ANALYSIS ON THE STUDY OF CHANGES IN MECHANICAL PROPERTIES OF AL6063-SIC

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Abstract:

The unique tolerability of the composite materials for the specific requirements make these materials more popular in a variety of applications such as aerospace, automotive (pistons, cylinder liners, and bearings), and structural components, resulting in savings of money, material, and energy. In this paper; fabrication of aluminium metal matrix composite (MMC) is prepared by liquid metallurgy route (stir casting technique). The objective of this experimental investigation is to produce two different metal matrix composite (MMC) specimens using Al6063 as a base material which reinforced with a ceramic additive (silicon carbide SiC, with grain size 1000 mesh) with same volume fraction of 10% by wt. By the addition of SiC_p particulates into the alloy of base metal Al6063; it was found increased value of the ultimate tensile strength, and hardness and decrease elongation of the composites. It was also investigated that the composite poured from lower layer (lower half) of melted matrix from crucible were with less values of tensile strength and hardness as compared to the composite poured from upper layer (upper half).

Key words:

Composite materials; Liquid state mixing; Mechanical properties;

1. INTRODUCTION

Aluminium alloys are widely used in a large number of industrial applications due to their excellent combination of properties, for example; good wear resistance, exceptional thermal conductivity, high strength to weight ratio, good tensile strength, and high ductility [1, 2]. Aluminium alloy are applicable for manufacturing automobile and aircraft components because of high strength to weight ratio in order to make the moving vehicle lighter, which results in saving in fuel consumption [3, 4].

Hardness of the composites found increased with increased SiC content. And some authors; G.R.C. Pradeep, A. Ramesh, G.B. Veeresh Kumar studied that finer the grain size better is the hardness and strength of composites leading to lowering of wear rates [1]. Most researchers [2-4, 11] agree that the wear rate of Al-Si alloys goes through a minimum at certain Si content. Silicon has received the most attention among all alloying elements studied. This is due to the fact that Al-Si alloys are corrosion resistant, strong, have low thermal expansion coefficients, and have superior tribological characteristics compared to the other aluminium alloys [7]. These

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alloys have been successfully used as substitutes for cast iron in applications such as pistons and cylinder linings for internal combustion engines [8, 9], swash plates, connecting rods, and sockets in refrigerant compressors [9].

The 6061 aluminium alloy exhibited its potential to act effectively as a self lubricating material under dry sliding conditions recording a minimum wear rate and co efficient of friction at 5 Wt % and 15 Wt % graphite content respectively [12]. Earlier authors have reported that during dry sliding aluminium alloy – graphite composite forms a layer of graphite with solid lubricant between the contacting surfaces [13]. This helps in reducing the friction and wear and post pones the onset of severe wear. The formation and retention of this lubricant layer, its thickness and hardness depends largely on the graphite content in the composite. Earlier works have also identified that with increasing graphite content richer graphite lubricating film formed on the lubricating surface lowers the wear rate [13].

In this paper, the material selection criteria involves the requirement of high strength and good corrosion resistance aluminium alloy for the matrix materials, and the inexpensive reinforcement particles which can result in increased ultimate tensile strength and hardness. The matrix materials used in the present work is Al 6063and the reinforcement materials are silicon carbide (SiC_p) particulates of grain size 1000 mesh) 10% by wt and by virtue of which the tensile strength, hardness, and Al–SiC were evaluated. And effects of SiC_p upper layer and lower layer of melted matrix in crucible were investigated in an attempt to understand the uniformity of SiC_p through-out the matrix.

2. EXPERIMENTAL TECHNIQUES

2.1 Stir Casting Design:

The stir casting is one of the best known methods of preparing metal matrix composites. The components selected as the parts of the casting setup were chosen specifically according to their properties and qualities. In today's world there is a tough competition between two technologies viz metal matrix composites and powder metallurgy. Both are the efficient methods of preparing alloys. However the method with least preparing cost will be preferred. At 1st it was aim to preparing such a setup which could prove itself useful for the desired research work. And the setup shown in Fig 1 made by us as our requirements.

Stir Casting Machine

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Fig (1)

2.2 Casting Operation And Procedure :

The liquid metallurgy route (stir casting technique) has been adopted to prepare the cast composites described as: Preheated SiC powder of particle size 1000 mesh was introduced into the vortex of the molten alloy after effective degassing. Mechanical stirring of the molten alloy for duration of 8 to 12 minute was achieved by using steel impeller. A speed of 650 rpm was maintained. A pouring temperature of 900 ^{o}C was adopted and the molten composite was poured into mild steel moulds as shown in fig (2). The extent of incorporation of SiC in the matrix alloy was 10 % by wt. Thus composites containing particles 10 wt % were obtained in the form of rectangular of 160*125* 25mm size shown in fig (3).

An electrical furnace was used at the first stage for melting the aluminium in a graphite crucible. Subsequent to the melting of the aluminium, the melt temperature was increased to 1000 ^{o}C and then 10% by wt. SiC particles which are preheated at 650 ^{o}C were introduced to the melt with vigorous stirring to make the melt homogenous under protective pure nitrogen gas atmosphere and then the upper layer (upper half) and lower layer (lower half) of melt from crucible were poured into two different permanent mild steel pre-heated (about 150 ^{o}C) moulds and the pouring temperature noted as 920 ^{o}C.

2.3 Material Used :

The matrix material for this experiment used Al60 and mechanical properties and chemical compositions are given in table (1). The reinforcing material selected was SiC 10% by wt. of grain size of 1000 mesh and table (2) gives the physical and mechanical properties of SiC_p. And Graphite crucibles of different size are used to heat up the SiC_p and to melt the matrix base material Al6063.

TABLE (1). MECHANICAL PROPERTIES AND CHEMICAL COMPOSITIONS OF MATRIX MATERIAL AL 6063 [matweb properties of Al 6063]

Alloy	*H.B.*	*U.T.S.(MPa)*	*M.O.E.(GPa)*	*Y.T.S.(MPa)*
6063	*20*	*89.6*	*68.9*	*43.3*

Al	*Cr*	*Cu*	*Fe*	*Mg*	*Mn*	*Si*	*Ti*	*Zn*	*Other total*
<=97.5%	*<= 0.10%*	*<= 0.10%*	*<= 0.35%*	*0.450- .90 %*	*<= 0.10%*	*0.20- 0.60 %*	*<= 0.10%*	*<= 0.10%*	*<= 0.15%*

TABLE (2) MECHANICAL PROPERTIES OF SiC [matlab properties of silicon carbide]

Elastic Modulus *(GPa)*	**Density (g/cc)**	**Knoop Microharness**	**Compressive Strength (Mpa)**
410	*3.10*	*3000*	*345*

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Fig (2) mild steel permanent mould with two different size

Fig (3) casted matrix composits

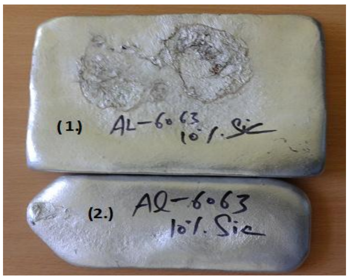

Fig (4) parmanent mould

2.4 Preparation Of Two Specimens For Testing :

From two different layers of melt from upper half and lower half were poured in two different moulds and then two different metal matrix composites were collected from the moulds as shown in fig (3). And then two specimens were prepared from matrix composite (1.) and matrix composite (2.) as shown in fig (4) and fig (5) respectively on shaper machine (model no 1140), power hacksaw machine. At first specimen (1) an specimen (2) both were prepared of size 160*20*18mm. And then for hardness testing policing has been done on both specimens and then Vickers Hardness testing was done for both specimens, and then both specimens were machined in the form of dumbbell for tensile testing, as shown in fig (4, 5)

Fig (4) **Al6063 with SiC 10% by wt. from upper layer of melted matrix**

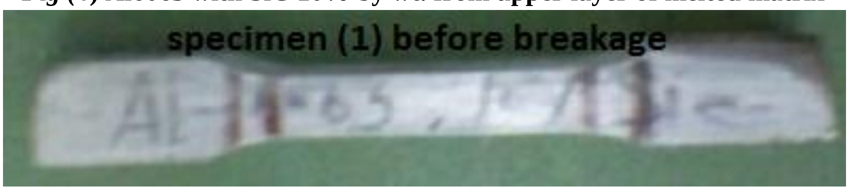

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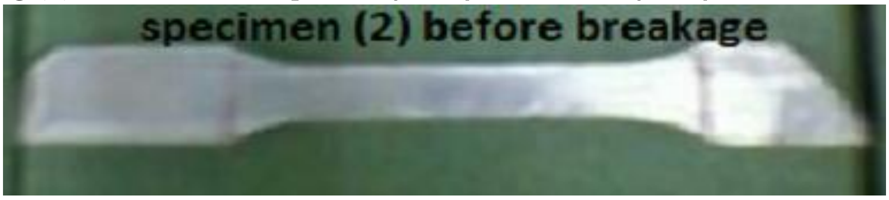
Fig (5) Al6063 *with SiCp 10% by wt. from lower layer of melted matrix*



3. *RESULTS*

3.1. Tensile Property:

The tensile properties of the composites studied are given in Table 3. It can be seen that the proof stress, the ultimate tensile strength increased in specimen. And it is observed that %age elongation decrease from 22 to 9.82. A ductile fracture appearance was observed with shearing effects on the surface. The mechanical properties such as hardness, tensile strength, elongation property test results of Al6063 and its composites containing SiC at various time of pouring are presented in these sections. Maximum load for specimen (1) is given by this graph (1); F_m = 30.600 KN and the area on which load was applied = 275.807 mm^2, so Tensile Strength = 111 N/mm^2.

Graph (1) for matrix with SiC 10% by wt. from upper layer of melted matrix in crucible

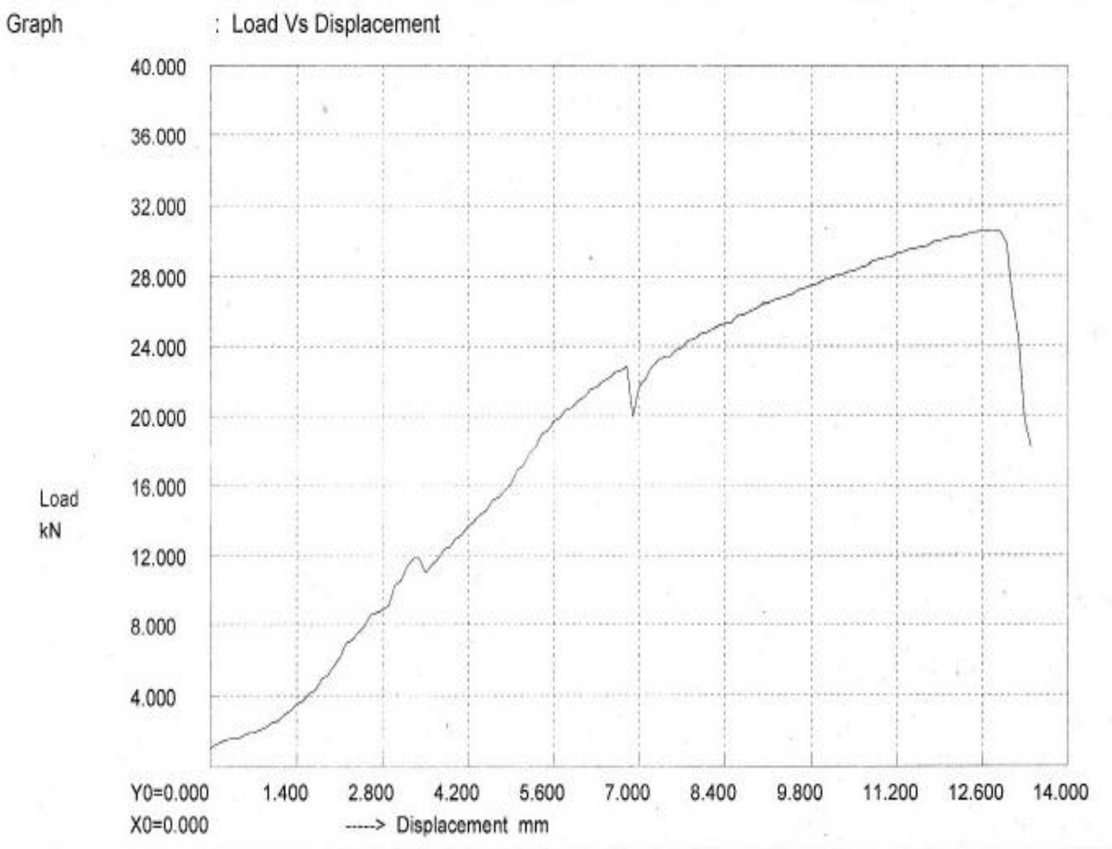


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TABLE (3) PHYSICAL AND MECHANICAL PROPERTIES OF AL6063 AND SIC(10 WT % UPPER LAYER OF MOLTEN MATRIX FROM CRUCIBLE)

Tensile Strength (Mpa)	Hardness (HV)	Elongation (%)
111	65.47	9.82

Then tensile strength was tested for specimen (2). Which was found less in comparison that of specimen (1). Maximum force F_m = 14.550 KN, and area of specimen on which force was applied = 135.494mm^2. Hence results for tensile strength of specimen (2) found = 107 N/mm^2 as shown in table (4). Testing was done on UTM, Model No: UTE 100, Sr. No. : 4/2010-4328

TABLE (4). PHYSICAL AND MECHANICAL PROPERTIES OF AL6063 AND SIC(10 WT % LOWER LAYER OF MOLTEN MATRIX FROM CRUCIBLE)

Tensile Strength (Mpa)	Hardness (HV)	Elongation (%)
107	51.83	10.24

Graph (2) for matrix with SiCp 10% by wt. with lower layer of matrix from crucible

3.2 Hardness :

Hardness is closely related to strength. It is the ability of a material to resist scratching, abrasion, indentation, or penetration. It is directly proportional to tensile strength and is measured on special hardness testing machines

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by measuring the resistance of the material against penetration of an indenter of special shape and material under a given load. The different scales of hardness are Brinell hardness, Rockwell hardness, Vicker's hardness [14]. The Vickers hardness of aluminium-SiCp composite specimen (1) and specimen (2) was tested.
The result for specimen (1) is shown in table (3) and that of specimen (2) in table (4). The Vickers hardness of all specimens increases due to addition of SiCp particles. The increase in hardness for the composites is not dramatic and may be due to the increase in their brittleness or due to very fine particles of grain size 1000 mesh.

The change in the hardness of composites with lower portion of melted matrix with less content of reinforcement SiCp particles which is reduced from 68.47 HV to 51.83.and table (5) represent the variation in hardness, tensile strength, and elongation. Hardness is evaluated at a load of 1kgf by using Vickers Hardness Tester; Model No. $VM50^{pc}$, Sr. No. 04/2010-1118.

TABLE (5) COMPARISON BETWEEN MECHANICAL PROPERTIES OF TWO SPECIMENS

Type Of Specimen	Tensile Strength (N/mm^2)	Hardness (HV)	Elongation (%age)
Specimen (1)	111	65.47	9.82
Specimen (2)	107	51.83	10.24

Fig (5) Specimens after breakage

3.3 Stress-Strain Diagrams :

The internal resistance of the material to counteract the applied load is called stress, and the deformation as strain. There are three types of stresses: Tensile stress: force acts to pull materials apart; Compressive stress: the force squeezes material; Shear stress: the force causes one part to slide on another part [14]. There are three types of corresponding strains. The metals are tested on a Universal Testing Machine. The stress-strain diagram is a diagram with values of stress (load) as ordinate and strain (elongation, compression, deflection, twist etc.) as abscissa. Mechanical properties depend upon the crystal structure, its bonding forces, and the imperfections which exist within the crystal [14].

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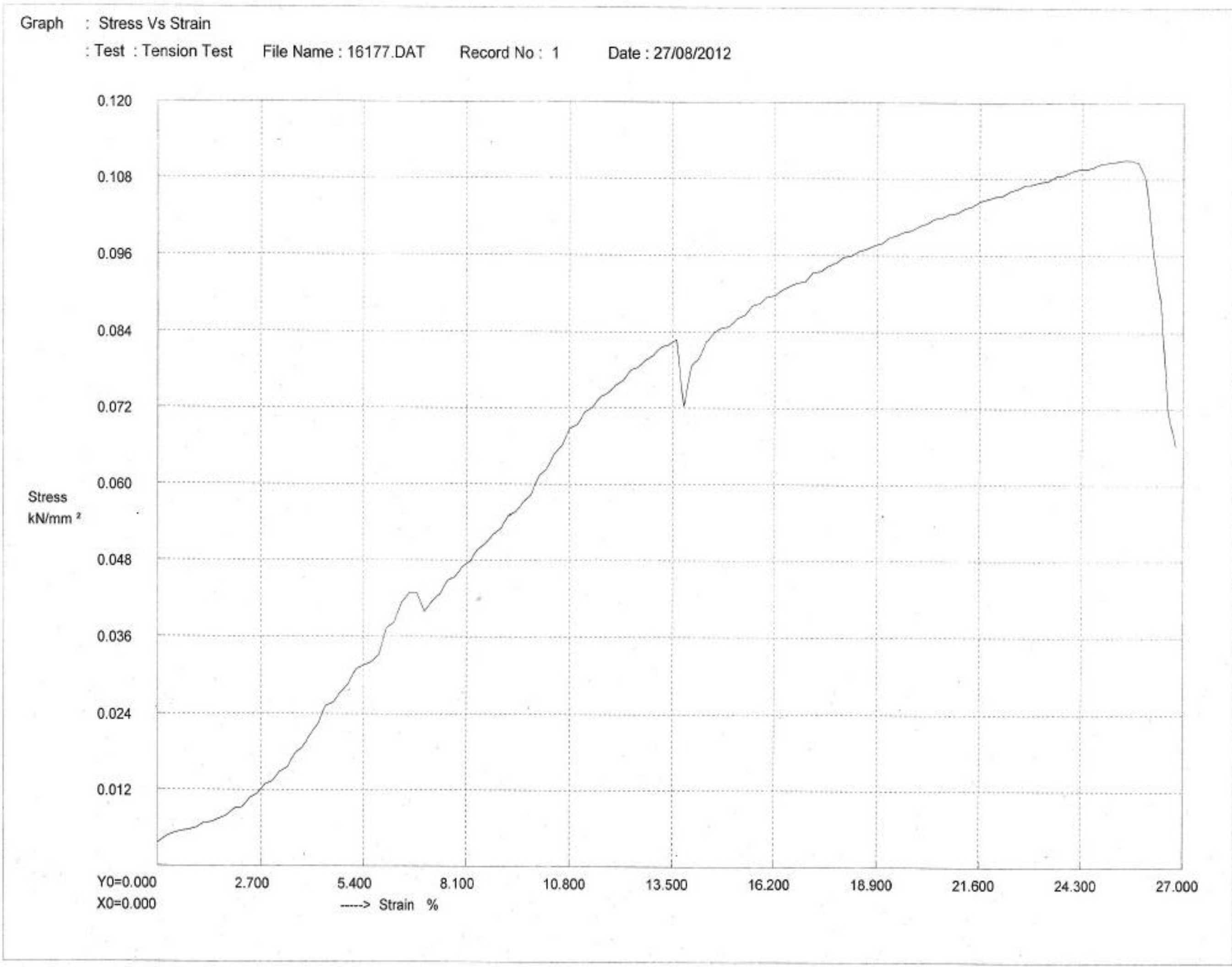
Stress and strain diagram for specimen (1)



Ductility of a material enables it to draw out into thin wire on application of the load. Mild steel is a ductile material. The wires of gold, silver, copper, aluminium, etc. are drawn by extrusion or by pulling through a hole in a die due to the ductile property. The ductility decreases with increase of temperature. The per cent elongation and the reduction in area in tension is often used as empirical measures of ductility Stress-Strain curves are unique for each material and are found by recording the amount of deformation (strain) at distinct intervals of tensile load. The linear portion of the curve is the elastic region and the slope is the modulus of elasticity or Young's Modulus [15].

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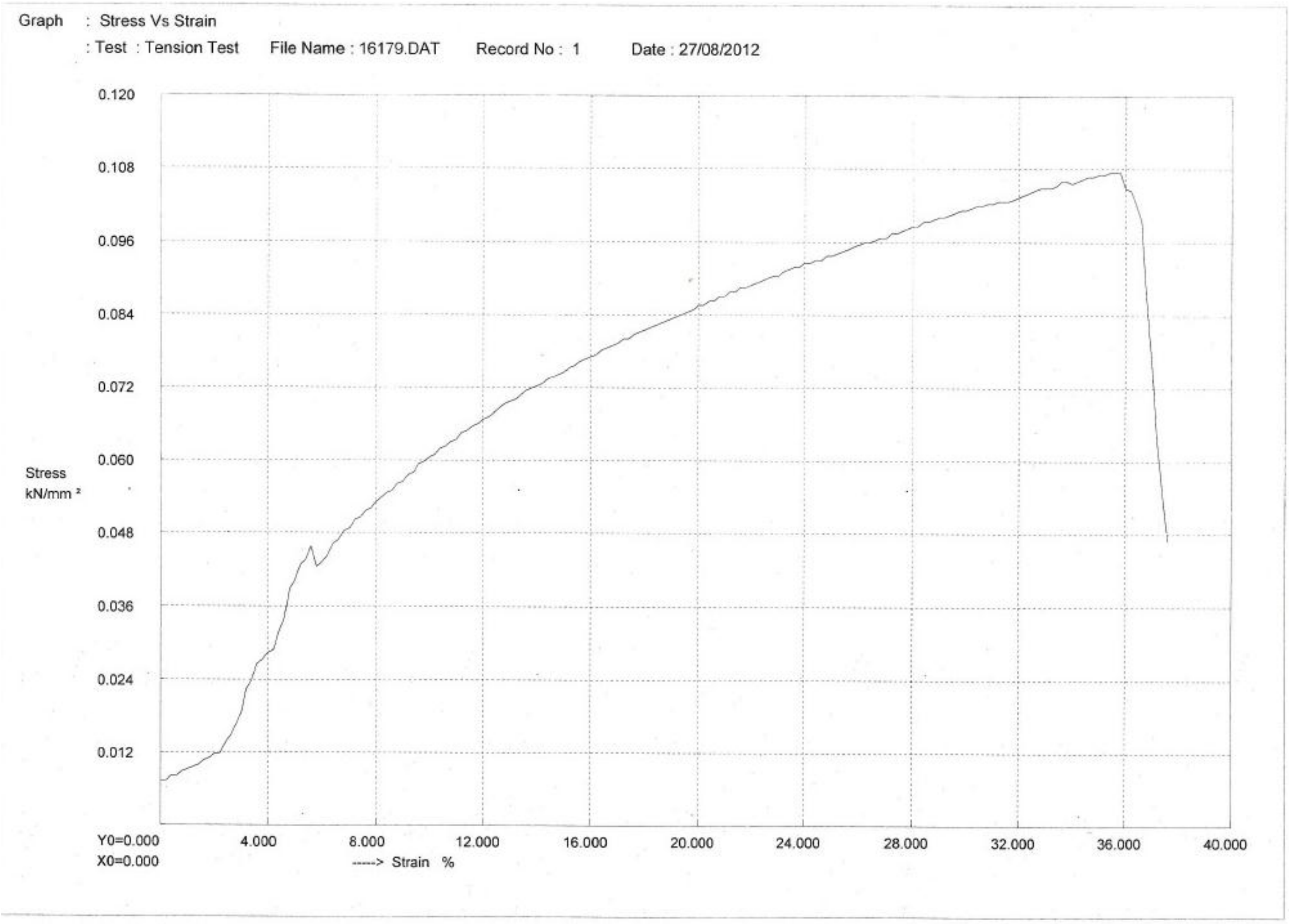
Stress and strain diagram for specimen (2)



4. **CONCLUSIONS**

The significant conclusions of the studies carried out on Al6063 - SiC composites are as follows.

- Casting of Al6063– SiC_p composites were prepared successfully using liquid metallurgy technique (stir casting method).

- Hardness of the composites found more in upper layer of melted matrix in crucible comparison to lower layer of matrix in crucible.
- Hardness decreases by 20.8% from upper half to lower half.
- Grater Tensile strength in upper layer in comparison with lower layer of matrix in crucible.
- Tensile strength decreases by 3.8% from upper half to lower half.
- Percentage elongation is also greater in the lower layer with the difference of 0.42.
- Percentage elongation increases by 4.49% from upper half to lower half.

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