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Investigation of corrosion behaviour of Al 7075 / B_4C / Al_2O_3 hybrid metal matrix composite

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Abstract

This work is carried out in order to develop a metal matrix composite material which has better strength, light in weight and has better corrosion resistance. Different engineering materials are used in different application like food industries, oil refinery industries, Automobiles and aerospace industries. Reduction of corrosion rate in engineering materials will increase the life span of the materials. The corrosion and mechanical behaviour of Al 7075 alloy composites with reinforcement of aluminium oxide (Al_2O_3) and boron carbide (B_4C) particle is studied in this work. Having the properties like lightweight and high strength, the application of Al 7075 alloy can be used in the structures of aircrafts, gears and shafts. This alloy can be manufactured by stir casting method which is of very economical than the other methods. By varying the volume fraction of aluminium oxide and boron carbide in the percentage ratios 5%, 10% and 15% the characteristics are studied. The reinforcement particles are distributed in the matrix and the microhardness test is conducted using Vickers hardness tester. The corrosion rate is calculated by Potentiodynamic polarization method with 3.5% wt. of Nacl solution. The corrosion rate of Al 7075+15vol% hybrid composites shows 0.336mm/year. It is found that, stir casting method is very much suitable to achieve the even distribution of reinforcements in the composite mixture, which led to better micro hardness of the material with better corrosion resistance compare to the base as cast alloy.

Introduction

In recent decades, aluminum-based composite materials have become more and more popular by replacing traditional engineering materials. The research community also continues to be interested in the development of aluminum-based composite materials with good wear resistance, rigidity, high strength-to-weight ratio and corrosion resistance. With these improved properties, the material can be used in structural applications, particularly in automotive engineering and aerospace industry. Al7075 alloy is used for such applications, but it has some obvious limitations, such as stiffness. This limitation can be overcome by adding ceramic particles to the alloy. Silicon carbide (SiC) is chemically appropriate for aluminum as it can produce a better bond between reinforcement and matrix without intermetallic phases [1], [2]. In addition, it also has other advantages, such as better thermal conductivity, better processability, and economy. Also, the Titanium carbide (TiC) posses better lattice matching with the aluminium; it has better wettability and can be easily matched with the matrix of aluminium alloy [3]. Out of great number of manufacturing approaches for placing reinforcements in the metal alloy, stir casting technique is found to be more promising due to its ability to produce components of large size and high volume production. In this work, for developing a hybrid composite with uniform particle distribution two steps stir casting method has been used [4]. The wear and frictional properties of the hybrid metal matrix composites was studied by performing dry sliding wear test using a pin-on-disc wear tester and 15% volume fraction of SiC gives the better properties [5].

The alloy Al7075, has been studied for its physical characteristics by adding different reinforcements using different manufacturing methods. Composite reinforced with B_4C in stirred casting, and the wear resistance of the material is found to increase with increasing volume of the reinforced part [6]. The tensile strength of the Al7075 composite has been enhanced to the tensile strength of the base alloy through SiC of 5 and 13µm.

Also, the composite with SiC under squeeze casting concluded that by adding 10% reinforcement can have better flexural strength tensile strength and hardness in heat treated conditions. Coating alloy with the silver nanoparticles has higher micro hardness value at high Ag – CNP contents. The alloy with stir casting method had better flexural strength, ultimate tensile strength, wear resistance and hardness [6]. The addition of 7% and 3% of silicon carbide and graphite to pure Al7075 has shown an increased in specific wear rate with change in load. The corrosion property of the alloy is better when treated with titanium oxide in 3.5% wt of NaCl solution [7]. Hydroxyapatite is used as a coating material to withstand the load on the implant applications. Analysis of biometric reveals the Ha coatings on Ti alloys using plasma spray techniques [8].

From the above discussion, it is found that information on the corrosion behaviour and mechanical properties of boron carbide (B_4C) and alumina (Al_2O_3) reinforcements in Al7075 composites is not sufficient. Thus, the work is to fabricate Al7075 hybrid with B_4C and Al_2O_3 particles under varying volume fractions and analyzing for their corrosion behaviour. The artificial neural network (ANN) gives the better optimized test parameters like load and temperatures for microhardness and corrosion resitance [9]. An ANN model with four various learning algorithms was used to predict the surface roughness and temperature. The life cycle assessment and dry machining are carried out in order to address the sustainability aspect [10].

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Section snippets

Materials and methods

The experiment has been carried out by using the Al7075 as base matrix. Particles of B_4C and Al_2O_3 were used as reinforcements. A two-step stir casting method is used to produce subsequent samples of mixed casting. The amount of matrix material and reinforcement material by calculating their volume percentage in the sample. Add about 5%, 10%, and 15% (volume) of reinforcement materials to prepare hybrid composites. Use a melting furnace to melt the base alloy and then stir.

Fig. 1 shows the …

Microstructure

The quality of the composite can be determined by the optical microstructure as an indicator. Thus from the optical photomicrographs, it is found that the distribution of the reinforcements were uniform, also indicates the increased reinforcement content in the composite. The micro structures of the different specimens are recorded in various magnifications ranging from 50X to 200X. The scanning electron microscope (SEM) image is taken for ABA0 contains pure Al7075, ABA5, ABA10 and ABA15. …

SEM image

To …

Conclusion

Al 7075 – (B_4C/ Al_2O_3) hybrid MMC were developed by using two-step stir casting process with different volume fraction. The corrosion test carried by using potentiodynamic polarization method and the test results provide the following conclusions,

1. Compared with the base alloy produced by the two-step stir casting method, the produced composite material has a higher microhardness value and high corrosion resistance. …

2. The SEM image of the composite material reveals the even distribution of the …

...

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. ...

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> *Citation Excerpt :*
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> …According to the results, the samples heat-treated at 460–480 °C for 24 h showed higher corrosion resistance compared to the untreated samples. Sambathkumar et al. [36] reported that corrosion resistance of hybrid (B4C+Al2O3) reinforced composite improves with the increase of reinforcement volume ratio. Pragathi and Elansezhian [37] analyzed the corrosion behavior and wear resistance of hybrid composites produced by adding B4C+catalytic agent (spent catalyst) into pure aluminium were investigated.…

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