Effect of Cryogenic Treatment on Hardness and Tensile Strength of AlSic-B4C Composites

Ranjitha P.[1], Dr. Ajaykumar B. S.[2] , Dr. Saravanabavan D[3]
[1]Assistant professor, Department of Mechanical Engineering, DSCE, Bangalore, Karnataka, India.
[2.]Professor, Department of Mechanical Engineering, K.S.I.T., Bengaluru, Karnataka, India.
[3] Associate Professor, Dept. of Mechanical Engineering, DSU, Bengaluru, Karnataka, India.

***Abstract*:- Aluminium alloys have low density and good mechanical properties, better corrosion resistance and wear, low thermal coefficient of expansion as compared to conventional metals and alloys. Hence they are widely used in aerospace and automobile industries. The admirable mechanical properties of these materials and their relatively lower production cost make them suitable for a variety of applications both from technological and scientific viewpoints. In the present investigations an attempt has been made to know the effect of cryo treatment on Thermal Conductivity, Hardness, Tensile strength, Deep cryo treatment on Al-6061 reinforcing with varying SiC and B4C contents. The composite is manufactured throughastircastingprocessinanelectricmeltingfurnace.The experimental study is performed by varying the weight percentage of Silicon carbide powder and boron carbide with pouring temperature and stirring time asconstant.**

Keywords: Aluminium Metal Matrix Composite, Stir Casting, Reinforcement Silicon Carbide and BoronCarbide, Taguchi Method

1. INTRODUCTION

Nowadays, with the modern development need of developments of advanced engineering materials for various engineering applications goes on increasing. To meet such requirements metal matrix composite is one of trustworthy sources. Composite material is one of the reliable solutions for such situations. In composites, materials are blended in such a way, to enable us to enhance the use of their parent material while minimizing to some extent the effects of their deficiencies. The simple term 'composites' gives indication of the combinations of two or more materials in order to improve the properties. In AMC one of the constituents is aluminum, forms a percolating network and is known as matrix phase. The other constituent is embedded in this aluminum and serves as reinforcement, which is usually non metallic and commonly ceramic such as SiC, Al_2O_3,B_4C etc.(1,2,3,4) Al 6061 is fairly a well liked choice as a matrix material to prepare MMCs owing to its better formability characteristics. It is widely used in numerous engineering applications including transport and construction where superior mechanical properties such as tensile strength, hardness etc. are essentially required.(6,7)

To further increase the properties of these composites, processes like heat treatment for whole material and surface processing are also carried out. On the other hand cryogenic treatment also known as sub zero treatment is done. It is an ancient process and widely used for the high precision parts and objects, especially for the ferrous and tooling materials earlier(8). The subjecting of the material to extreme cold hardens, strengthens and molecular alignment in the micro level is fine and smooth the material has longer life (9). Now the cryogenic treatment which is whole material treatment is widely used in many automotive, aerospace, electronic and mechanical engineering industries to improve mechanical strength and dimensional stability of components For the past few years the cryogenic treatment for the nonferrous metals such as aluminium and magnesium alloys has been done for the their improvement of properties (10). The improved mechanical properties and microstructure changes of the metals and alloys in cryogenic processing drew the attention of researchers towards this process. The researchers (11, 12, 13, 14) showed the beneficial effects of cryogenic treatment on nonferrous metal aluminium. The effect of cryogenic treatment on the wear performance of copper alloy showed least significant changes (15). This led to the idea of analyzing the properties when MMCs are undergoing cryogenic treatment. This field is rapidly growing and is used by many manufacturers. The present work intends to build a facility to research the process and results of the cryogenic treatment. This helps to create standards for both processing and testing that are currently unavailable. Hence it gives the significance that mechanical properties of the MMCs developed are evaluated at cryogenic temperatures. Thus in this experimental work cryogenic treatment was applied to Al6061/SiC MMCs to study its effect on , Hardness, and Tensile strength

2.0. EXPERIMENTAL SET UP AND PROCEDURE

AlSiC-B_4C composite are for combination of **1, 2, 3 and 4%** SIC are casted by using stir casting process for combination of **1, 2, 3 and 4%** SIC are casted by using stir casting process.(4) Then the jobs are subjected for Deep cryo treatment process. The jobs are cooled down to Deep Cryo Temperature **-196^0** c at a rate of **3^{0}c/**min from room temperature in computerised Cryo Processor, soaked at that temperature for a period of **24** Hrs and then brought back to room Temperature at a rate of **3^{0}c/min**. then the Deep Cryo Treated specimen tested for various Properties and compared with Untreated samples.

2.1 Hardness test.

Brinell hardness has been determined for reinforced alloy and hybrid composites developed using Al 60613wt. % as the alloy with the SiC and B_4C particles added as reinforcements in amounts of 1, 2, 3 and 4 wt.% respectively.

The Brinell hardness has been measured for unreinforced alloy and cast composites with 5 mm hardened steel ball indenter of 250 Kg load was applied for 30 seconds on a sample and then the diameter of indentation was measured with help of the tool maker's microscope.

For each indentation, an average of two diameters measured perpendicular to each other was used to obtain the corresponding hardness. On each sample at-least eight indentations for hardness measurement were made at different locations and the average of these readings is reported as the average hardness value of the material. Brinell hardness number has been found out by using Standard formulae.

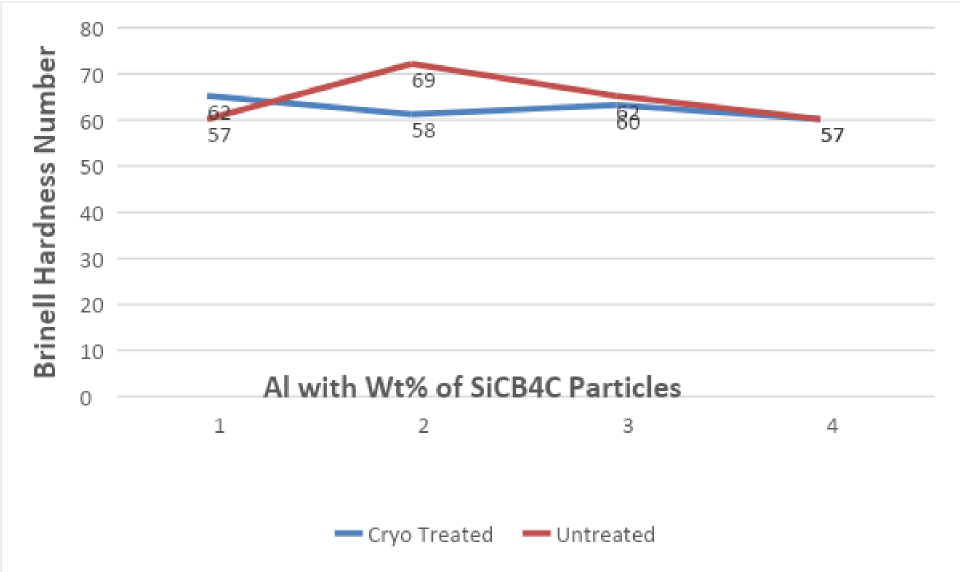

Fig 1: Indicating the variation in hardness number for different percentage of SiC+B_4C particles

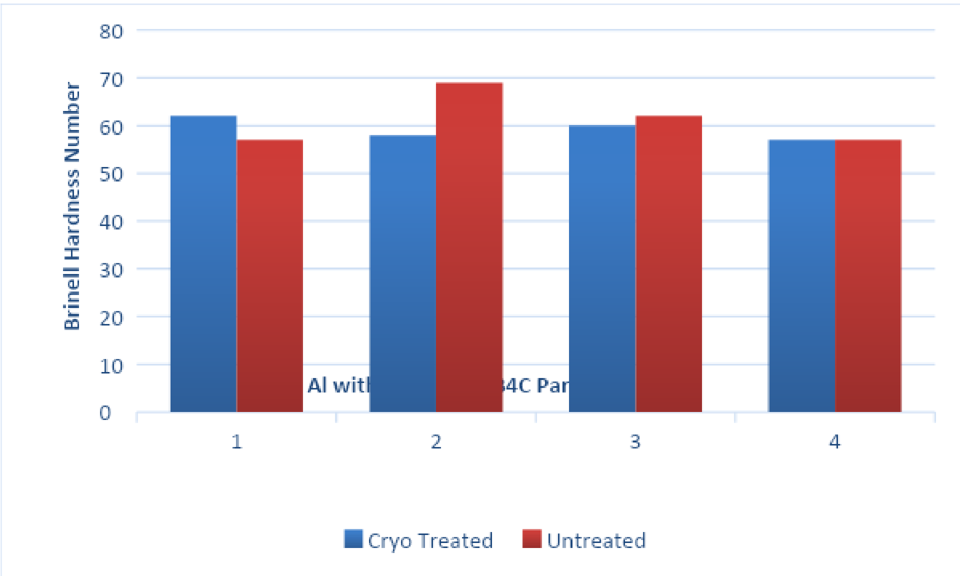

Fig 2: Bar chart shows variation in BHN between Untreated and Deep Cryotreated AlSiC+B4C Composites.

From fig (1) and fig (2) indicates that as the percentage of SIC increases hardness value also increases. But Deep Cryotreatment on composites has helped in increasing the hardness on composites due to Improvement in wear resistance This is in concurrence with the investigation has carried out by Earlier investigators.(11,12,13,14,15)

As the percentage of B_4C increases from 1% to 4% the hardness also correspondingly increases upto 2% and then decreases in case of treated and untreated one.

The hardness value does not change for AlSiC+4%B_4C for untreated and treated once, but hardness has been decreased for the presence of 2% and 3% B_4C on AlSiC except 1% B_4C.

The effect of 2% B_4C and 4% B_4C has indicated the same treatment in case of tensile strength. The above findings or in concurrence with the investigations on above set composites.

2.1 Tensile test.

Tensile test is carried out on UTM as per standard procedure on below tensile test specimen as indicated in fig (4) and values are recorded at maximum load bearing capacity of the job and correspondingly tensile strength has been assessed by using formulae.

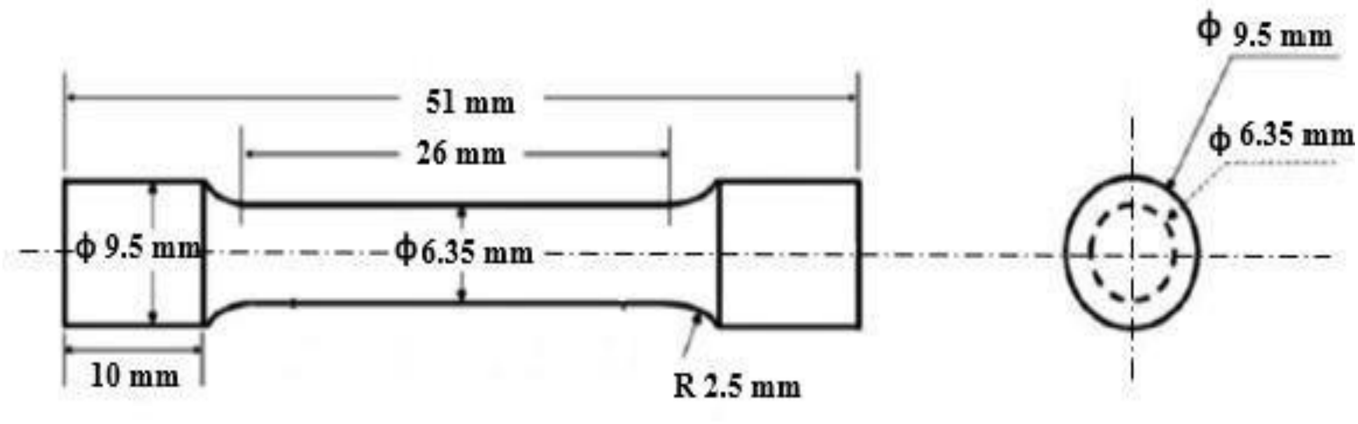

Fig. 3: Schematic representation of tensile specimen ASTM E8 standard

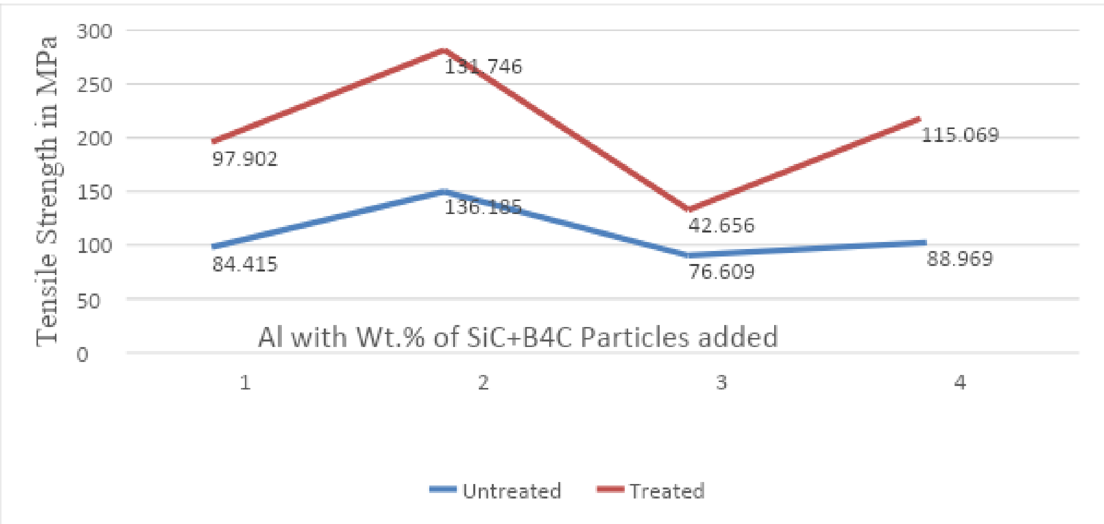

Fig. 4: Indicating the variation in tensile strength for different percentage of SiC+B4C particles

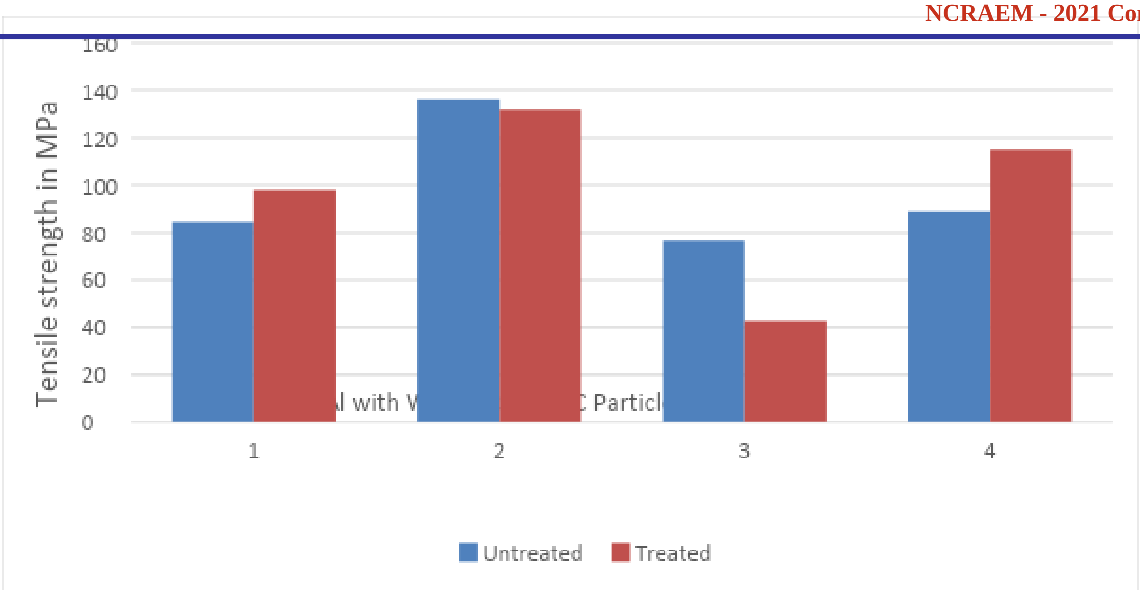

Fig 5: Bar chart shows variation in tensile strength between Untreated and Deep Cryotreated AlSiC+B_4C Composites

From fig (4) and fig (5) indicates that as the percentage of SIC+B_4C increases tensile strength also decreases. But deep Cryotreatmen helps in improving toughness on composites, which in turn has reduced the tensile strength on composites without incurring loss to its hardness property.

As the percentage of B_4C increases from 1% to 4%, tensile strength also correspondingly increases up to 2% and then decreases beyond 2% in case of untreated composites.

A peculiar behavior has been observed correspondingly to deep cryo treatment on above set composites. The tensile strength, yield load and yield strength has been increased in comparison with the rest of the percentage of B_4C on composites. Deep cryo treatment AlSiC+4%B_4C composites can be used on those components where cushioning effect is predominant. Elongation also has been increased for above set composites by an amount of 5% in comparison to untreated one.

Tensile strength has been found to be moved (TS: 136.185Mpa) for untreated AlSiC+2%B_4C composite in comparison with deep cryo treatment (TS: 131.746Mpa) on it. But yield load and yield strength has been found to be less in comparison with AlSiC+4%B_4C composites. The above combination can be used on those components where ductility is predominant.

3.0 CONCLUSION

The aluminium metal matrix composites have been produced successfully by the addition of 1, 2, 3 and 4 wt.% of Silicon carbide (SiC+B_4C) powder to molten Al 6061 alloy by liquid stir casting method followed by casting in permanent mould. The influence of increasing amounts of SiC+B_4C powder addition has helped in increasing the mechanical properties.

The conclusions of the present study are outlined below.

1) Stir casting technique (Liquid Metallurgy) was successfully adopted in the preparation ofAl6061 SiC+B_4C alloy and composites containing 1, 2, 3 and 4 wt. % of SiC+B4C powder reinforcement

2) The variation in tensile strength, yield load and yield stress and hardness value for 2%, 4% B_4C on AlSiC composites provides guidelines for the use of deep cryo treated 2% B_4C and 4% B_4C depending upon its applications on components to be used for manufacturing the product.

Acknowledgement

The authors whole heartedly express gratitude to the Chemical and Metallurgical analysis lab and mentors in executing the research work

Funding: This research received no external funding

Conflicts of Interest: The authors declare no conflict of interest

REFERENCES:

[1] D.B. Miracle, S.L. Donaldson(Eds.), ASM Handbook: Composites, Vol.21, ASM International, Materials Park, Ohio, p 1029-1032, 2001.

[2] Bodunrin, M.; Alaneme, K.K.; Chown, L.H. Aluminium matrix hybrid composites: A review of reinforcement philosophies; mechanical, corrosion and tribological characteristics. J. Mater. Res. Technol. **2015**, 4, 434–445.

[3] Pitchayyapillai, G.; Seenikannan, P.; Raja, K.; Chandrasekaran, K. Al6061 hybrid metal matrix composite reinforced with alumina and molybdenum disulphide. Adv. Mater. Sci. Eng. **2016**, 2016, 6127624

[4] S.; Annamalai, A.; Kuppan, P.; Oyyaravelu, R. Fabrication of hybrid metal matrix composite reinforced with SiC/Al2O3/TiB2. Mech. Mater. Sci. Eng. **2017**, 9, 301–305.

[5] Mahdavi, S.; Akhlaghi, F. Effect of SiC content on the processing, compaction behavior, and properties

M.A.Processing methods and property evaluation of Al2O3 and SiC reinforced metal matrix compositesbasedonaluminium2xxx alloys

[6] Ashwath, P.; Xavior, M.A.Processing methods and property evaluation of Al2O3 and SiC reinforced metal matrix composites based on aluminium 2xxx alloys

[7] Reddy, P.S.; Kesavan, R.; VijayaRamnath, B. Investigation of mechanical properties of aluminum 6061-siliconcarbide, boron carbide metal matrix composite. Silicon **2017**, 9,1–8.

[8] Basithrahman, A. Experimental analysis of mechanical properties of aluminium hybrid metal matrix composites.Int.J.Eng.Res.Technol. **2016**, 5,132–135.

[9] Sendooran S, Raja P, (2011) Metallurgical Investigation onCryogenic Treated HSS Tool, International Journal of Engineering Science and Technology 3:(5) 3992- 3996

[10] Bensely A., Senthilkumar.D, Mohan Lal D., Nagarajan G.,Rajadurai A. (2007), Effect of cryogenic treatment ontensilebehaviorofcasecarburized steel- 815M1, Materials Characterization, 58: (5),485-491

[11] Zhirafar S., Rezaeian A., Pugh M., (2007) Effect of cryogenic treatment on the mechanical properties of 4340 steel, Journal of MaterialsProcessing Technology,186:(1-3),298-303.

[12] Khomamizadeh, (2009), Effect of deep cryogenic treatment on microstructure, creep and wear behaviors of AZ91magnesium alloy Materials Science and Engineering A,523:27–31

[13] Lulay K.E., Khan K., and Chaaya D. 2002, The Effect of Cryogenic Treatments on 7075 Aluminum Alloy, Journal of Materials Engineering and Performance,:11(5) 479-480.

[14] Jiang Xian-Quan, Ning Li, Hong He, Zhang Xiu-Jin, HaoYang, Effect of Cryogenic Treatment on Mechanical Properties and Microstructure of 3102 Al alloy, Materials Science Forum, : 546-49 (2), 845-848.

[15] Guozhi Ma, Ding Chen, Zhenhua Chen, Wei Li,(2010) Effect of cryogenic treatment on microstructure and mechanical behaviors of the Cu- based bulk metallic glass matrix composite, Journal of Alloys and Compounds, 505,(1)319-323