4, 8 wt% of TiC were magnificently prepared via Stir casting. The experimental and FEA tensile testing result was studied. From the result the experimental was found to be the lowest than the FEA due to nominal level of interface and minimum level of particles distribution in the Al-MMCs. Design of steel and Al/TiC Al-MMCs specimens were successfully designed by ANSYS12.0. The reinforcement of particle has enhanced the experimental tensile strength values of aluminum matrix specimen from 112.09 (MPa) to 245.71 (MPa). The tensile strength of steel specimen is 316.09 (MPa). Finally we conclude thus the FEA method is more accurate when compared with experimental results.

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