Tensile Properties of Titanium Carbide Particulates Composites

Suraya. S, Sayuti. M, Sulaiman. S, and Arifin. M.K.A

Abstract— **In this research, Aluminium alloy 11.8% Silicon alloy with titanium carbide as a particulate were manufactured by sand and die casting methods. Tensile properties of these composite materials were investigated by different weight percentages, 5%, 10%, 15% and 20%wt. The effects of reinforce materials on weight percentages were investigated. The experimental results show that using permanent metallic moulds has better tensile properties result compare using sand casting moulds.**

I. Introduction

WITH current trends of using lightweight, environment friendliness, quality, performances and economical materials for a variety engineering application, metal-matrix composites (MMCs) may find special application as they exhibit a wide range of mechanical behavior (e.g., tensile and compressive properties, creep, notch resistance, and tribology) and physical properties(e.g., intermediate density, thermal diffusivity)[1]-[2]. Parallel to this development, metal matrix composite (MMCs) have been attracting emergent interest [2].

A metal matrix composite (MMCs) are composite material combining two or more materials, one of which is a metal, where the tailored properties can be attained by systematic combination of different constituents [3]. It is composed of an element or alloy matrix in which a second phase is embedded and distributed to achieve some property improvement [4]. Based on the size, shape and amount of the second phase, the composite property varies [5]. Particulate reinforces composites, often called as discontinuously reinforced metal matrix composites, constitute 5-20% of these new advanced materials.

II. Experimental Work

In the research project, the main materials used were LM6 aluminium alloy as a matrix material and titanium carbide as a particulate reinforced added in different weight percentages, %wt. LM6 is based on British specifications that conform to BS 1490-1988 LM6. LM6 alloy is a eutectic alloy that have lowest melting point that can be seen from Al-Si phase diagram.

In the casting methods, the liquid matrix material is reinforced by a particulate. The powder mixtures prepared for four different percentages of titanium carbide particulate based on its weight fraction from 5%, 10%, 15% and 25% are added to the aluminium-11.8% silicon alloy matrix to make composite cylinder composite castings by sand and permanent metallic mould process. Figure 1 shows the sand and permanent metallic mould for this research. Tensile tests are conducted to determine the tensile properties. The flow chart for the experimental work is shown in Figure 2.

Figure 1 Sand and permanent metallic mould

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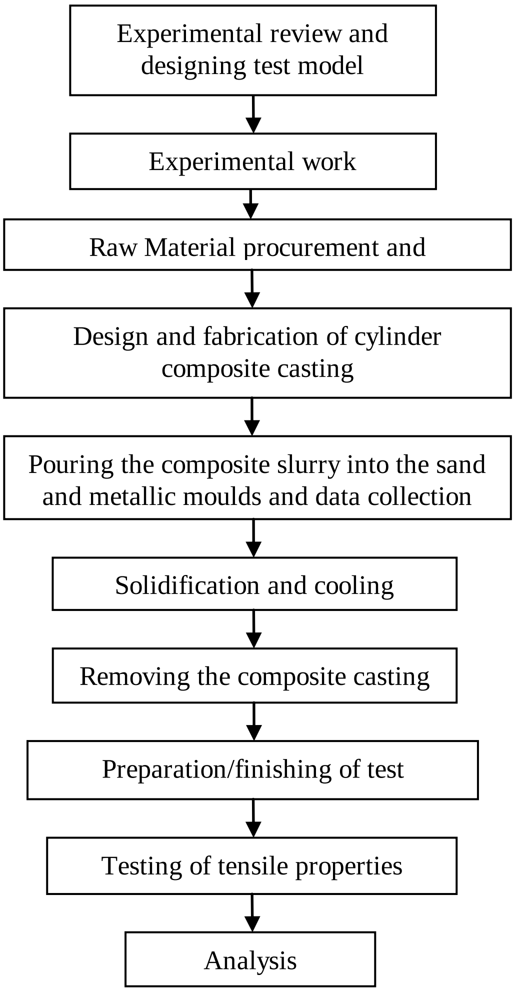

Figure 2 Overview of the research project

Tensile strength is a ratio of the maximum load a material can support without fracture when being stretched to the original area of a cross section. For tensile testing, the test specimens were made according to the ASTM B557M-94 with the thickness 6mm. This standard shows the test method that will cover the determination of the tensile properties of wrought and cast aluminium and magnesium alloy products excepting aluminium foil in the form of standard dumbbell-shaped test specimens when tested under defined of pretreatment, temperature, humidity, and testing machine speed [6]. The speed control 2.00mm/min. Tensile test were performed using an 100 KN servo hydraulic INSTRON 8500 UTM testing machine. Each test result reported in this paper is the average obtained from at least three test specimens.

III. Results And Discussion

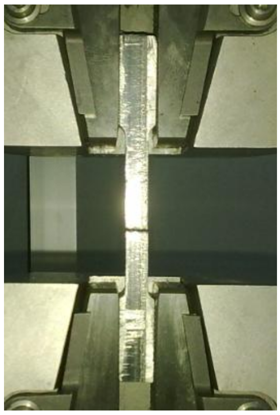

Figure 3 Specimen after testing

Figure 3 shows the specimen after testing. Table 1 shows the value of maximum load, P (N), tensile strength, σ and modulus young. Figure shows the value of maximum load against weight percentages, %wt during the experiments until the specimens failed.

Table 1 The comparison of Tensile Strength, σ (MPa) and Modulus Young (MPa) for 0%, 5%, 10%, 15% and 20% permanent metallic mould (A) and sand mould (B)

Weight percentage (%wt) of titanium carbide	Tensile Strength, σ (MPa) (A)	Modulus Young, E (MPa) (A)	Tensile Strength, σ (MPa) (B)	Modulus Young, E (MPa) (B)
5	139.33	8409.78	107.52	9493.18
10	132.55	7760.79	103.94	9022.05
15	123.83	13278.85	84.50	10485.62
20	140.34	8393.39	82.71	8382.71

In the research, the results of tensile strength and modulus young of the aluminium alloy 11.8% silicon carbide with titanium carbide particulate are tabulated in the Table 1. From the table, it is depicted the result that the value of tensile strength for the 5% titanium carbide particulate is the greatest and the weakest is 20% titanium carbide particulate, ($\sigma_{5\%} < \sigma_{10\%} < \sigma_{15\%} < \sigma_{20\%}$) and for modulus young for 15% titanium carbide particulate is the greatest and 20% is the weakest, ($E_{15\%} < E_{5\%} < E_{10\%} < E_{20\%}$) for sand casting mould and for permanent metallic mould the highest value of tensile strength is 20% titanium carbide particulate and the lowest is 15% titanium carbide particulate, ($\sigma_{20\%} < \sigma_{5\%} < \sigma_{10\%} < \sigma_{15\%}$) and for modulus young for 15% titanium carbide particulate is the greatest and 10% is the weakest, ($E_{15\%} < E_{5\%} < E_{20\%} < E_{10\%}$) . Figure 4 shows the tensile strength, σ and Figure 5 shows the modulus young, E of each weight percentages.

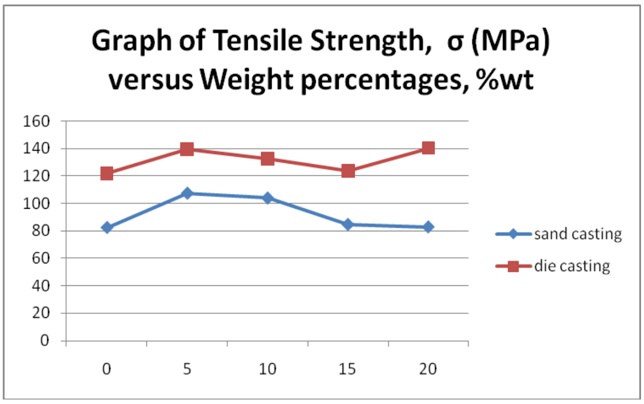

Figure 4 Graph of tensile strength versus weight percentages

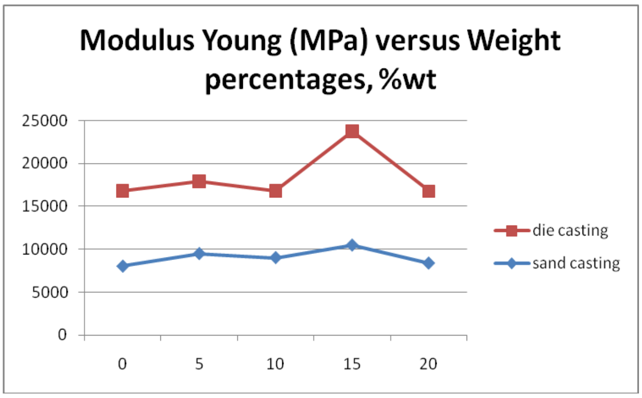

Figure 5 Graph of modulus young versus weight percentages

The TiC particles acting as barriers to dislocations in the microstructure make the value of tensile strength increased. This dislocation increases the dislocation density, which provides an affirmative contribution to strength of the composite. This result was well supported and evidenced from the literature citation [7]-[8]. Therefore, it is well understood that the optimum value of adding the titanium carbide particulate to the alloy matrix is 5% by weight percentages for sand casting mould and 20% for permanent metallic mould.

The maximum addition of the titanium carbide particulate in the matrix is the saturation limit which yields the optimum and greatest properties. For further addition, declines the properties. Metallurgically due to the second phase titanium carbide reinforcement in the matrix alloy, the dutility of the matrix material is decreased and the titanium carbide composite material is transformed to a ductile - brittle material. This is the cause that tensile strength is decreased with increased addition of titanium carbide particulate in the LM6 alloy matrix and it is well supported and evidenced from the literature citation [9].

IV. Conclusion

Through this research, aluminium alloy 11.8% silicon carbide with 5%, 10%, 15% and 20% titanium carbide particulate was observed when tested under tensile loading as per ASTM B557M-94. It was found that the weight percentages of 5% titanium carbide particulate for sand casting mould and 20% titanium carbide for permanent metallic mould mould possessed the highest tensile strength of 107.52MPa. Whilst the lowest value of tensile strength was observed for 20% titanium carbide particulate for sand casting mould and 15% titanium carbide for permanent metallic mould. Based on findings, it is concluded that, pouring the composite slurry mixture in permanent metallic mould have better tensile strength and modulus young compare using sand mould.

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