EFFECT OF AGING CONDITIONS ON MECHANICAL PROPERTIES OF AL 6061 BASED HYBRID COMPOSITE

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ABSTRACT

The effect of different aging conditions on the Mechanical properties was evaluated for Al 6061 based hybrid composites containing mica particulates of 200 microns and short e-glass fibres of 2-3 cm length in different compositions. Vortex type of stir casting was employed in which reinforcements were introduced.

The test specimens were machined to ASTM standards and were subjected to solution heat treatment and artificial ageing. Single aging and double aging was carried out on the specimens. The properties like ultimate tensile strength (UTS) and hardness studies are presented. A degree of improvement in both ultimate tensile strength (UTS) and hardness was observe in double aged casting over single aged and as-cast condition.

The microstructures of the composites were studied to know the dispersion of the mica and e-glass fibre in matrix. It has been observed that addition of reinforcements significantly improves ultimate tensile strength along with hardness properties as compared with that of unreinforced matrix.

Keywords: Mica, e-glass fibre, Al6061 hybrid composite, mechanical properties, stirs casting.

INTRODUCTION

Metal Matrix Composites (MMCs) have received increasing attention in recent decades as engineering materials. The introduction of a ceramic material into a metal matrix produces a composite material that results in an attractive combination of physical and mechanical properties, which cannot be obtained with monolithic alloys. There is an increasing need for knowledge about the processing techniques and mechanical behaviour of particulate MMCs in view of their rising production volumes and their wider commercial applications[8]. Interest in particulate reinforced MMCs is mainly due to easy availability of particles and economic processing technique, adopted for producing the particulate reinforced MMCs.

The most conventional method of production of composites by casting route is vortex method, where the liquid aluminium containing 2-5% Mg is stir with an impeller and ceramic particles are incorporate into vortex formed by stirring of the liquid metals. Addition of Mg into the liquid metal reduces the surface tension [7] and there by avoids the rejection of the particles from the melts. Without addition of Mg recovery of the particles into the melt is quite low. Hence 2-5%

Mg is generally add to the Al melts before incorporation of the particles

Multi-stage heat treatment known as retrogression and re-ageing (RRA) is a process used to enhance the mechanical and corrosion resistance properties of aluminium. The RRA process was first developed by Cina and Gan and their results showed that 7xxx series of aluminium alloys are known to respond to retrogression and re-aging thermal treatments [1]. This paper presents preliminary findings on the influence of single aging and re-ageing called double ageing heat treatment on the tensile and hardness properties aluminium alloy 6061 hybrid composite.

MATERIALS USED

Matrix Material

Al 6061 alloy, which exhibits excellent casting properties with reasonable strength, was used as a matrix material. This is a popular aluminium alloy with good strength and is suitable for mass production of starting lightweight metal castings. The chemical composition of the Al 6061 alloy is shown in the Table-1.

White Mica of 200 microns was selected as particulate form reinforcement. E-Glass fibre of 2-3 mm length and 9μm in diameter is also considered as fibre reinforcing material. The chemical composition of the E-Glass fibre is given in the Table-2.

Mg	Si	Fe	Cu	Ti	Cr	Zn	Mn	Be	V	Al
0.92	0.76	0.28	0.22	0.10	0.07	0.06	0.04	0.003	0.01	Bal

Table-1 Chemical composition of Al 6061 by weight percentage.

SiO_{2e} % by wt	Al_2O_3 % by wt	CaO % by wt	MgO % by wt	B_2O_3 % by wt
54.3	15.2	17.2	0.6	8.0

Table-2 Chemical composition of E-Glass fibre by weight percentage.

EXPERIMENTAL WORK

Preparation of the composite

Al 6061 alloy was melted at 700°C, which is superheated by 100°C above the liquidus temperature of the matrix alloy. The vortex technique was adopted to fabricate the specimens in which a vortex was created in the melt of the matrix alloy using Al_2O_3 coated mechanical stirrer. The preheated Mica particulates and E-Glass fibers were introduced into the molten slurry.

A small amount of Mg, which improves the wetability of the reinforcements, was added together with reinforcing materials. Stirring was carried out continuously till the interface between the particles, fibers and the matrix promotes wetting and then finally poured into the metallic mould. 10 specimens of various compositions were produced as shown in table 3.

Heat-Treatment

The procedure for heat treatment involves the following steps

i) Solutionizing
ii) Quenching
iii) Two-step aging
   a) First step at lower temperature
   b) Second step at higher temperature

Solutionizing & Quenching

Solution treatment for 2 hrs, soaking temperature of 480 ±5°C was adopted followed by oil (SAE30/40) quench at room temperature was carried out. Figure.1 shows the heat treatment cycle.

Aging

Single aging: this step is carried out at a temperature of 120 ±5°C for a period of 16- 24 hrs.

Double aging: after the first step aging, second step aging is carried out at 170 ±5°C for period of 16-18 hrs.

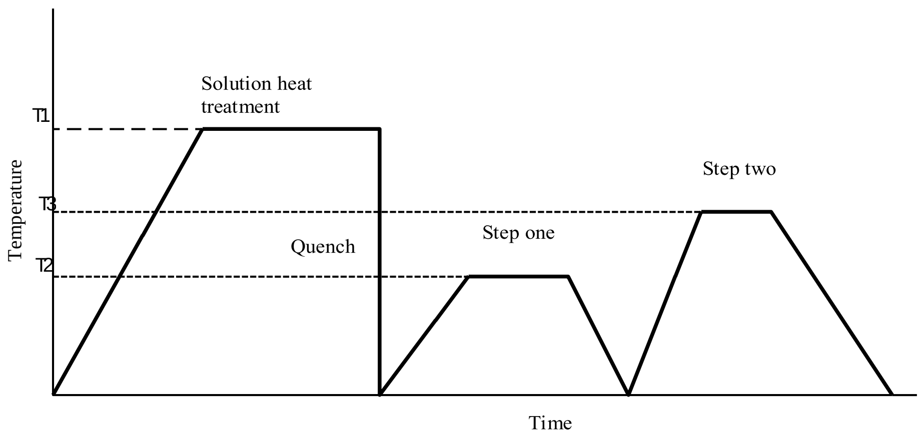


Fig. 1 Schematic representation of temperature Vs time plot showing both solution and precipitation heat treatments (artificial ageing).

RESULTS AND DISCUSSIONS

Microstructure analysis

Figure-2 shows typical microstructure of the Al 6061 Hybrid Composites containing 2% Mica and 2 % e-glass fiber. Micrograph clearly reveals minimal micro porosities in the casting. No clustering of reinforcements was observed in the matrix, and the dispersion of Mica particles and e-glass short fibers is seen to be almost uniform. Figure 3 shows there is good bonding between matrix material and the reinforcements. Also it is clearly evidenced that the particulates are concentrated in the boundary region which indicates good strength.

.Fig 2: Microstructure of 2wt% mica 2wt% e-glass fiber, Al6061 Composite specimen

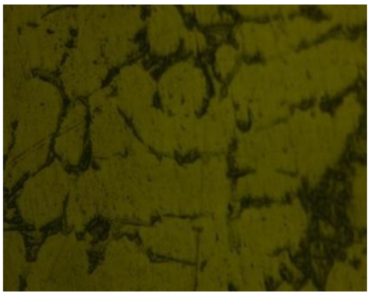


Fig 3: Grain boundary of the composite

Tensile test

Test specimens were prepared according to (ASTM 8) IS 1608-2005/ISO 6892-198 standards. The heat treated and aged specimen was loaded in Universal Testing Machine until the failure of the specimen occurs. Tests were conducted on composites of different combinations of reinforcing materials and ultimate tensile strength were measured. For conducting a standard tensile test, a specimen that has been measured for its cross-sectional area and gauge length is placed in the testing machine and the extensometer is attached. Simultaneous readings of load and elongation are taken at uniform intervals of load. Uniaxial tensile test is conducted on the fabricated specimen to obtain information regarding the behavior of a given material under gradually increasing stress strain conditions.

Specimens	% MICA	% E-GLASS	UTS (As-Cast)	UTS (Single Aged)	UTS (Double Aged)
A1	1	1	118.69	108.23	138.08
A2		2	120.12	112.24	137.02
A3		3	124.81	120.31	142.32
A4	2	1	130.28	129.62	148.58
A5		2	141.56	148.04	153.64
A6		3	143.02	150.23	156.41
A7	3	1	132.56	138.36	149.55
A8		2	134.03	141.28	150.24
A9		3	131.24	142.89	151.08
Plain	0	0	125.33	122.56	144.25

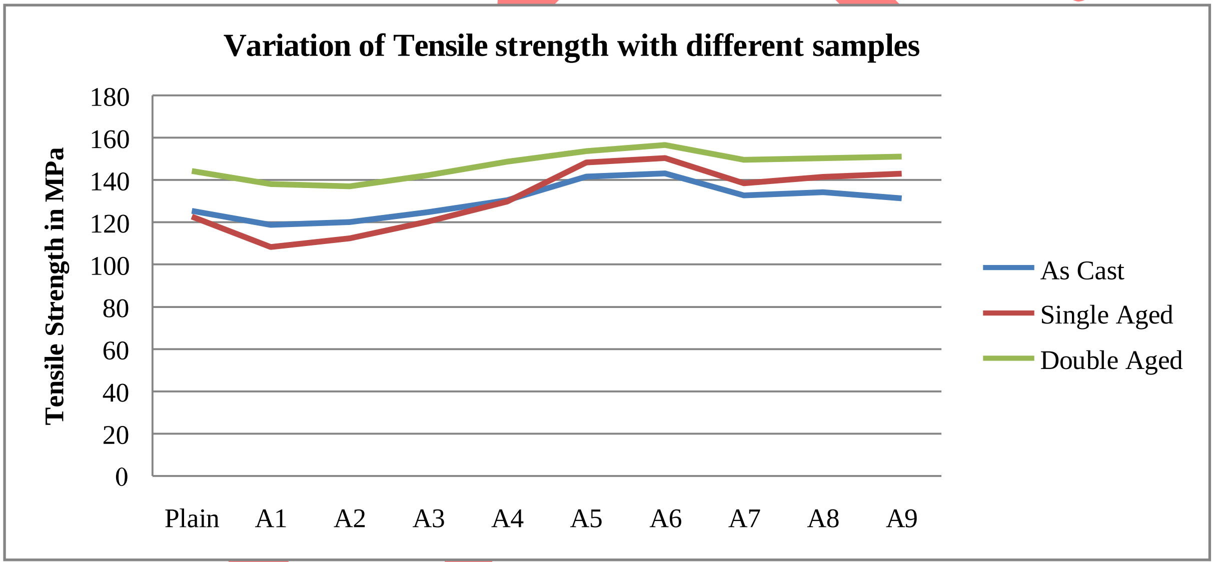
Hardness

Hardness test was carried out using Brinell hardness tester. Test specimens of 20 mm thickness were machined from as-cast, single aged and double aged of various compositions mentioned.

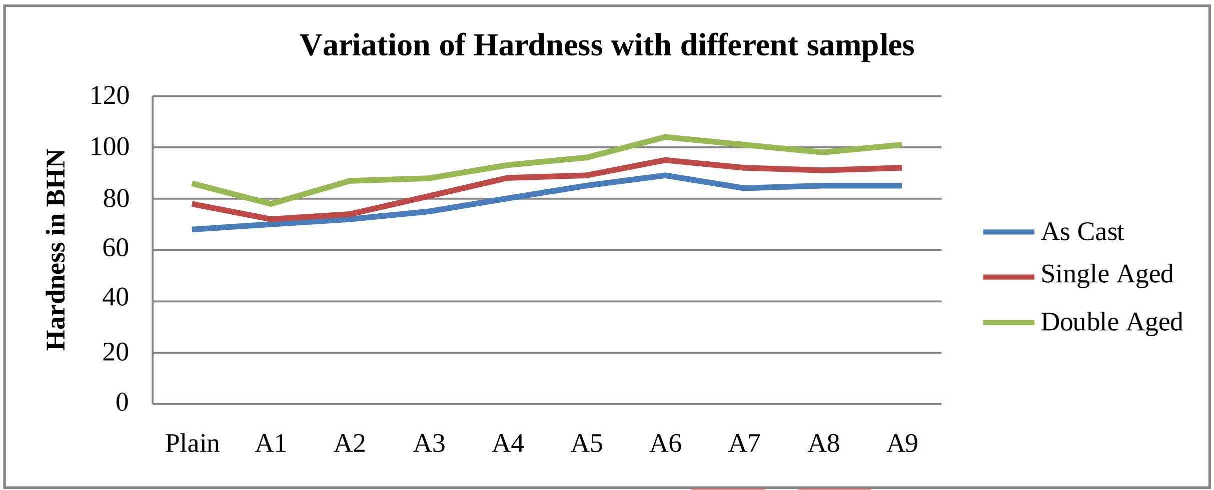
Steel ball of 2.5 mm diameter and 60 Kgf load was used.

Table 3. Hardness values in BHN for different composition

Specimens	% MICA	% E-GLASS	BHN (As-Cast)	BHN (Single Aged)	BHN (Double Aged)
A1	1	1	70.45	72.36	78.87
A2		2	72.23	74.54	87.77
A3		3	75.05	81.25	88.36
A4	2	1	80.54	88.32	93.57
A5		2	85.24	89.56	96.24
A6		3	89.32	95.22	104.08
A7	3	1	84.54	92.87	101.21
A8		2	85.29	91.26	98.34
A9		3	85.64	92.38	100.94
Plain	0	0	68.84	78.23	86.44



Graph 1. Shows Evaluation of Tensile strength for samples with various Compositions and aging conditions



Graph 2. Shows Evaluation of hardness for samples with various Compositions and aging conditions

CONCLUSION

Based on this study conducted on the mica, e-glass containing Al6061 composite material, with different *aging* conditions the following conclusions can be made

a) Using stir casting method, mica and e-glass fiber can be successfully introduced in the Al6061 alloy matrix to fabricate hybrid composite material.

b) From the microstructure analysis it is evident that the composites fabricated have fairly even distribution of reinforcements in the composite material;

c) The hardness of the specimens increased with increase in wt% of mica and e-glass content in the composite. This is due to the strengthening of Al6061 alloy matrix by the reinforcements.

d) It is also observed that tensile strength of the composite developed increased with increase in wt% of mica and e-glass content.

e) The results obtained clearly indicate that, the double aged specimens have better tensile strength and hardness compared to the as cast and single aged specimens.

f) It is evidenced that composites with 2% Mica and 2% E-glass has better tensile strength and hardness compared to other proportions.

REFERENCES

[1] B.M. Cina and R. Gan "Reducing the susceptibility of Alloys particularly Aluminium Alloys to Stress Corrosion Cracking", Israel Aircraft Industries Ltd, U.S. Patent 3856584, 1974-12-24

[2] H. Loffler and I. Kovacs and J. Lendvai, "Review: Decomposition processes in Al-Zn-Mg alloys", Journal of Materials Science,Volume 18, 1983, p2215-2240

[3] K.C. Danh et. al., " A TEM study of microstructural changes during RRA in 7075 aluminium alloy", Metallurgical Transactions A,1983, 14(9), p1843 – 1850.

[4] J. K. Park, A. J. Ardell, "Effect of Retrogression and Reaging treatments on the microstructure of Al-7075-T651" Metallurgical Transactions A, 15 A, 1984, p1531-1543

[5] L. K. Berg, J. Gjonnes, et. al., "GP Zones in Al-Zn-Mg alloys and their role in artificial aging", Acta Materialia, Volume 49, 2001,p3443-3451.

[6] Antonio B, "On the microstructural changes during the retrogression and re-aging of 7075 type aluminium alloys", Materials Science and Engineering, 72, 1985, p L5-L8.

[7] D.A. Koss, S.M. Coply. 1971. Metall. Trans. 24: 551.

[8] Alakesh Manna, B. Bhattacharayya. 2005. Influence of machining parameters on the machinability of particulate reinforced Al/SiC-MMC. Int J Adv Manuf Technol. 25: 850-856.

[9] M.T. Milan and P. 2004. Tensile and Fracture Toughness Properties of SiCp Reinforced Al Alloys: Effects of Particle Size, Particle Volume Fraction, and Matrix Strength. JMEPEG. 13: 775-783.

[10] R. Escalera-Lozano, C.A. Gutiérrez, M.A. Pech-Canul, M.I. Pech-Canul. 2006. Corrosion characteristics of hybrid Al/SiCp/$MgAl_2O_4$ composites fabricated with fly ash and recycled aluminum. Materials Characterization. 58(2007) 953-960.