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CORROSION BEHAVIOR OF AA7075-TIB2 NANO COMPOSITES

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Abstract: Conventional monolithic materials have limitations in achieving good combination of strength, stiffness, toughness and density. To overcome these shortcomings and to meet the ever increasing demand of modern day technology, composites are most promising materials of recent interest. The present research work involves the study of AA 7075-TiB2 composite through stir casting 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 Diboride (TiB2) was the reinforcement in the matrix of AA 7075 alloy which can be suitable for space, aircraft and automotive components at elevated temperatures. 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 corrosion resistance of AA 7075-TiB2nano composites were improved by 35% and 52% than AA 7075 alloy respectively.
Keywords: AA 7075 alloy, TiB2reinforcement, metal matrix composites, nano composites and corrosion resistance.

Introduction

Composite is a mixture of two or more distinct constituents or phases. Both constituents 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].

AA7075 alloy-based composites are widely used in automotive, aerospace and mineral processing industries because of improved properties such as strength, stiffness, tribological behavior and a low thermal expansion coefficient.Recently, in-situ techniques have been developed to fabricate aluminum–based metal matrix composites (MMCs), which can lead to better adhesion at the interface and hence better mechanical properties. In the in situ process, ultrafine ceramic particles are formed by the exothermic reaction between the elements or their compounds with molten aluminum alloy. These in situ routes provide advantages such as uniform distribution of reinforcement, finer reinforcement particle size, clear interface and thermodynamically stable reinforcement.

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].

S.Sasikumar et al.[3] have investigated study of mechanical and machining behavior of AA 7075-3%TiB2 in-situ composite. S. Kumar et al.[4] have investigated the effect of temperature on the wear behavior of Al-7Si-TiB2 in-situ composites increasing temperature the wear rate of Al-7Si alloy increased drastically and decreased with the weight percent of TiB2 particles. The powdered reinforcements can be added to matrix in molten state at high temperature [5].The two mostcommonly 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].

A Matrix Material

Experimental Procedure

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.

Table 1 Chemical Composition of AA7075 Al Alloy

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	0.00 7	0.01 1	0.007	0.000 1
Mt	Ca-.	B-	Zr-	V-	Be-	Sr-
%	0003	0.00 7	0.00 8	0.00 4	0.000 7	0.000 1
Mt	Co	Sb-	Ga-	P-	Li-	Al-
%	0.000 5	000 1	0.00 2	0.00 1	0.000 1	89.70

- Reinforcement choice (Titanium diboride)

Titanium diboride (TiB2) 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. TiB2 is very similar to titanium carbide (TiC) and many of its properties are superior to those of TiC. With respect to chemical stability, TiB2 is better than tungsten carbide or silicon nitride. Current use of this material is in specialized applications in areas such as impact resistant armors, cutting tools, crucibles and wear resistant coatings.

Table 2.1 Chemical analysis (wt %) of the titanium diboride reinforceme

Mt	Ti	B	C
%	67-69	29-32	0.5
Mt	O	N	Zr
%	1.0	0.20	0.015

Planetary Ball Mill PM 100

Planetary ball mills are used wherever the highest degree of fineness is required. Apart from the classical mixing and size reduction processes, the mills also meet all the technical requirements for colloidal grinding and have the energy input necessary for mechanical alloying processes. The extremely high centrifugal forces of the planetary ball mills result in very high pulverization energy and therefore short grinding times.

Fig.1: Planetary Ball Mill (PM 100)

This machine is used for reducing grain size of TiB2 to nano particles.

Stir casting

In the present investigation, AA7075 was used as the matrix material and TiB2nano particulates were used as reinforcement material. All the aluminum based metal matrix (AA7075)nanocomposites containing 0%, 1.5%, 3%, 4.5%, 6% and 7.5% wt. TiB2nanoparticulates were successfully synthesized by stir casting method.

XRD Analysis# Measurement Condition
X-ray tube target= Cu
voltage = 40.0 (kV) current = 30.0 (mA)
Slits
divergence slit = 1.00000 (deg) scatter slit = 1.00000 (deg) receiving slit = 0.30000 (mm)
Scanning
drive axis = Theta-2Theta

Fig.2: Stir casting machine

Result And Discussionscan range = 10.000 - 80.000 scan mode = Continuous Scan scan speed = 6.0000 (deg/min) sampling pitch = 0.0200 (deg) preset time = 0.20 (sec)

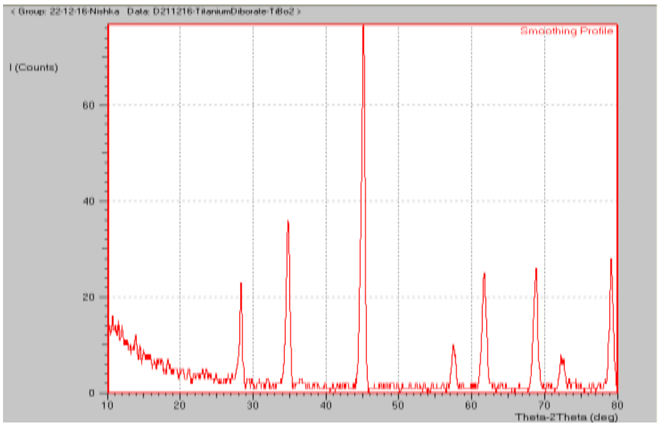

Fig.3: XRD Analysis of TiB2nano particles

Compressive

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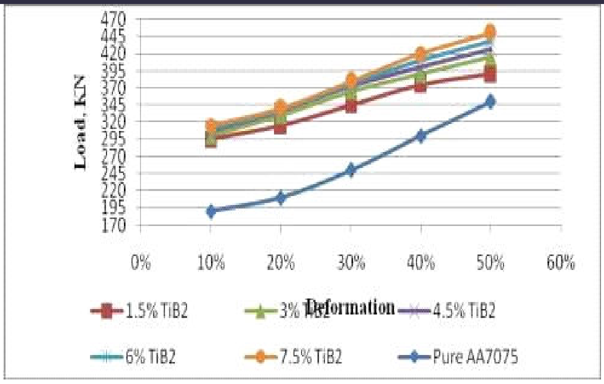

behavior
Fig.4: Effect of aspect ratio 1of AA7075 and its composites onload.

The compressive tests were conducted at 10%, 20%, 30%, 40% and 50% deformations on the top surface of the AA7075 alloy and its TiB2nanocomposites with a constant cross head speed to assess the deformation behavior for aspect ratio 1. The specimens were machined to dia 25x25 mm length and dia and then subjected to upset forging at 10% height reduction with successive increments from 10% to 50% height reduction.

Fig. 4 shows the effect of compressive load on AA7075 alloy and AA7075/TiB2nanocomposites. It can be observed that compressive load shows increasing trend with increasing percentage of TiB2nanoparticulates. This increase was observed from 190 KN for AA7075 alloy to 315 KN at 7.5% TiB2nano particulate reinforced composite. The compressive load of the nanocomposites increases slightly with increasing the percentages of TiB2nanoparticles. This could be due the AA7075 aluminum alloy and TiB2nanoparticles having different strength to weight ratio. For 50% deformation, compressive load increased from 350 KN of AA7075 aluminum alloy to 450 KN of 7.5% TiB2nano particulate reinforced composite.

Examination of Hardness test

Vickers hardness tests were carred out on the AA 7075 alloy and its TiB2nano particulate reinforced composites to determine the strength and thereby to judge deformation ability. The applied load during the testing was 10 kgf, with a dwell time of 10secs with a square-base diamond pyramid indenter. It was observed that there is a significant improvement in the hardness of the composites at the rate of 30%, when compared with matrix alloy.

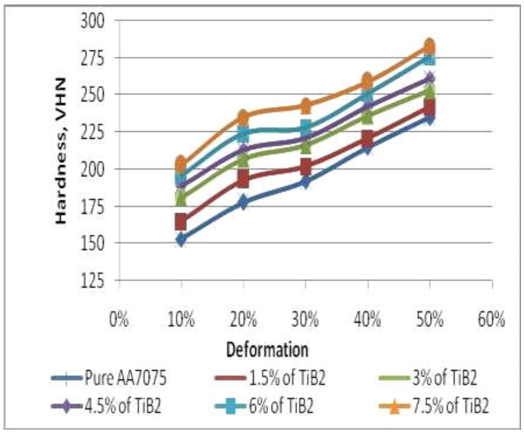

Fig.5: Hardness profile of AA7075 and its nano compositesat various deformation stages under compression

TiB2 being a hard reinforcement, it renders the inherent property of hardness to the matrix material, thereby enhancing its resistance to deformation. It is an experimentally proven fact that addition of hard reinforcement into a soft ductile matrix material like aluminum alloy, the hardness of the matrix material can be improved significantly. The hardness behavior of composites was also affected

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by grain refinement of matrix alloy and fine and even distribution of reinforced TiB2nanoparticles. Reduction in grain size always enhances the hardness of the composites. Smaller the grain size, higher will be the obstructions for dislocation motion, thereby improving the resistance to plastic deformation resulting in increased hardness.

Corrosion Behavior

Corrosion tests were carried on AA7075 alloy and the TiB2nanocomposites in 10% HCl solution. Both alloy and the nanocomposites with same concentration of HCl show a similar trend of dissolution, i.e. a gradual increase in weight loss with time. However, all TiB2nanocomposites show a better resistance towards dissolution than the AA7075 alloy. Presence of fine Al2O3 layer on the overall nanocomposites reduces this effect further, resulting in reduced dissolution. Here corrosion test is done on all AA7075 alloy and its TiB2 nano composites which were earlier subjected to compression deformation at 10%, 20%, 30%, 40% and 50% height reduction.

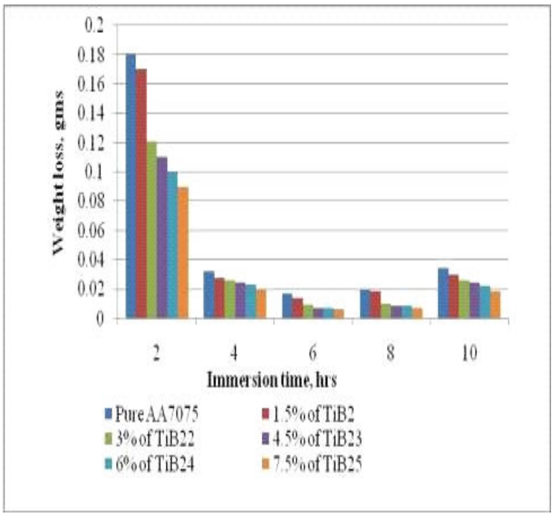

Fig.6: Corrosion behavior of AA7075 and its nano composites at 10% deformation

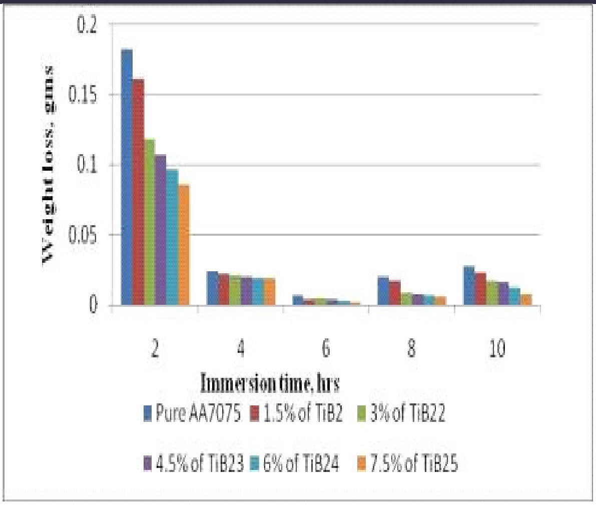

Fig.7: Corrosion behavior of AA7075 and its nano compositesat 20% deformation

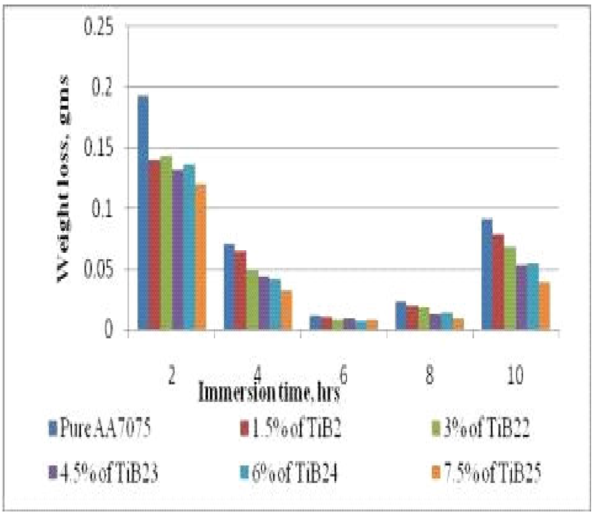

Fig.8: Corrosion behavior of AA7075 and its nano composites at 30% deformation

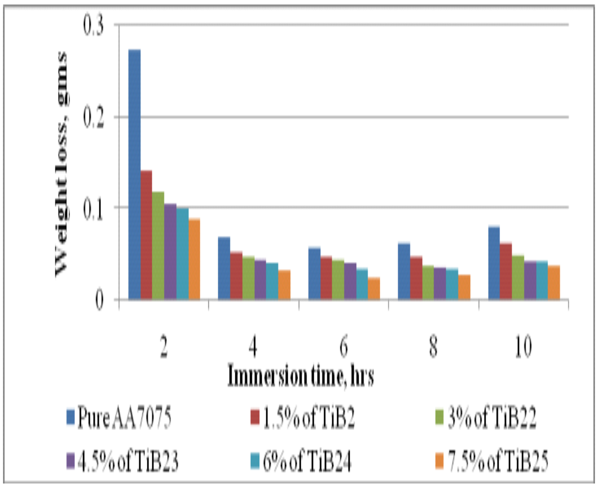

Fig.9: Corrosion behavior of AA7075 and its nano composites at 40% deformation

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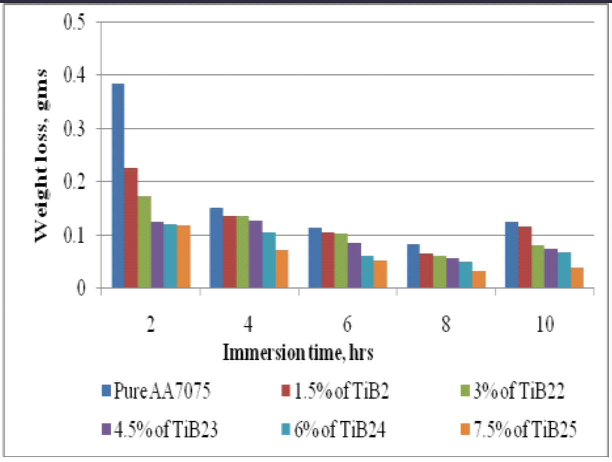

Fig.10: Corrosion behavior of AA7075 and its nano compositesat 50% deformation

The weight loss obtained through the present experimentation is reported here. It was observed that weight loss was higher for the unreinforced aluminum alloy when compared to the AA7075-TiB2reinforced nanocomposites. From fig.6-10, it can be observed that AA-7075 alloy and its nanocomposites shows less corrosion in all the mediums. Further the corrosion rate of the TiB2reinforced nano compositeswas lower than that of the corresponding metal matrix alloy. The decrease in corrosion rate with increase time period can be noticed clearly from fig.6-10. The corrosion result indicates an improvement in corrosion resistance as the percentage of TiB2nanoparticulates increased in the composite, which shows that the TiB2nanoparticulates directly or indirectly influenced the corrosion property of the composites. B.Sathish et.al. [8] obtained similar results in glass short fiber reinforced AA7075 alloy composites and reported that the corrosion resistance increases with increase in reinforcement. From the fig.6-10, it can be clearly observed that for both the as cast AA7075 alloy and its nanocomposites, corrosion rate decreases monotonically with increase in TiB2nano particulate reinforcement content. The above studies have finally revealed that the rate of corrosion is decreasedwith increase of reinforcement content.

Conclusions

The following conclusions can be drawn as the result of the experimental study of AA 7075 and its TiB2nanocomposites on compressive behavior, hardness and stress- strain relation.

- Load required for deforming of base AA7075 alloy and its TiB2nanocomposites increased with increase in reinforcement content.
- Hardness of AA7075 alloy and its TiB2nanocomposites increased with increase in deformation of aspect ratio 1.
- Corrosion resistance of AA7075 alloy and its TiB2nanocomposites increased with increase in reinforcement content.

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