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Production and Characterization of Al 6061–TiB_2 In – situ Metal Matrix Composite

Lawrance C.A[1] and Dr. P. Suresh Prabhu [2]

Associate Professor, Department of Mechanical Engineering, LBS College of Engineering, Kasaragod, Kerala, India[1]

Research Director, Karpagam University, Coimbatore, Tamilnadu, India[2]

Abstract: Many researchers are getting attracted by aluminium matrix composite due to its properties like high hardness, strength, wear resistance, stiffness and specific modulus. However, the presence of coarse reinforcement particles and their non uniform distribution and micro structural heterogeneity affect adversely the mechanical properties of aluminium alloys. The composites fabricated using in-situ method, to a certain extent, can eliminate these limitations. Entrapment of fine and small sized particles in the matrix-reinforcement interface helps in the creation of stronger interfacial bond. Aluminium 6061 alloys are widely used in many engineering applications in construction and transportation where superior mechanical properties such as hardness and tensile strength are essentially required. TiB_2 is a refractory compound that exhibits high hardness and strength, high melting point and modulus. Using halide salts namely potassium hexafluro titanate (K_2TiF_6) and potassium tetrafluro borate (KBF_4) an attempt has been made to investigate the degree of in-situ reaction in the synthesis of Al 6061 – TiB_2 metal matrix composite.

Key words: Aluminium matrix composite (AMC), Al 6061 alloy, In-situ, Al 6061- TiB_2 metal matrix composite.

I. INTRODUCTION

Metal matrix composites have emerged as an important class of materials for structural, wear, thermal, electrical, automobile, aeronautical applications, primarily as a result of their ability to exhibit superior strength to weight ratio when compared to other commercial alloy. Metal matrix composites can be synthesized in a number of ways, these including liquid phase processes, solid phase processes and two way processes. The composites processed using these methods suffer from matrix reinforcement interfacial thermodynamics instability, thus limiting their ambient and high temperature mechanical properties. In order to overcome these limitations efforts have been made to synthesize metal matrix composites in a single step from necessary raw materials to ensure good matrix to reinforcement compatibility and microstructural homogeneity. In-situ process represents one such category of techniques used to synthesize metal matrix composites[1].

Aluminium alloy Al 6061 is widely used in many engineering applications including construction and transportation where superior mechanical properties such as tensile strength, hardness etc are essentially required [2]. A typical chemical composition of Al 6061 is presented in the TABLE.

In-situ process involves the synthesis of composites such that desirable reinforcement, matrices and interfaces are formed during processing. The successful synthesis of in-situ composites involves a good understanding of thermodynamics and reaction kinetics in order to obtain the desirable end product. The composites synthesized using in-situ techniques exhibit the presence of a uniform distribution of reinforcement that tends to be fine and associated with a clean interface with the metallic matrix which assists in the formation a strong bond between the reinforcement and metallic matrix.

TABLE: Chemiical composition of Al 6061

Element	Weight %
Mg	1.08
Si	0.63
Mn	0.52
Cu	0.32
Fe	0.17
Ti	0.02
V	0.01
Al	Remainder

Most of the studies reported so far are related to the fabrication and the mechanical properties of silicon carbide reinforced or alumina reinforced aluminium alloy composites [3]. Information related to the synthesis of in-situ TiB_2 reinforcement is however very limited [4] – [6]. Accordingly, the present study focuses on the synthesis of in-situ metal matrix composite using Al 6061 alloy and two halide salts namely potassium hexafluro titanate (K_2TiF_6) and potassium tetrafluro borate (KBF_4) and the effects of processing parameters on the size and the weight percentage of TiB_2 reinforcement formed as a result of reaction between salts and molten aluminium. The in-situ based manufacture of the AMC under study was

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extensively reported in the literature [7, 8]. However, production of the AMC with Al 6061 as the matrix alloy containing TiB_2 as the composite material is not widely reported. The objective of the present work is to investigate the mechanical properties and microstructure of the Al 6061-TiB_2 composite with various reaction holding times at 850° C.

II. EXPERIMENTAL PROCEDURE

Aluminium alloy 6061 was the metal matrix phase and the two halide salts namely Potassium hexafluoride (K_2H_6Ti) and Potassium tetrafluro titanate (KBF_4) were used in-situ for the formation of TiB_2, the reinforcement phase. The AMC for this work was fabricated at the Department of Metallurgical and Materials Engineering, National Institute of Technology Karnataka, Surathkal, Mangalore, South India through the in-situ process involving the salt-metal reaction between the titanium containing K_2TiF_6 and the boron containing KBF_4 salts in the presence of molten aluminium 6061 alloy. During the in-situ reaction process, the elements Ti and B are introduced from the two salts into the molten aluminium and made to react within it. The reaction used to produce the composite is as follows:

$$3K_2TiF_6 + 22Al + 6KBF_4 \rightarrow 3Al_3Ti + 3AlB_2 + 9KAlF_4 + K_3AlF_6 + Heat \quad (1)$$

$$3Al_3Ti + 3AlB_2 \rightarrow 12Al + 3TiB_2 \quad (2)$$

Processing:

Aluminium 6061 alloy was first melted at 850° C in an electrical resistance furnace using a graphite clay crucible as shown in the following figure 1 showing a stir casting set up.

Figure 1: Stir casting set up

The two types of salts were then added to the molten aluminium alloy in the atomic ratio in accordance with Ti/2B using the stirring method. The stirrer used was mild steel stirrer coated with zirconium, coating being applied to mild steel stirrer to avoid possible contamination of the molten metal. Chemical reaction between the two salts and the molten aluminium alloy took place to form in-situ TiB_2 particulates in aluminium alloy. The period of chemical reaction was varied in steps of 10 minutes from 20 to 50 minutes at 850°C to investigate the relationship between the degree of reaction and the the growth behaviour of Ti-B_2. After the reaction the composite was cast into rods of 16 mm diameter using a cast iron die as shown in the figure 2.

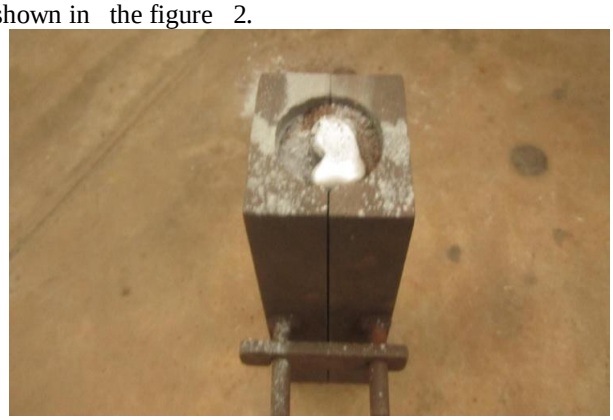

Figure 2. Composite casting in the cast iron die

The casted composite bars are shown in the figure 3.

Figure 3. Casted Composite bars

III. RESULTS AND DISCUSSION

Tensile specimens were prepared for tensile testing which is to be carried out at room temperature at a constant displacement rate. Tensometer is used to carry out the the tensile test. Similarly, specimens for hardness testing were prepared to test the hardness of the composite.

IV. CONCLUSIONS

By exothermic reaction between K_2TiF_6 and KBF_4 salts in aluminium alloy 6061, in-situ aluminium alloy 6061- TiB_2 composites were synthesized successfully. Volume of cryolite slag increases with reaction holding time.Variation in the weight percentage of TiB_2 will take place because of change in the volume of cryolite slag.

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