

# Properties of Hybrid MMCs containing Al as base material and mixed with SiC and E-glass

Prashant Sharma

*Rajiv Gandhi University of Technology, Bhopal (M.P), India*

A. Paul

*Maulana Azad National Institute of Technology Bhopal, India*

**Abstract - Hybrid MMCs especially that containing aluminium form a very important part of property analysis in the field of material science as they have a wide range of applications mostly in the space industry. The study of corrosion is equally important as it is a subject extremely complex and difficult to analyze because of the large number of variables involved. Hence it is an almost necessary that engineer familiarizes the principles of corrosion. An engineer whose design must not only attain the strength required by a structure, but also should give a serious thought and prevent the deterioration of the metal or alloy or composites as a result of the material being exposed to the so causing environment.**

## I. INTRODUCTION

Aluminium based hybrid metal matrix composite containing silicon carbide and E-glass of fixed percentages by weight was prepared by liquid vortex method of casting.

Al 6061 is heated to its melting temperature and is maintained at that temperature.

The reinforcement namely silicon Carbide particulates and short E-glass fibers are added so as to obtain the required orientation. AL 6061 is varied as 86%, 90%, 94% and 98%. The silicon carbide particulates are varied as 2%, 4%, 6%, 8% and fiber as 0%, 2%, 4% and 6% respectively.

## II. THE CASTING PROCESS:

The furnace and crucible were cleaned properly. After ensuring the proper electric connection, the furnace was switched on. The temperature of the furnace was set to 120°C and maintained at the same temperature for 15 minutes time duration. This helps in drying the moisture content of the furnace.

The aluminium 6061 ingots, Silicon carbide powders, E-glass were weighed as per their percentage by weight in each of the four compositions required. The weighed aluminium 6061 ingots were placed in the fire clay crucibles. Using the electronic temperature controller the required temperature to be attained is set to 830°C. This was done to allow the metal to get superheated and melt totally (The melting point of aluminium is 660°C). The furnace lid was closed and sealed to make it airtight. Later the furnace was switched on and temperature was set to 800°C. Temperature was recorded from time to time using a calibrated chromel – alumel thermocouple with the help of partially integrated differential digital electronic temperature controller. The temperature was raised to 830°C and retained at that temperature for 15 minutes to aid complete melting.

Simultaneously the weighed E-glass and the silicon carbide power were preheated in the same muffle furnace. This was done to reduce the temperature gradient between the constituents of the composite during the temperature during the stirring process, which will reduce porosity, reduce the chilling effect due to addition of cold substances and give a better casting. The glass particles used in the present investigation were of spherical morphology.

Once the required temperature was attained the molten aluminium in the crucible was taken out and placed under the stirrer. The stirrer was rotated at a speed of 550 rpm and a vortex was created in the melt. The depth to which the impeller was immersed was approximately one third the height of the molten metal from the bottom of the crucible. Vortex on the surface of the melt allows for the better mixing of the glass fibers in molten Aluminium. The speed of the stirrer was regulated to 550 rps. Care should be taken not to increase the speed of the stirrer as in which case the lighter E-glass, due to the centrifugal effect may settle towards the center of the rotating mixture and result in an improperly mixed composite. The weighed amounts of silicon carbide and E-glass were added carefully to the molten aluminium while stirring.

The rate of addition of E-glass during stirring was optimized to around 50 grams per minute as to fast a rate led to segregation of the glass fibers in the composite. After a thorough stirring the mixture was replaced in the furnace to attain the required temperature after which it was again taken out, stirred and poured into the prepared dies.

The molten uniform composite is carefully poured into the assembled dies and allowed to solidify with the following precautions having been taken ;

1. The dies should be packed in a layer of sand thoroughly to aid the process of faster cooling and directional solidification.
2. There should be non-interrupted flow of molten mixture to prevent misruns of the mixture.
3. The dies should be properly clamped to prevent cold shuts.
4. The rate of pouring should be optimized to the shot metal defect wherein the cold mixture splashes and causes unnecessary ruptures and formation of scales.

Once the defect free casting of the composite is obtained it is sent for machining to process the casting into standard corrosion specimens.

### III. EXPERIMENTAL PROCEDURE

1. Preparation of the acidic solutions containing hydrochloric acid of different normalities.
2. Immersion of the corrosion specimens in the acidic solution for the required time.
3. Removal and cleaning of the corroded specimens.

$$\text{Corrosion Rate (C.R)} = \frac{534XW}{DXAT} \quad \text{mils per year}$$

Where

W = Weight loss due to corrosion in the static immersion corrosion test in grams.

If W1 = Weight of the specimen before the conduction of the test.

W2 = Weight in grams after the conduction of the test, then

W= (W1-W2) in grams

D= Density of the composite in g/cm

= (% Al \* DensityAl + % SiC \* Density Sic+ % E-Glass \* Density E-Glass )

Where Density = 2.8 g/cc.

Table 1: Corrosion Rates of composite containing 98% Al 6061, 2% SiC, 0%E-Glass

SL.NO	Time in hours	Normality	W1 g	W2 g	W g	Corrosion Rate Mpy
1	96	1	8.8065	6.2394	2.5671	2620.13
2	72	1	8.4548	5.8418	2.613	3555.95
3	48	1	8.4671	5.9439	2.5232	5150.62
4	24	1	8.7376	6.2718	2.4658	10066.9
5	96	0.75	8.8834	6.6984	2.185	2230.14
6	72	0.75	8.874	6.7968	2.0772	2868.8
7	48	0.75	8.9158	6.8286	2.0872	4260.61
8	24	0.75	8.7957	7.2037	1.592	6499.52
9	96	0.5	8.789	7.0792	1.7098	1745.12
10	72	0.5	8.7	6.594	2.106	2865.99
11	48	0.5	9.0069	7.1348	1.8721	3821.53
12	24	0.5	8.7313	7.2423	1.489	6079.01
13	96	0.25	8.3042	7.156	1.1482	1171.92
14	72	0.25	8.8888	7.9051	0.9837	1338.69
15	48	0.25	8.3615	7.3023	1.0592	2162.15
16	24	0.25	8.4656	8.2016	0.264	1077.81

Table 2: Corrosion Rates of composite 94% Al 6061, 4% SiC, 2% E-Glass

Sl.No.	Time in hour	Normality	W1 g	W2 g	W g	Corrosion Rate Mpy
1	96	1	8.3311	5.6635	2.6676	2728.15
2	72	1	8.4905	5.8781	2.6124	3562.27
3	48	1	9.0028	6.3012	2.7016	5525.85
4	24	1	8.2407	5.4685	2.7722	11340.51
5	96	0.75	8.1	5.6316	2.4684	2524.43
6	72	0.75	9.0375	6.3738	2.6637	3632.22
7	48	0.75	8.4145	5.9347	2.4798	5072.18
8	24	0.75	8.664	6.6447	2.0143	8158.28
9	96	0.5	8.3947	6.4249	1.9698	2 014.51
10	72	0.5	8.2408	6.4277	1.8131	2472.34
11	48	0.5	8.5373	6.6961	1.8412	3765.99
12	24	0.5	8.2878	7.1609	1.1269	4609.92
13	96	0.25	8.9868	7.82	1.1668	1193.29
14	72	0.25	8.8143	7.8415	0.9728	1326.51
15	48	0.25	8.9095	7.9168	0.9927	2030.47
16	24	0.25	8.7479	8.3922	0.3557	1455.097

Table 3: Corrosion Rates of composite containing 90% Al 6061, 6% SiC, 4% E-Glass.

Sl.No.	Time in hour	Normality	W1g	W2g	Wg	Corrosion Rate Mpy	
1	96	1	9.0031		6.3733	2.6298	2694.899
2	72	1	8.3792		5.8805	2.4987	3414.07
3	48	1	8.7795		6.26	2.5195	5163.74
4	24	1	8.916		6.5551	2.3609	9677.37
5	96	0.75	8.9094		6.6608	2.2486	2304.26
6	72	0.75	8.8774		6.7275	2.1499	2937.5
7	48	0.75	9.0461		6.9579	2.0882	4279.78
8	24	0.75	8.6402		6.8469	1.7933	7350.77
9	96	0.5	8.7444		6.9433	1.8011	1845.69
10	72	0.5	8.8741		7.1698	1.7043	2328.65
11	48	0.5	8.3249		6.7621	1.5628	3202.97
12	24	0.5	8.6618		7.3206	1.3412	5497.6
13	96	0.25	8.5142		7.5307	0.9835	1007.85
14	72	0.25	8.961		8.0315	0.9295	1270.85
15	48	0.25	8.7447		7.7784	0.9663	1980.44
16	24	0.25	8.4125		8.1128	0.2997	1228.48

Table 4: Corrosion Rates of composite containing 86% Al 6061, 8% SiC, 6% E-Glass.

Sl.No.	Time in hour	Normality	W1g	W2g	Wg	Corrosion Rate Mpy	
1	96	1	8.722		6.0231	2.6989	2771.28
2	72	1	8.2206		5.6613	2.5593	3503.91
3	48	1	8.1725		5.5625	2.61	5359.99
4	24	1	8.4606		6.0074	2.4532	10075.96
5	96	0.75	8.5447		6.1292	2.4155	2480.28
6	72	0.75	8.0667		5.7668	2.2999	3148.28
7	48	0.75	8.1272		6.029	2.0982	4308.94
8	24	0.75	8.4261		6.571	1.8551	7619.399
9	96	0.5	8.1626		6.2971	1.8655	1915.53
10	72	0.5	8.4059		6.6643	1.7416	2384.41
11	48	0.5	8.5444		6.9008	1.6436	3375.36
12	24	0.5	8.2051		6.7718	1.4333	5886.95
13	96	0.25	8.1748		7.1179	1.0569	1085.24
14	72	0.25	8.1761		7.304	0.8721	1193.98
15	48	0.25	8.2939		7.4202	0.8737	1794.262
16	24	0.25	7.995		7.4598	0.5352	2198.21

## IV. CONCLUSION

From the figures obtained the following preliminary observations were made.

1. The corrosion rate followed a geometrical curve of an exponential nature.
2. The corrosion rate decreased exponentially in the following 2 cases.
  - (a) Decrease in the normality of the acidic aqueous medium
  - (b) An increase in the content of E-glass and silicon carbide as percentages by weight in the composition of the composite.

[1] The slope of the curve decreased and became unpredictable as the normality of the solution decreased.

Localized corrosion processes play a major role in the corrosion performances of MMCs. An improved understanding of these processes as they relate to materials selection, fabrication and processing various means of incorporating corrosion control into the design of these materials and would render them more viable to technological applications. Specific recommendations and critical areas of investigations are listed below.

1. Improved bonding techniques
2. Selection of metal host that are resistant to crevice and pitting attack.
3. Limitation of the number of metal-metal, reinforcement-reinforcement, metal-reinforcement bonding interfaces.
4. Reduction in the volume of reinforcement to prevent galvanic corrosion rates.
5. Selection or modification of components to minimize the electrochemical potential differences.
6. Modification of components to reduce galvanic corrosion rates.
7. Development of alternative processing and heat treatment to produce pit resistant microstructures.

## REFERENCES

- [1] D.M. Aylor, AND R.M. Kaln, "recent advances in the united states and japan, ASTM special technical publication 864," ed.j.Vinson and m. TAYA.
- [2] D.M. Aylor, DTNSRDC report no.SME 86-71, (Bethesda,MD: David Taylor Naval Ship research and development center, 1986).
- [3] M.C. Porter and E.G. Wolff, "advances in structural composites," (paper on.AC-14 presented at the society of aerospace materials process engineering, 12 national symposium exhibit,western period co. north Hollywood, California, 1967).
- [4] D.L. dull, w.c.harrigan jr.,and m.f. amateau, in "proceedings of the1964 triservice corrosion of military equipment conference, "vol 1,ed.F.h. meyer,(Dayton, oh: Alr force materials laboratory report AMFL- TR-75-42, 1975),248.
- [5] J.H payer and P.G.sullivan, "Bicentinnial of materials", national SAMPE technical conference series, volume 8(Azusa California: Society for the advancement of materials and processes engineering, 1976).
- [6] C.R. Crowe,"Localised currents from grapite/aluminium and welded SiC/AL metal matrix composites," NRL report 5415, Washington, D.C. Naval Reasearch Laboratory, 1985). P.P. Trzaskoma, corrosion, 42 (1986). P.P Trzaskoma, J.Electrochem.Soc(1982).
- [7] H.H.Uhlig,"Corrosion and corrosion control," second edition.1971.
- [8] P.P. Trzaskoma."The corrosion behavior of a graphite Fiber/Magnesium metal matrix composite in aqueous chloride solution" (paper presented at the 168 meeting of the electrochemical society. Las Vegas, Nevada, Oct 1985).Z.Szklarska-Smialowrka,"Pittin corrosion of metals,"(Houston 1986).
- [9] P.P.Trzaskoma, E.Mcafferty and C.R.Crowe J.Electrochem. Soc (1983).
- [10] K.D. Lore and J.S. Wolf, abstract 154, The electro chemical society extended abstracts vol 81, The electro chemical society Denver, Colorado meeting Oct 1981.
- [11] P.P.Teaskome, Corrosion (1990).
- [12] P.P. Trzaskome,abstract 257, The electro chemical society extended abstracts, vol86, San Diego,California meeting Oct 1986.
- [13] R.C.Paciej and V.S. Agarwala, Corrosion (1986).
- [14] Patricia Traskome, Naval research laboratory.
- [15] H.Osono, k.Matsusaka and T.kino: proceedings of the fifth international conference on ultra high purity metar ashimmoto Y.ueda Mater. Trans JIM, 35(1994),262-265.