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# Study of mechanical and machining behavior of AA 7075-3%$TiB_2$ in-situ composite

S.Sasikumar[1], K.R.Ramkumar[2], S.Iniyan[3], M.Gowthaman[4], Dr.S.Sivasankaran[5]

U.G. Scholars, Department of Mechanical Engineering, KPR Institute of Engineering and Technology, Arasur, Coimbatore, India[1,2,3,4]

Associate Professor, Department of Mechanical Engineering, KPR Institute of Engineering and Technology, Arasur, Coimbatore, India[5]

**ABSTRACT:** This paper investigates the study of mechanical and machining behavior of AA 7075-3%$TiB_2$ in-situ composite prepared by liquid metallurgy route. This in-situ method involves formation of reinforcements within the matrix by the chemical reaction of two or more compounds which also produces some changes in the matrix material within the vicinity. Titanium Boride ($TiB_2$) was the reinforcements in the matrix of AA 7075 alloy which can be suitable for space, aircraft and automotive components at elevated temperatures. The composite was prepared with the formation of the reinforcement inside the molten matrix by adding salts of Potassium Tetrafluoroborate ($KBF_4$) and Potassium Hexafluorotitanate ($K_2TiF_6$). The mechanical properties in terms of hardness and impact test were carried out. The sample of AA 7075 alloy was also casted and tested for comparison. It was observed that the hardness and impact strength of AA 7075-3% TiB2 in-situ composite was improved by 25% and 10% than AA 7075 alloy respectively. The casted samples were subjected to turning using CNC turning machine. The chip morphology and the surface roughness were measured and reported.

**KEYWORDS:** AA 7075 Al alloy, $TiB_2$, metal matrix composite, In-situ, hardness test, machinability.

## I. INTRODUCTION

Composite is a mixture of two or more distinct constituent or phase. Both constituent have to be present in reasonable property. Constituent phases have different properties, and hence the composite properties are noticeably different from the properties of the constituents. The constituent that is continuous and is often but not always, present in the greater quantity in the composite is termed as matrix. The second constituent is referred to as the reinforcing phase or reinforcement phase as it reinforces the mechanical properties of matrix.The reinforcement is harder, stronger and stiffer than matrix in most cases [1].

Metal matrix has the advantage over polymeric matrix in applications requiring a long-term resistance to severe environments, such as high temperature. The yield strength and modulus of most metals are higher than those for polymers, and this is an important consideration for applications requiring high transverse strength and modulus as well as compressive strength for the composite [2].The microstructures of metal and ceramic matrix composites, shows particles of second as reinforcement, are known as particulate reinforced composites. Reinforcements are added as form of small particulates in square and round shaped. The size and volume of the particles are quasi homogeneous and quasi isotropic. The powdered reinforcements can be added to matrix in molten state at high temperature [3].The two most commonly used metal matrices are based on Aluminum (Al) and Titanium (Ti). Both of these metals have comparatively low densities and are available in a variety of alloy forms. Although Magnesium (Mg) is even lighter, its great affinity toward oxygen promotes atmospheric corrosion and makes it less suitable for many applications. Al and its alloys have attracted the most attention as matrix material in metal matrix composites (MMCs). Commercially, pure Al has been used for its good corrosion resistance. Al alloys, such as 2021, 6061, and 7075, have been used for their higher tensile strength to weight ratios [2].

## II.EXPERIMENTAL PROCEDURE

A Matrix Material

In this study, AA 7075 alloy was selected because of its low specific weight and high strength to weight ratio and also its excellent machinability, formability and weldability. This alloy is widely used in automotive industry, aircraft industry and defense industries. The chemical composition of the used material is given in Table 1.

| | | | | | | |
|---|---|---|---|---|---|---|
| Mt | Si | Fe | Cu- | Mn- | Mg- | Zn- |
| % | 0.2 | 0.23 | 1.71 | 0.06 | 2.46 | 5.29 |
| Mt | Ti- | Cr- | Ni- | Pb- | Sn- | Na- |
| % | 0.054 | 0.21 | 0.007 | 0.011 | 0.007 | 0.0001 |
| Mt | Ca-. | B- | Zr- | V- | Be- | Sr- |
| % | 0003 | 0.007 | 0.008 | 0.004 | 0.0007 | 0.0001 |
| Mt | Co | Sb- | Ga- | P- | Li- | Al- |
| % | 0.0005 | 0001 | 0.002 | 0.001 | 0.0001 | 89.70 |

Table 1 Chemical Composition of AA7075 Al Alloy

B. Reinforcement choice (Titanium Diboride)

Titanium diboride ($TiB_2$) is well known as a ceramic material with relatively high strength and durability as characterized by the relatively high values of its melting point, hardness, strength to density ratio, and wear resistance. $TiB_2$ is very similar to titanium carbide (TiC), and many of its properties are superior to those of TiC. With respect to chemical stability, $TiB_2$ is better than tungsten carbide or silicon nitride.Current use of this material is in specialized applications in areas such as impact resistant armour, cutting tools, crucibles, and wear resistant coatings.

C. Stir casting

AA 7075-x$TiB_2$ (x = 0 and 3 wt. %) were prepared by the addition of Potassium hexaflurotitanate ($K_2TiF_6$) and Potassium tetrafluro borate ($KBF_4$). The chemical reaction is a multi-stage reaction. The compound reaction is shown in eq.(1).

$$3K_2TiF_6 + 6KBF_4 + 22Al \rightarrow 3TiB_2 + 12\ Al + (9KAlF_6 + K_3AlF_6) \quad ..... \quad (1)$$

The amounts of salts required were calculated by weight basis.The salts were carefully weighed and added to the molten alloy at a super heating temperatureof 790$^oC$. After the addition of the salts to the molten alloy, they were stirred well in order to distribute the salt in the melt uniformly. The exothermic reaction between the salts yield in situ formed $TiB_2$ particulates in the alloy.The pure AA 7075 of 1Kg is casted without reinforcement through stir casting method. Then, AA 7075 is mixed with $TiB_2$ (reinforcement) and casted through stir casting method. The $TiB_2$ reinforcement was formed by mixing the two salts $K_2TiF_6$ and $KBF_4$.

## III. RESULT AND DISCUSSION

A. Examination of Hardness test

Hardness tests were used to determine the strength of a material to judge deformation ability. Rockwell hardness was carried out on the Al 7075 composite material. The material hardness was tested based on the standard of as per IS: 1500-205 of 'A' scale. The Rockwell hardness number of Al 7075 (as received rot alloy), Al 7075 (as cast alloy), and Al 7075 - 3% $TiB_2$ and the corresponding graph is shown in Fig.1. Given load are 100 Kgf., Ball size is 2.5 mm, (Indenter).From Fig.1, it revealed that the strength of AA 7075-3% $TiB_2$ composite exhibited move strength and as casted and received alloy. The increase in strength was attributed of the presence of $TiB_2$ particles enhanced the strength of matrix. A 7075 - 3% $TiB_2$ composites showed the improvement of hardness by 12% and 135% for AA 7075 as casted alloy and AA 7075 as received alloy respectively. The hardness of as casted AA 7075 alloy exhibited 2.25 times higher than as received AA 7075 alloy. This was expected the presence of pores in as casted condition might be acted as stress raiser against the applied weight

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B.Examination of Impact behavior

Impact testing is testing an object's ability to resist high-rate of loading. An impact test is a test for determining the energy absorbed in fracturing a test piece at high velocity. Impact resistance is one of the most important properties for a part designer to consider, and without question, the most difficult to quantify. The impact resistance of a part is, in many applications, a critical measure of service life. More importantly these days, it involves the perplexing problem of product safety and liability.

Izod impact testing is an ASTM standard method of determining the impact resistance of materials. An arm held at a specific height (constant potential energy) is released. The arm hits the sample and breaks it. From the energy absorbed by the sample, its impact energy is determined. A notched sample is generally used to determine impact energy and notch sensitivity. The results of impact test values for the present investigated samples are shown in Fig2.

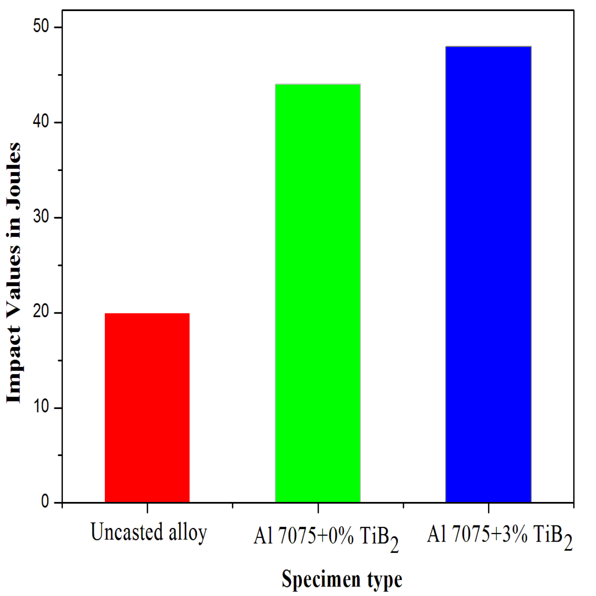



Fig. 1 Rockwell hardness number for varies type of specimen

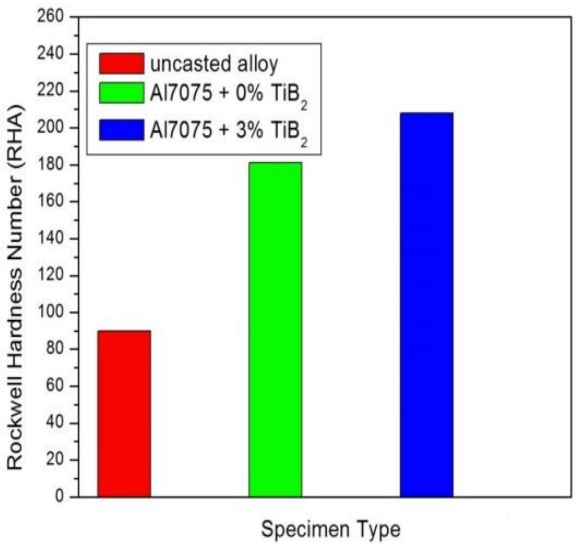



Fig.2 Izod impact value for varies type of specimen

From Fig 2, it was observed that the energy absorption capacity of AA 7075-3% $TiB_2$ composite showed improved impact strength than as casted

AA 7075 alloy. This was expected that the $TiB_2$ might be observed. More impact load with the matrix. However, the impact strength of AA 7075 as casted and AA 7075 -3% $TiB_2$ composite exhibited poor value than as received rot alloy of AA 7075.

From Fig 2, it was observed that the energy absorption capacity of AA 7075-3% $TiB_2$ composite showed improved impact strength than as casted AA 7075 alloy. This was expected that the $TiB_2$ might be observed. More impact load with the matrix. However, the impact strength of AA 7075 as casted and AA 7075 -3% $TiB_2$ composite exhibited poor value than as received rot alloy of AA 7075. This was attributed to more ductile nature of as-received alloy than the other two casted samples. Because, the casted samples were having more porosity than the bulk one of as-received alloy.

C.Evaluation of surface roughness

Surface roughness, often shortened to roughness, is a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small the surface is smooth. Roughness is typically considered to be the high frequency, short wavelength component of a measured surface.

Roughness plays an important role in determining how a real object will interact with its environment. Rough surfaces usually wear more quickly and have higher friction coefficients than smooth surface. Roughness is often a good predictor of the performance of a mechanical component, since irregularities in the surface may form nucleation sites for cracks or corrosion. On the other hand, roughness may promote adhesion.

Although roughness is often undesirable, it is difficult and expensive to control in manufacturing. Decreasing the roughness of a surface will usually increase exponentially its manufacturing costs. This often results in a trade-off between the manufacturing cost of a component and its performance in application.

D.Examination of chip morphology

Chips formed during turning of AA 7075 by different parameters are shown in Fig.3.4. In this, depth of cut is kept constant for different speed and feed for both Al 7075 of 0% $TiB_2$ and Al 7075 of 3% $TiB_2$. For 0% reinforcement component, it was observed that cutting speed (s = 1000 rpm) and lower value of feed rate (f = 0.1 mm/rev), the chips formed were continuous, regular size, curled shape. At lower value of depth of cut (d = 0.25 mm), the chip thickness formed was thinning one. However, for the same lower value of cutting speed and feed rate, the chip thickness formed was increased as the depth of cut increased. Moreover, the observed chip curliness was also decreased. At higher value of speed and feed, the chips was underwent too much thickening with non-uniformity nature.

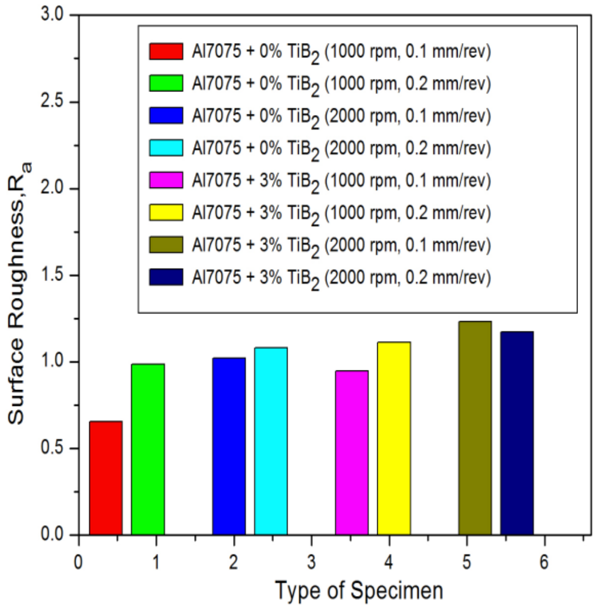
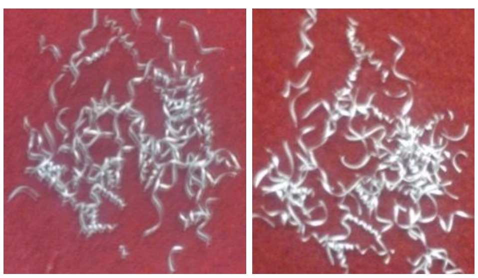
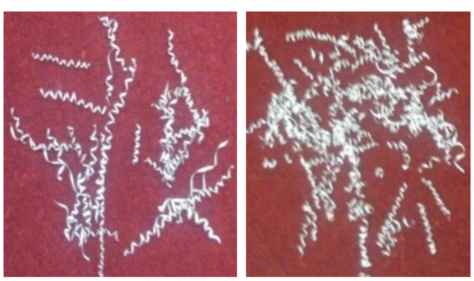



Fig. 3.Surface roughness values for varies type of specimen



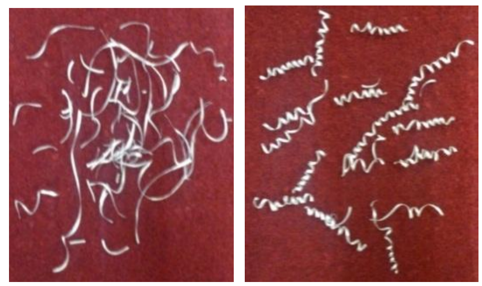
Speed = 1000 rpm Speed = 1000 rpm
Feed = 0.1 mm Feed = 0.2 mm



Speed = 2000 rpm Speed = 2000 rpm
Feed = 0.1 mm Feed = 0.2 mm

Fig. 4 Chip morphology evaluation for Al 7075 of 0% $TiB_2$

Speed = 1000 rpm Speed = 1000 rpm
Feed = 0.1 mm Feed = 0.2 mm



Speed = 2000 rpm Speed = 2000 rpm
Feed = 0.1 mm Feed = 0.2 mm

For 3% reinforcement component, for the cutting speed of 2000 rpm and feed rate of 0.2 mm/rev, the chips formed were typically continuous but of regular size, curl shape and thickness is high at cutting speed of 1000 rpm and feed rate of 0.2. Further increasing of feed rate, the chips formed had under gone very thinning, smooth, continuous with uniformity. Consequently, the force required turning the materials leads to generation of heat and vibration would be decreased. Therefore machinability can be obtained in these turning parameters. These results indicate the possibility of more tool wear, more cutting force led to poor in surface finish and less tool life.

## IV. CONCLUSIONS

The following conclusions can be drawn as the result of the experimental study of AA 7075, AA 7075 - 3% of TiB2 in-situ composite on hardness, impact and machining behavior.

- ❖ The hardness of AA 7075 - 3% of TiB2 composite exhibited more than AA 7075 alloy due to presence of hard ceramic particles of TiB2 in the matrix.
- ❖ The impact strength of AA 7075 - 3% of TiB2 composite produced more value than AA 7075 alloy.
- ❖ The surface roughness value of AA 7075 - 3% of TiB2 composite exhibited more value with respect to more spindle speed and feed rate when compared to AA 7075 alloy.

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