SCRUTINY OF RESISTANCE DISSIMILARITY ON HYBRID METAL MATRIX COMPOSITES BY ANECDOTAL QUENCHANTS

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***Abstract:** The Al 7075 alloy matrix materials exhibiting excellent mechanical properties with the addition of SiC and B_4C particulates as reinforcement. Stir cast method is preferred for preparing composite specimen materials. Then the composites were prepared for heat treatment process by subjecting to solutionizing followed by quenching in different media for improving the mechanical and physical properties. Further, all the specimens are subjected to artificial aging at a temperature of 120˚C for different time duration. The hardness properties are examined for the composite materials before and after heat treatment by brinell hardness test machine. The distribution of reinforcement particles are seen using optical microscope. Due to excellent increase in the hardness the material removal rate decreases. It is also observed that Al 7075 hybrid metal matrix composite experimented under identical heat treatment conditions reveal significant enhancement in hardness.*

***Keywords:** HAMMCs, Solutionizing, Artificial ageing, Microstructure, Hardness.*

1.0Introduction:

In the recent development, metal matrix composites congregate to meet the increasing overall demand for light weight, high performance, eco-friendly, wear, and corrosion resistant materials. The Hybrid Metal Matrix Composites (HMMCs) are in advance extensively used in some areas due to its enhanced mechanical properties (and lighter density) when compared with metals/alloys, particularly in applications where weight and strength are of most important consequence. The advantages of particulate reinforced composites over others are their formability with expenditure benefit and its different strengthening mechanisms [1]. Hybrid Aluminium Metal Matrix Composites (HAMMCs) are suitable for appliances which oblige characteristics such as combined strength, damping properties thermal conductivity, and co-efficient of thermal expansion along with lesser density. The unique properties of HAMMCs enhance their usage in automotive and tribological applications [2-4] such as in pistons, brake drum, brake disc and cylinder block. The current improvement in metallic matrices, for the fabrication of HAMMCs consist of generally used metals viz., Al, Mg, Ti, Cu and their alloys reinforced with hard ceramic particles usually silicon carbide, alumina, [5,6] and soft particles usually graphite, talc etc.[7,8]. The reinforcements like fibers, whiskers and particulates [9] are employed particularly in Al-alloy composites leading to a latest invention of tailorable engineering materials with superior specific properties [10, 11]. This creates significance among the researchers to deliberate both on investigational and systematic segments of HAMMCs to expand an enhanced perceptive about the mechanical behavior of these materials and their exceptional wear resistance.

In engineering materials system, the heat treatment processes are incredibly essential for improving the composite material properties. The main purpose of heat treatment is to create the material system structurally and physically strong and fit for engineering application [12]. Heat treatment of aluminium alloys favors the maximum concentration of hardening solute to dissolve into solution. This method is suspiciously conceded out by heat treatment of an alloy to a temperature at which one single, solid phase exists. By this heat treatment, the solute atoms that are originally part of a two phase solid dissolve into solution and originates as one single phase. Once the alloy is heated to the recommended solutionizing temperature, it is quenched at a rapid rate such that the solute atoms don’t have enough time to precipitate out of the solution. As a result of the quench, a super saturated solution now exists between solute and aluminium matrix [13, 14].

Rapid quenching creates a saturated solution resulting in increased hardness and mechanical properties of the material system. In addition to these studies, the highest degree of corrosion resistance is obtained through maximum rates of quenching [15]. Quenching takes place in three distinct stages namely vapour blanket stage, boiling stage and liquid cooling stage. The vapour blanket stage begins when hot part submerged in unbroken blanket which surrounds the object. This blanket exists between the specimen and quenching media if the heat from the surface of the object exceeds the amount of heat needed to form maximum vapour per unit area of the object.

Previous studies [16-24] of the ageing behavior of the composite with discontinuous ceramic reinforcement are different from that of the aluminium matrix alloys. The hardening effect of these composites by ageing depends on several factors such as matrix material, type of reinforcement including its size, shape and volume fraction, processing technology and ageing temperature. There is lack of information for ageing behavior of Al 7075composites. The present work is aimed at investigating the consequence of quenching media and ageing duration on the hardness property of Al 7075 HAMMCs.

2.0 Materials Selection

In this paper, SiC and B_4C particulates reinforced with Al 7075 matrix composite is selected as it provides excellent combination of strength to weight ratio and damage tolerance at elevated and cryogenic temperatures. The nominal chemical composition of Al 7075 alloy is given in Table 1. The particulate reinforcement size are presented in table 2. Hardness of the specimens was measured using brinell micro hardness tester by applying a load of 100 kgf and the average hardness from 10 different data of the experiments was considered.

Table 1:Chemical composition of Al7075 by weight percentage

Elements	Si	Fe	Cu	Mn	Ni	Zn	Ti	Mg	Cr	Al
% wt	0.06	0.18	1.62	0.074	0.05	5.62	0.049	2.52	0.22	Balance

Table 2:Reinforcement Size

Particulate	Size	Shape
SiC	25	Angular-Irregular
B4C	8	Angular-Irregular

3.0 Preparation of Hybrid Aluminum Metal Matrix Composites (HAMMCs)

In manufacturing particulate reinforced MMCs, stir casting technique is one of the popular Liquid Metallurgy Routes (LMR) and is known as a very promising route for manufacturing near net shape hybrid metal matrix composite components at a normal cost [25]. This is the one of the vortex methods to create a good distribution of the reinforcement material in the matrix [26, 27].In the present work, stir casting technique is used to fabricate Al 7075 alloys with varying weight percentage of SiC and B4C reinforcement. In order to achieve good binding between the matrix and particulates, one weight percent of magnesium alloy is added. Temperature can be easily controlled and measured. The stirrer is used to stir the molten metal in semi solid state. The melt was maintained at a temperature between 750 to 800˚C for one hour. Vortex was created by using a mechanical stirrer. SiC with particulates size 25µm and B4C with particulates size 8 µm are preheated at 400˚C and added into the melt with constant mechanical stirring for about 10 min at 500 to 650 rpm condition. Four specimens Al7075 reinforced with 3% SiC, 3% SiC 3% B4C, 7% SiC 4% B4C and 4% B4C composites were made with the same procedure. Once the reinforcement are mixed well ,the bottom portion of the furnace is opened and made to flow in the die which was kept down the furnace. After cooling the specimen was taken from the die. Then the composite were machined as a rectangular piece of dimension 50X50&5 mm . The specimen faces were metallographically polished. Hardness measurements were carried out on the specimens. Specimens were tested using Brinell hardness tester machine. A load of 500 Kgf for a period of 30 seconds was applied with a ball indenter of 10 mm diameter. The test was carried out at five different regions. Hardness was determined by measuring the indentations diameter produced. The average of all the five readings was taken as the hardness of the composite.

4.0 Heat Treatment Process

Al 7075 matrix alloy with SiC and B4C particulates reinforced composites were subjected to solutionizing treatment at a temperature of 475˚C for a period of 2 hr using muffle furnace, followed by quenching in three different quenchants viz, air, water and ice. Artificial ageing treatment was carried out for duration of 2 hr to 10 hr in steps of 2 hr.

5.0 Results and Discussion

5.1 Hardness Survey:

Hardness test was carried out using Brinell hardness tester with six indentations of each sample and then the average values were used to calculate hardness number. A considerable increase in hardness of the matrix was seen with the addition of SiC and B_4C particles .The hardness of HAMMCs increases with the weight fraction of particulate in the alloy matrix. It is observed that with increased weight % of reinforcement in the matrix alloy, there is a significant improvement in the hardness of the composites. The hardness of HAMMCs increases with weight percentage of particulate in the Al alloy matrix. The added amount of SiC and B4C particulates in matrix will enhance hardness due to the dislocation pile up of the matrix lattice.Fig(1-3) shows that the sample with 3% SiC and 3% B4C particulates have lesser hardness . But the sample with 7wt% SiC 3wt% B_4C showed higher hardness .Hence from the strength and hardness point of view, 7 wt% SiC and 3 wt% B_4C can be considered as the optimum weight percentage of the particulate for the application considered in this work. This trend is similar to the results of other researchers [25]. The variation of hardness with increased weight % of reinforcement in the Al 7075 matrix alloy and heat treated Al 7075 particulate composites are as shown in the figures. Maximum hardeness was measured for Al7075 7%SiC and 3% B4C composites. On air quenching and ageing for 8 hr, a maximum improvement in hardness around 28%, was observed for the composite Al 7075 7 wt % of SiC and 3% B_4C . On water quenching and ageing for 8 hr, considerable increase in the hardness around 22% was observed. Ice quenching and ageing for 8 hr, results in maximum improvement in hardness of around 19% .

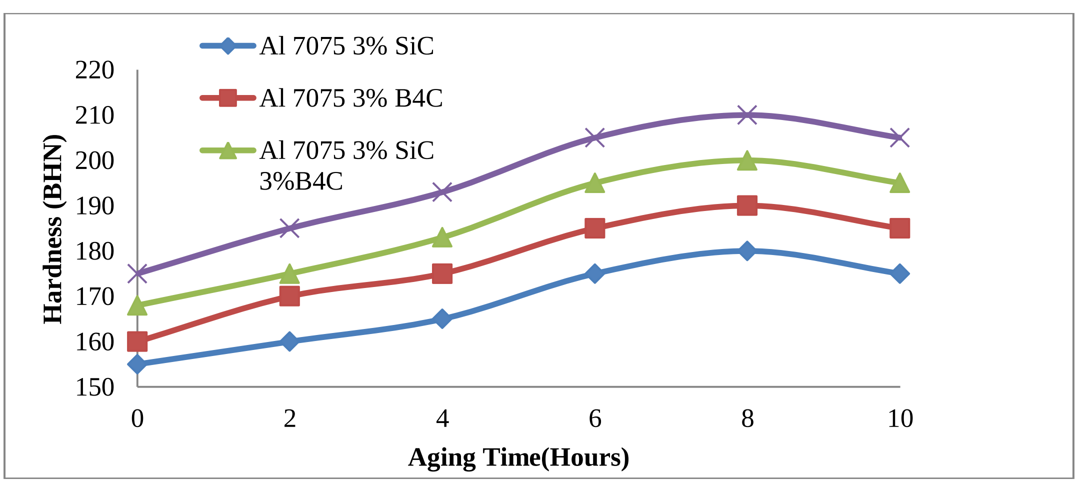

Fig 1 Solutionizing Temperature: 475˚C, Quenching Media : Air, Ageing Temp: 120˚C

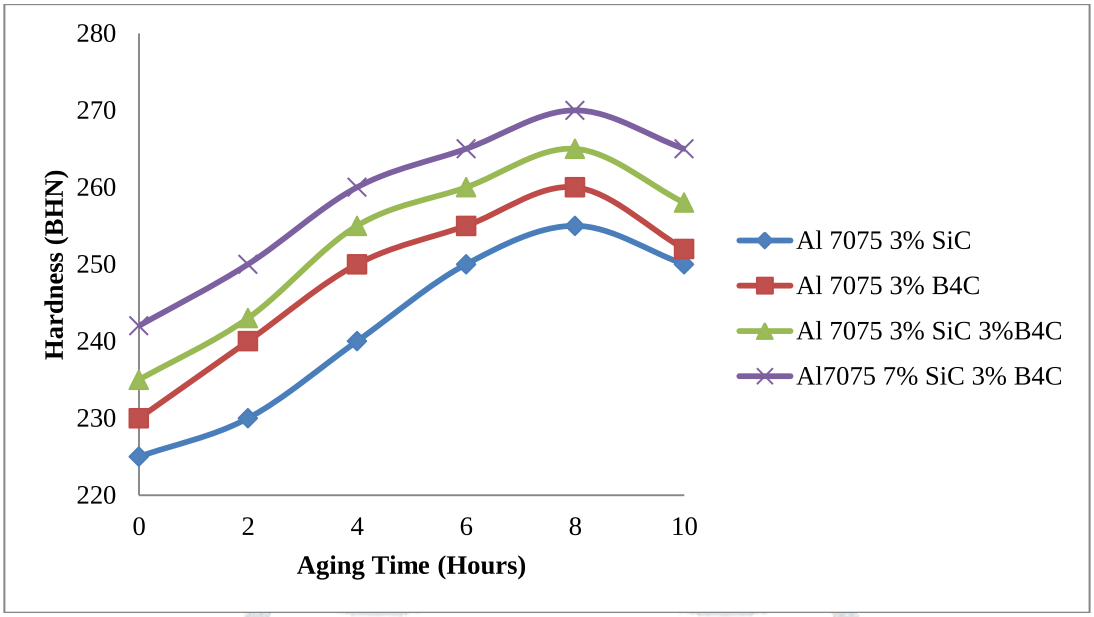

Fig 2 Solutionizing Temperature: 475˚C, Quenching Media : Water, Ageing Temp: 120˚C

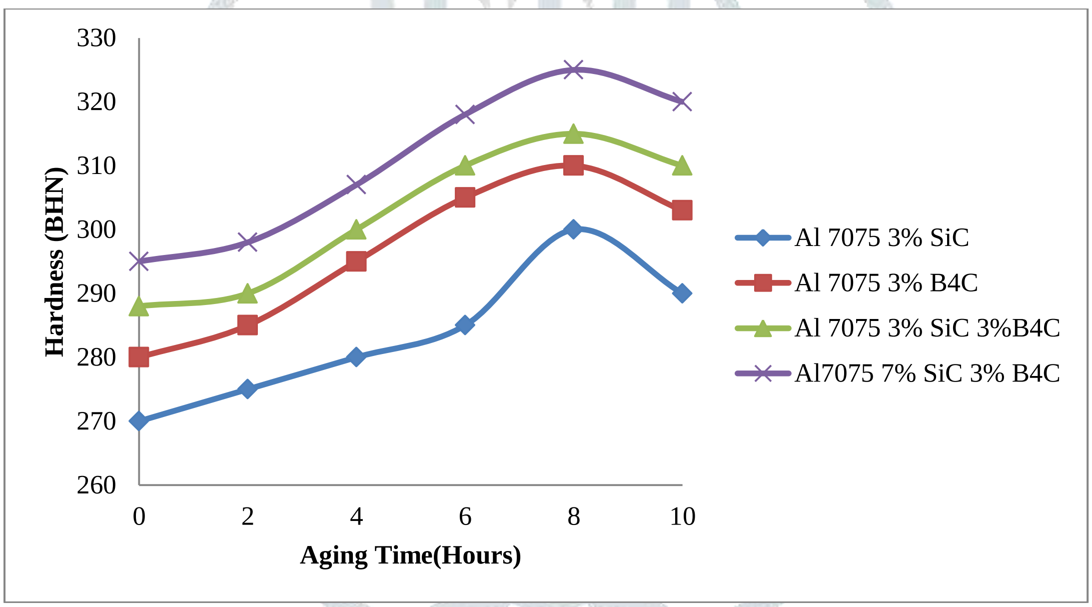

Fig:3Solutionizing Temperature: 475˚C, Quenching Media :Ice, Ageing Temperature: 120˚C

6.0 CONCLUSION

Hardness increases with ageing duration,reaches a peak value at 8 hr and with further increase in ageing duration, there is a decrease in hardness. Hardness of composites increased significantly with increased content of SiC and B_4C. Heat treatment has a significant effect on hardness of Al 7075 matrix composites. Ice quenching followed by artificial ageing for 8 hr resulted in maximum hardness of composites.

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