Investigation of Al 5383 Composite with Lithium and Alkali Resistant Glass Fiber for Ship Building Materials

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ABSTRACT

Aluminum alloys are widely used in aerospace, defense, automobiles and marine industries. In marine industries the demand for materials goes on increasing due to the service life of materials. Normally ocean water has more salt content, which easily corrosion takes place, so to prevent this Glass Reinforced Plastics are used, which have high corrosion resistance. In this paper Aluminum 5383 alloy is selected based on the wrought alloy type which is having improved corrosion resistance with increased fatigue strength. In addition to this Aluminium 5383 have high ductile and malleable properties hence composite of aluminium 5383 alloy is made with lithium and glass fiber. As, when every 1% of lithium is mixed with Aluminium 5383 alloy it get reduce 3% of its weight. In this paper Glass reinforced plastics are added as mixture with aluminium 5383 alloy and by adding lithium which increase corrosion resistance for cargo ship building applications. Since the AMMCs material reduces the weight of the ship since the efficiency of the engine may increases. Hence to reduce the weight, aluminium is added with 2.5% of lithium. Finally testing were carried out and when glass fibre is mixed with aluminium 5383 alloy it gives better corrosion resistance compared to bar aluminium.

KEY WORDS: Aluminum 5383 Alloy, Lithium Glass reinforced plastics, Cargo Ship Building.

1. INTRODUCTION

Aluminum 5383 alloy is a versatile engineering material that has a high global market. Aluminium alloys are widely used in building and architecture, packaging, transport, and electrical conductors. Aluminium 5383 is a wrought alloy, which has high fatigue strength, more weldability and formability is easy using in conventional method. The major contents are Aluminium have 91.9% to 95.3%, Magnesium have 4 to 5.3%, Manganese have 0.7% to 1%, then Zinc have ≤ 0.40% , Silicon have ≤ 0.25%, Iron have ≤0.25%, Chromium have ≤0.25%, copper have ≤ 0.20%, zirconium have ≤0.20%, titanium have ≤ 0.15% , remainder less than 0.05% percentage

Table.1. Chemical composition for aluminium5383 alloy

Element	Content (%)
Aluminium, Al	91.9 - 95.3
Magnesium, Mg	4- 5.2
Manganese, Mn	0.70 – 1
Zinc, Zn	≤ 0.40
Silicon, Si	≤ 0.25
Iron, Fe	≤ 0.25
Chromium, Cr	≤ 0.25
Copper, Cu	≤ 0.20
Zirconium, Zr	≤ 0.20
Titanium, Ti	≤ 0.15
Remainder (each)	≤ 0.050
Remainder (total)	≤ 0.15

Table.2. Physical Properties for Aluminium5383 alloy.

Properties	Metric	Imperial
Density	2.66 g/cm³	0.0961 lb/in³
Melting point	585 - 641°C	1090 - 1190°F

Table.3. Mechanical properties for Aluminum 5383 alloy

Properties	Metric	Imperial
Tensile strength	305 MPa	44200 psi
Yield strength	220 MPa	31900 psi
Elongation at break	10%	10%
Shear modulus	26.4 GPa	3830 ksi
Poisson's ratio	0.33	0.33

Table.4. Thermal properties for Aluminium5383 alloy

Properties	Metric	Imperial
Thermal expansion co-efficient 20-100°C	23.8 µm/m°C	13.2 µin/in°F
Thermal conductivity	117 W/mK	812BTU in/hr.ft².°F

2. MATERIAL SELECTION

Lithium: Lithium is a chemical element, which belongs to alkali group; it is soft-sliver white metal. Lithium have high strength-to-weight alloys, it is the lightest metal and have least dense solid element. When 1% lithium is added to another material the composite of weight will be reduced to 3%.

Alkali Resistant Glass Fibre: Alkali Resistant (AR) Glass fibres are manufactured from a specially formulated glass composition with an optimal percentage of Zirconium (ZrO2) prepared as per ASTM standard. Where us alkali resistance of glass fiber appears in white of off-white. The density of alkali resistant glass fiber (ARGF) is 2.6 kg/ $m^{3.}$ The electrical conductivity is very low but chemical resistance is very high.

Alkali resistant glass fiber has excellent workability, compatibility, Improves freeze/thaw resistance and uniform dispersion. Where the Modulus of elasticity is 72 GPa (10 x 106 psi) and Tensile Strength is 1,000 to 1,700 MPa (150 to 250 x 10^3 psi).

Appearance : White or off-white
Physical State : Solid
Softening point : 860°C (1580°F)
Melting point : non applicable
Decomposition temperature : size and mat binders start to decompose at 200°C
Density : 2.6 (water = 1)
Water solubility : insoluble

Stir Casting:

Operating Voltage : 400/440V,
Maximum Temperature : 900°C
Skin Temperature : Up to 75°C
Dimension of Retort : 100 mm x 300 mm (ID x Depth)
Retort : Stainless steel AISI 310
3Phase and AC 50 Hz 28 Pouring : Motorized –Automatic
Capacity : 2 Kg

Figure.1. Molding Cavity

Testing:

Brinell hardness Test: Brinell hardness test machine consist of indenting with a diameter of 10mm hardness steel by using carbide ball load is applied at 3000kg. The load can be varied from 1500 kg or 500 kg for soften mat

Specimen : Aluminium5383
Load (p) Kg F : 187.5
Diameter of Impression (d) : 1.4mm
Area (A) : 16 mm^2
Brinell hardness number : 110 kg/mm^2
Specimen : Al5383+Li+ARGF
Load (p) Kg F : 187.5
Diameter of Impression (d) : 1.4mm
Area (A) : 16 mm^2
Brinell hardness number : 111.357 kg/mm

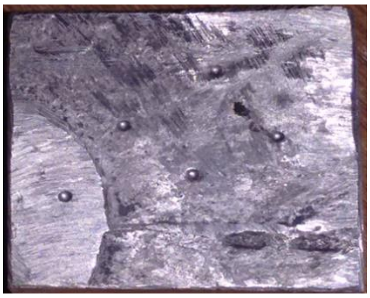

Figure.2. After Brinell hardness and Rockwell Hardness Test

Rockwell Hardness: Initially test load range from 3 kgf to 10kgf measured by using "superficial" Rockwell scale where the specimen is prepared as per ASTM standard

Table.5. Rockwell Hardness Test Result

Specimen	Load	Indenter	Hardness
Aluminium5383	100	Ball and 1/16inch	20
Al5383+ Li +ARGF	100	Ball and 1/16inch	22.5

Double Shear Test: Shear Strength is defined as the maximum load typically applied normal to a fastener's axis that can be supported prior to fracture. Ultimate shear strength = Ultimate load / 2*cross sectional area

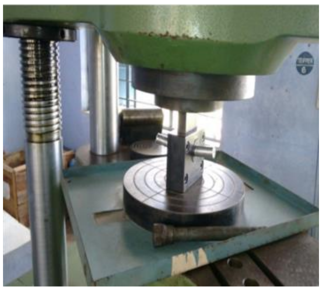

Figure.3. Double shear Stress

Charpy Impact Test: Impact tests are designed to measure the resistance to failure of a material to a suddenly applied force

Specimen : Aluminium 5383+ lithium+ ARGF
Width (mm) :10
Depth (mm){below notch} : 6
Area (mm^2) : 60
Frictional Energy (J) : 6
Energy spent in Breaking : 10
Energy Absorbed by Specimen (J) : 4

Calculation:

Load at failure (W) :75.08 N
Diameter of rod (d) :20mm
Cross sectional area of the rod (A) :314mm^2
Ultimate Double shear stress (Z) : W/2A N/mm^2
Z : (75.08) / (2*314)
Z : 0.1195 N/mm^2

Result: Ultimate Double shear stress (Z) = 0.1195 N/mm^2

Corrosion Test: Nacl corrosion test for composites:

Preparation: Initially 10gm of Nacl diluted with 190ml of pure water. The totally percentage of Nacl is 5%, which is diluted in 95% of composites of aluminium5383 alloy and lithium and alkali resistance glass fiber. Then the test piece is immersed in the salt water of a one day observation. Initially calculated the initial weight of composite and after one day calculate the final weight of an composite material. This enhances to calculate entire weight loss percentage.

Observation:

Nacl-5%, 10gm for 200ml test
Pure water -95%, 19mlfor 200ml test
Initial weight of specimen=25.980gm
Final weight of specimen=25.980gm
Observation time=20 hrs

Formula: Weight loss percentage = [(Initial weight - Final Weight) / initial weight]*100

Calculation:

Weight loss percentage = [(25.980-25.980)/25.980]*100

Weight loss percentage =0%

Result: Weight loss percentage=4.908%.

Hcl corrosion test for composite material: Initially 8.5ml of Hcl is diluted with 191.5ml of pure water. The totally percentage of Hcl is 0.5M concentration, which is diluted in pure water of composites of aluminium5383 alloy and lithium and alkali resistance glass fiber.

Then the test piece is immersed in the salt water of a one day observation. Initially calculate the initial weight of composite and after one day calculates the final weight of a composite material, where we can calculate the total weight loss percentage.

Figure.4. Corrosion Test in Nacl and Hcl

Observation:

HCl	: 0.5, 8.5ml for 200ml test
Pure water	: 191.5mlfor200ml test
Initial weight of specimen	: 25.670g
Final weight of specimen	: 24.41g
Observation time	: 20hrs

Formula: Weight loss percentage = [(Initial weight - Final Weight) / initial weight]*100

Calculation:

Weight loss percentage	= [(25.670-24.41)/25.670]*100
Weight loss percentage	=4.908%
Result: Weight loss percentage	=4.908%.

3. CONCLUSION

Thus 1.8% of lithium when mixed with 97.5% of aluminium5383 alloy-h116 grade and added with 0.7% of alkali resistance glass fiber is successfully fabricated by using stir casting method. Brinell hardness test gives value of 111.06004 kg/mm² of hardness where Rockwell hardness test gives 22.5HRB. Double shear stress test was made in which load failure take place at 75.80N.

When corrosion test was done using 5% of Nacl in an observation of 20hours, there is no observation of weight loss occurred. Finally when every 1% of lithium is added with a material, its total weight gets reduced by 3%. When an AR-Glass fibre is mixed with aluminium 5383 alloy to increases the corrosion resistance compare to bare aluminium.

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