Journal of Mines, Metals and Fuels, *71(12A): 131-136; 2023. DOI: 10.18311/jmmf/2023/43185*

Print ISSN : 0022-2755

Journal of Mines, Metals and Fuels

Contents available at: *www.informaticsjournals.com/index.php/jmmf*

Study the Hardness Behaviour of Heat Treated Aluminium 7075-Aluminium Nitride Particulate Composite

T. L. Annapoorna[1], Batluri Tilak Chandra[1], Sanjeeva Murthy[1] and H. S. Shivashankar[2]

[1]Department of Mechanical Engineering, Sri Sidhartha Institute of Technology, Tumkur - 52102, Karnataka, India; annapoornatl@ssit.edu.in, batluritilakchandra@ssit.edu.in

[2]Department of Mechanical Engineering, Siddaganga Institute of Technology, Tumkur - 572103, Karnataka, India

Abstract

Composite materials with an aluminium matrix and ceramic reinforcement are becoming more popular in design application. The addition of AlN reinforcement increases the hardness of aluminium 7075 composite. In the current study, stir casting method was used to manufacture aluminium 7075-AlN composites by increasing the weight of AlN particles from 0 to 10 percent by a step of 2 weight percent. The As-cast and its composites underwent a solutionizing treatment for two hours at a temperature of 470° C, which was followed by extinguishing in different media, such as air, water, and ice. Then the specimens are subject to artificial ageing at 120c.microstructure analysis and hardness test was carried on both as cast and Al7075-AlN metal matrix composites. Al7075-AlN MMCs show an improvement in hardness when compared with Al7075.

Keywords: *Al7075, AlN, Ageing, Solutionizing.*

1.0 Introduction

In several industrial sectors metal matrix composites are gaining more popularity because of improved properties which contrasted with metals, specifically when in application strength and weight are important and also to its lighter density. Aluminium and aluminium metal matrix composites were being used in automobile field as a material system such as cylinder, push rods, brake disc, connecting rod and piston etc.,[1] in particular, the composite properties depend on the matrix and nature of the particulate reinforcement and relative percentage of reinforcement[2]. Aluminium nitride is considered for reinforcement material due to its enhanced property like high strength, thermal suitability, good thermal expansion co-efficient, and its good dispersion with aluminium matrix material[3]. Al7075 alloy has many advantages, including formability, weldability, resistance to corrosion, and affordability for the manufacturing of aluminium particle reinforced composites by stir casting method considered being better method among various conventional processing methods[4,6]. The development of as-cast aluminium alloy (al7075)-aluminium nitride particulate composite had been made to study the hardness property of as-cast Al7075-AlN and T6 heat treated Al7075-AlN metal matrix composites by varying the wt% of aluminium nitride Particulate[7-12].

2.0 Experimentation

2.1 Composite Preparation

Aluminum 7075 alloy is employed as the matrix material and aluminium nitride is used as the reinforcement

**Author for correspondence*

Table 1. Chemical composition of Al7075 matrix material

Elements	Cu	Mg	Si	Fe	Mn	Cr	Zn	Ti	Al
chemical composition	1.539	2.191	1.783	0.290	0.275	0.117	4.416	0.047	89.3

material in the current study to prepare composites. Al7075 matrix material's chemical content is described in Table 1.

Clean extruded Al7075 alloy is placed within an electric furnace, the furnace temperature is increased to 750° C, and the furnace is held at this temperature for 30 minutes until the aluminium alloy has completely melted. 0.5% of magnesium to the total weight of Al7075 alloy is added in the crucible as magnesium acts as a wetting agent to bind matrix and reinforcement. Through the side of the vertex created by mechanical stirring with a stir impeller, preheated aluminium nitride reinforcement was continually injected into the molten metal. The ideal speed of 450 rpm is determined and selected prior to this experiment. This is to avoid unacceptable porosity content in the casting due to excessive gas content that resulted from over agitating of metals[5]. The liquid alumina coated impeller and stirring rod is used to avoid metals contamination in the molten metal, stirring process is carried out to facilitate uniform dispersion of particulate aluminum nitride into the melted molten metal. After stirring the composite mixture melts for five minutes, the cast is instantly placed into a permanent mould. After the solidification, metal matrix composite (Al7075/AlN) is taken out from the mould[13,14]. The developed as cast Al7075 alloy and its composites were hot forged and subjected to heat treatment process with solutionzing temperature 470°c of 2 hours and quenched in medium i.e. air, water and ice and ageing process is carried. Microstructural studies were done on both cast and heat-treated MMCs.

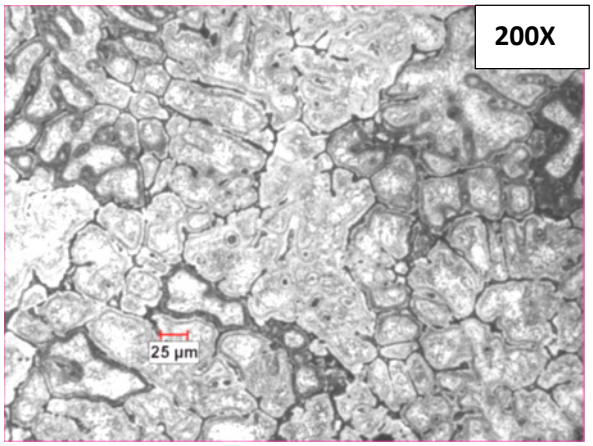
2.2 Hardness Testing

The hardness specimen was machined and testing was carried out according to ASTM E10-95 standards of dia 20mm and height 10mm. the Brinell hardness tester having loading capacity various from 500 Kgf to 3000kgf and having minor load of 500kgf and 10 mm ball indenter. Initially the specimen is placed in the platform on the tester and minor load is applied to the specimen by means of 10 mm ball indenter and load is applied 30 seconds for each intention. The five trials are conducted for every specimen of as-cast and heat-treated Al7075-AlN MMCs at diverse locations.

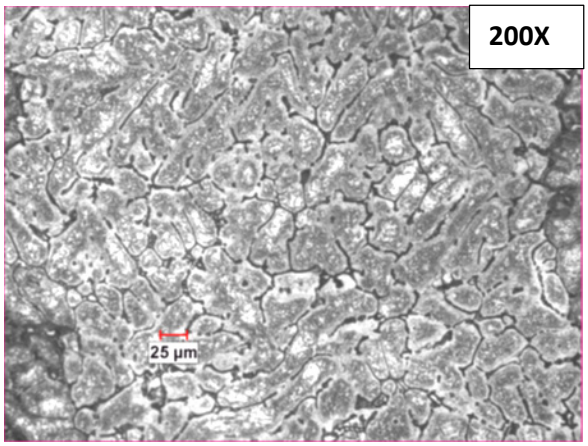
3.0 Results

3.1 Microstructural Analysis

Before performing the optical microstructure analysis on the samples, the samples are first rough polished using a



Al7075andAlN 0wt%



Al7075 and AlN 2wt%

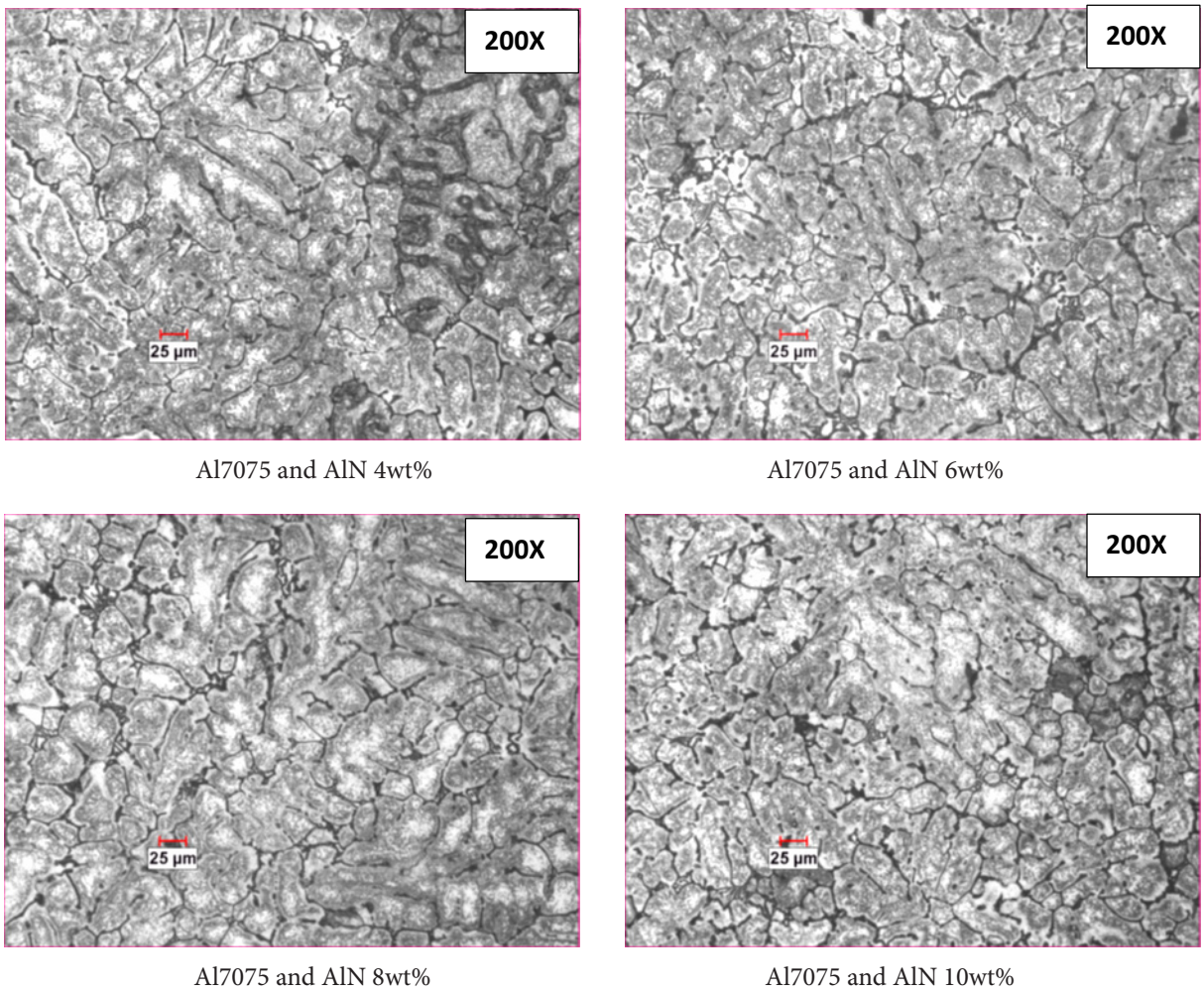


Figure 1. Optical microstructure of Aluminium alloy (Al7075) – Aluminium nitride composites.

sequence of silicon carbide sheets with grit sizes of 100, 200, 400, 600, and 1000. Next, using three thick diamond pastes on a velvet cloth, fine polishing is performed using magnesium oxide paste. The specimens for microstructural examination were prepared with etching by killers' reagent, microstructure analysis is as shown in Figure 1.

The uniform distribution of aluminum nitride particulates in Al7075 MMCs at different percentages of weight is observed in Figure 1. Aluminium nitride particulates appear to be homogeneous distribution in the Aluminium7075 MMCs. It is achieved by the appropriate use of process parameters and effective stirrer action. The mechanical characteristics of the matrix alloy are improved by uniform AlN particle distribution.

3.2 Hardness

Figure 2 Exhibit the effect of hardness with increased weight % of reinforcement particles with unheattreated Al7075-AlN composite. It is noticeable that as the increase in percentage of reinforcement aluminium nitride particles in the composite material increases the hardness. This is due to adding reinforcement made the Al7075 into brittle.

Figures 3, 4 and 5 it is evidence that effect of heat treatment on hardness property on both Al7075 alloy and Al7075-AlN MMCs when quenched in three different

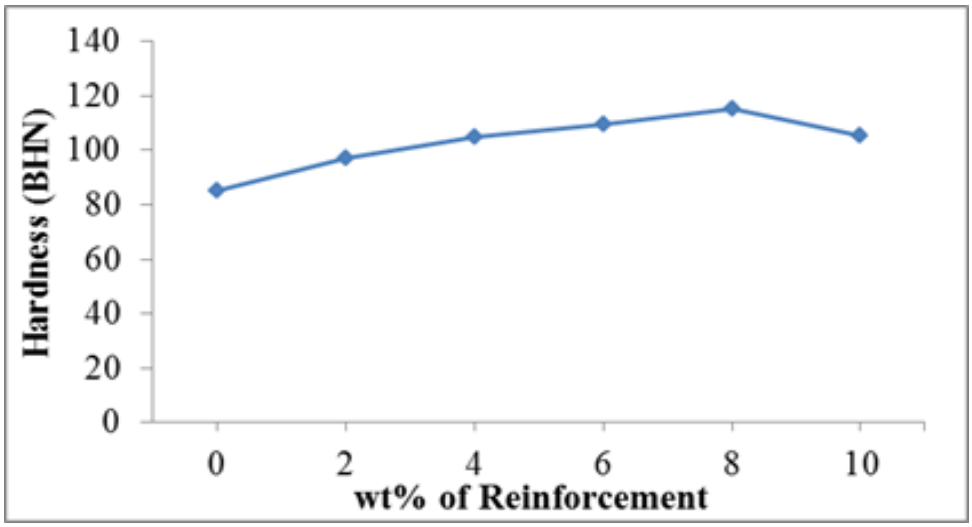


Figure 2. Hardness effect for increased wt% of reinforcement for unheatreated Al7075-AlN MMCs.

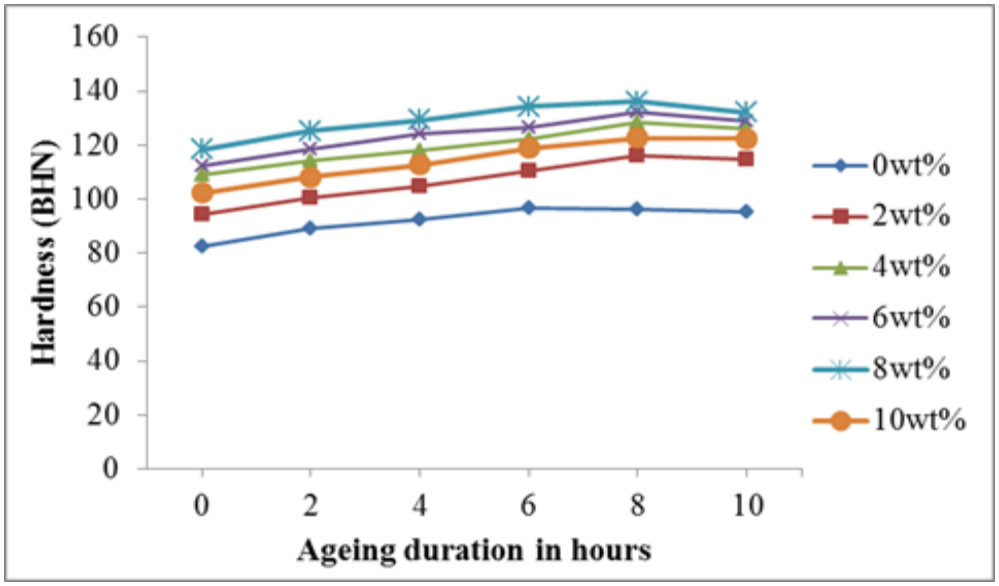


Figure 3. Hardness effect by increasing AlN wt% and heat treated with Air quench.

mediums of air, water and ice. From consideration of all the three-quenching medium, increased hardness was shown in 8 hrs of ageing duration.it is absorbed that ice quenched with 8 hours of ageing period Al7075-8 Wt% of Aluminium nitride particulate composite shows the improved hardness as compare to the other quenching medium i.e. air and water. Intermetallic precipitates are caused by an increase in hardness over time as aging progresses. The composites' hardness is increased when MgZn2 (intermetallic precipitate) is present. As the amount of aging grew, the hardness reduced. Coarser intermetallic precipitates are responsible for this.

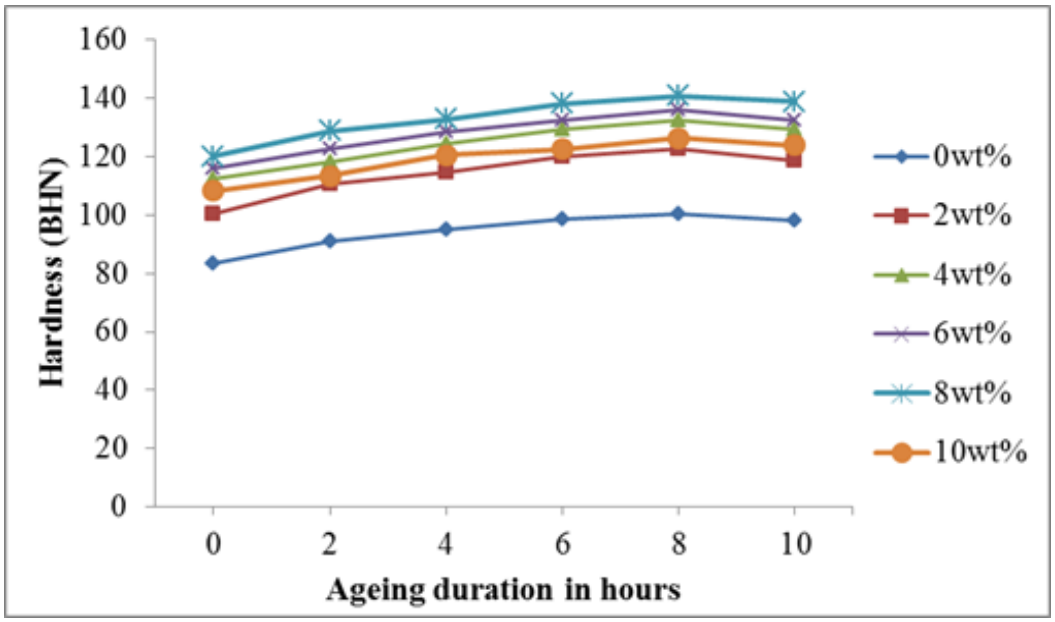


Figure 4. Hardness effect by increasing AlN wt% and heat treated with water quench.

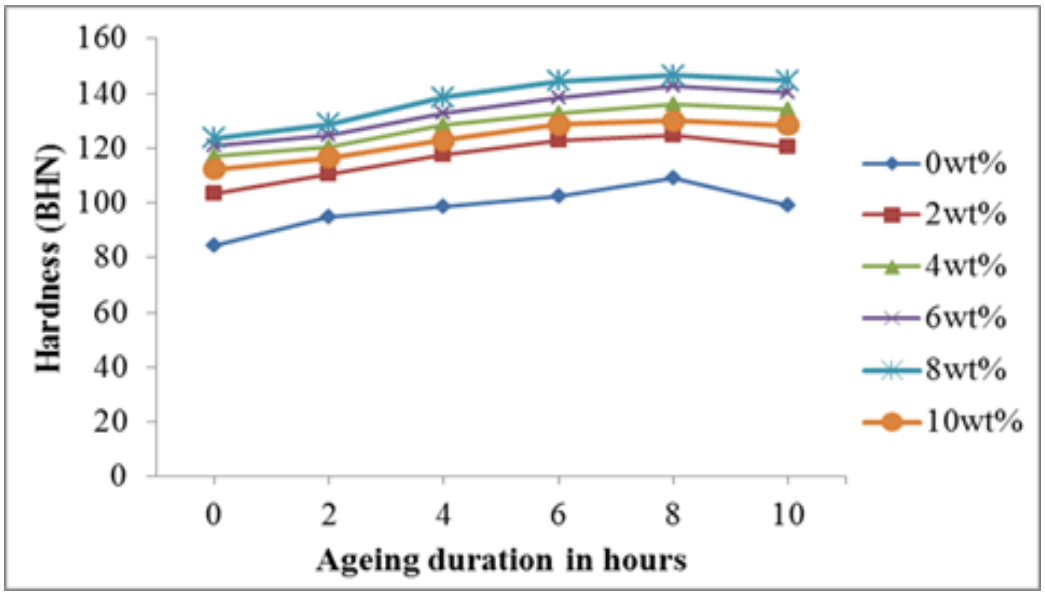


Figure 5. Hardness effect by increasing AlN wt% and heat treated with ice quench.

4.0 Conclusion

- The successful development of Al7075-aluminum nitride particulate reinforced MMCs is done by the method of stir casting followed by forging and T6 heat treatment.
- The resulting composite's microstructure demonstrates improved bonding between the reinforcement and matrix and practically uniform dispersion of aluminum nitride reinforcement particles.

- The hardness increases, AS increases in weight percentage of AlN particulate in Al7075 metal matrix composites. After the heat treatment process quenched in ice medium with ageing 8-hour ageing hour results in maximum hardness of composites.

5.0 References

1. Schwartz MM. Composite Materials Handbook. 1992, McGraw-Hill, Second Edition.
2. Vinoth Babu N, Moorthy TV. Synthesis and characterization of Al7075/Sic composite by stir casting. Applied Mechanics and Materials. 2014; 592-4. https://doi.org/10.4028/www.scientific.net/AMM.592-594.760
3. Saravanan C, Subramanian K. Effect of particulate reinforced aluminium metal matrix composite-a review. Mechanics and Mechanical Engineering. 2015; 19(1).
4. Sharma SC, Pual Vizhian S, Shashishankar A, Krishna M. Influence of heat treatment on microstructural and tensile properties of Aluminium E-Glass short fiber composites. Journal of Mechanical Behaviors of Materials. 2011; 14(4-5). https://doi.org/10.1515/JMBM.2003.14.4-5.305
5. Wahab MN, Daud AR, Ghazali MJ. Preparation and characterization of stir cast-aluminium nitride reinforced aluminum metal matrix composites. IJMME. 2009; 4(2).
6. Milan MT. Tensile and fracture toughness properties of SiC reinforced Al alloys: Effect of particulate size, particulate volume fraction, and matrix strength. JMEPEG. 2004; 13:775-83. https://doi.org/10.1361/10599490421358
7. Ravindra Sagar CS, Chandra BT. Heat treatment effect on the hardness of aluminium LM13-MgO particulate composite. IJERAT. 2018; 4(1). https://doi.org/10.7324/IJERAT.2018.3180
8. Ramesh D, Swamy RP, Chandrashekar TK. Effect of weight percentage on mechanical properties of frit particulate reinforced Al6061 composite. ARPN Journal of Engineering and Applied Science. 2010; 5(1).
9. Pai C, Ramani G, Pillai RM, Sathyanarayana KG. Role of Magnesium in cast aluminium alloy matrix composites. Journal of Material Science. 1995; 30:1903-11. https://doi.org/10.1007/BF00353012
10. Ashok Kumar B, Murugan N. Metallurgical and mechanical characterization of stir cast Al6061-T6-AIN composite materials and design. ELSEVIER. 2012; 40. https://doi.org/10.1016/j.matdes.2012.03.038
11. Behera R, Das S, Chatterjee D, Sutredhar G. Forgeability and machinability of stir cast aluminium alloy metal matrix composites. JMMCE. 2011; 10(10):923-39. https://doi.org/10.4236/jmmce.2011.1010072
12. Bharathesh TB, Ramesh CS, Verma SM, Keshavamurthy R. Influence of heat treatment on tribological properties of hot forged Al6061-TiO_2 composites. International Journal of Emerging Technology and Advance Engineering. 2013; 3(6).
13. Baradeswaran A, Elaya Perumal A. Influence of B4C on the tribological and mechanical properties of Al7075-B4C composites. ELSEVIER, Composites. 2013; 54:146-52. https://doi.org/10.1016/j.compositesb.2013.05.012
14. Ravi B. Fabrication and mechanical properties of AL7075-SiC-TiC hybrid metal matrix composites. IJESI. 2017; 6(10):12-9.