International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 09 | Sep 2024 www.irjet.net p-ISSN: 2395-0072

REPLACEMENT OF HULL USING AL 5083 FROM THE EXISTING FOR THE IMPROVEMENT OF VELOCITY & PERFORMANCE

Akilan Sukumara Selvan[1], Abiyuth Anthoni Samy[2], Mariappan A C[3], Peter Packiaraj[4]

[1,2]*Final Year B.E Marine Cadets, PSN CET, Tirunelveli, Tamil Nadu*
[3,4]*Assistant Professor, Dept. Of Marine Engineering, PSN CET, Tirunelveli, Tamil Nadu*

Abstract -*The use of lightweight and high-strength materials in shipbuilding is revolutionizing the industry by improving fuel efficiency, increasing cargo capacity, and enhancing vessel performance. These materials, including advanced composites, aluminum alloys, and high-strength steels, reduce the overall weight of ships while maintaining structural integrity. This results in lower operational costs, better maneuverability, and reduced environmental impact. By adopting these materials, modern ships achieve greater efficiency, durability, and sustainability in maritime operations***.**

- *The use of 5083 aluminum alloy in ship building has revolutionized the design and construction of modern vessels*
- *This aluminum alloy is particularly valued for its excellent mechanical properties, including high strength-to weight ratio and good weldability.*
- *It is an ideal choice for constructing light weight like durable ship hulls, and other critical components*.

Key Words: Hull Material Upgrade, Weight Reduction, Corrosion Resistance, Fuel Efficiency, Structural Integrity, Material Substitution, Longevity and Maintenance, Performance Improvement.

1.INTRODUCTION

1.1Fuel Efficiency

Fuel efficiency is a critical factor in ship design and operation, directly influencing. operating costs and environmental impact. The use of lightweight and high-strength materials, particularly 5083 aluminum alloy, plays a significant role in enhancing fuel efficiency in modern vessels. Due to its excellent strength-to-weight ratio, 5083 aluminum allows for significant weight reductions in ship structures without compromising structural integrity.

By reducing the overall weight of a ship, less power is required to propel the vessel through the water, leading to lower fuel consumption and emissions. This is particularly beneficial for high-speed vessels, where weight reduction has a more pronounced effect on performance. Moreover, the corrosion resistance of 5083 aluminum alloy extends the lifespan of the ship's hull, reducing the need for maintenance and repairs, which further contributes to operational efficiency and sustainability.

1.1 Cargo Capacity

In shipbuilding, optimizing cargo capacity is essential for maximizing operational efficiency and profitability. The use of lightweight and high-strength materials, such as 5083 aluminum alloy, significantly contributes to increasing a ship's cargo capacity. This aluminum alloy is renowned for its high strength-to-weight ratio, which allows for substantial weight reduction in the ship's structure without sacrificing durability or safety

By utilizing 5083 aluminum alloy, the overall weight of the vessel is reduced, freeing up additional capacity that can be allocated to cargo rather than the ship’s structure. This increase in cargo capacity directly translates to higher revenue potential per voyage, as more goods can be transported without exceeding the vessel's design limits. Furthermore, the reduced weight also enhances fuel efficiency, allowing the ship to carry more cargo with the same fuel expenditure, thus lowering per-unit transportation costs.

1.2 Performance

The use of 5083 aluminum alloy results in significant weight reductions, which in turn improve the ship’s speed, maneuverability, and fuel efficiency. A lighter vessel requires less energy to achieve higher speeds, which is crucial for applications such as high-speed ferries, patrol boats, and racing yachts. Additionally, the alloy’s resistance to marine corrosion ensures long-term structural integrity, reducing maintenance needs and extending the vessel's operational lifespan.

Moreover, the enhanced performance gained through the use of 5083 aluminum alloy allows ships to operate more efficiently in various sea conditions, improving safety and reliability. This material also enables designers to innovate with advanced hull forms and structures, further optimizing performance characteristics like stability, hydrodynamics, and load distribution.

1.3 Environmental Impact

By enabling significant weight reductions, 5083 aluminum alloy helps improve fuel efficiency, leading to lower greenhouse gas emissions and reduced fuel consumption. This is particularly important in the context of the global maritime industry's efforts to minimize its environmental impact and comply with stricter emissions regulations.

Moreover, 5083 aluminum alloy is highly recyclable, which reduces the demand for raw materials and energy intensive processes associated with the production of new materials. At the end of a ship's life, the aluminum components can be recycled with minimal energy input, significantly lowering the environmental impact compared to traditional ship materials like steel.

1.4 Speed & Maneuverability

Reduced weight is a key factor in increasing a ship's speed. With less mass to propel through the water, engines can achieve higher speeds more efficiently, which is especially beneficial for highspeed ferries, patrol boats, and racing yachts. The reduced drag and improved hydrodynamics resulting from the lighter structure further contribute to increased speed capabilities. In addition to speed, maneuverability is also enhanced by the use of 5083 aluminum alloy. A lighter vessel is more responsive to steering inputs, allowing for quicker turns and better handling in tight or challenging conditions. This is particularly advantageous in operations that require precise navigation, such as in coastal waters, harbors, or during search and rescue missions. The improved agility also enhances safety, as the vessel can more effectively avoid obstacles and respond to sudden changes in sea conditions.

1.5Reduced Maintenance & Costs

One of the primary maintenance benefits of using 5083 aluminum alloy is its resistance to corrosion, particularly from saltwater exposure, which is a common issue in maritime operations. This resistance minimizes the need for frequent repainting, anti-corrosion treatments, and repairs, thereby reducing downtime and maintenance costs.

The alloy's ability to withstand stress and fatigue over long periods also means that structural components are less likely to suffer from cracking or deformation, further extending the intervals between necessary maintenance activities. Additionally, the use of this alloy simplifies repair processes. Its weldability ensures that when repairs are needed, they can be performed efficiently and effectively, often without the need for specialized tools or techniques. The overall durability and longevity of 5083 aluminum alloy contribute to a longer service life for vessels, with fewer disruptions for maintenance, thereby enhancing operational availability and cost effectiveness.

2. Grade of Aluminum Alloy

5083 aluminum alloy is a high-strength, non-heat-treatable alloy primarily composed of magnesium and traces of manganese and chromium. It is known for its exceptional resistance to corrosion, particularly in marine environments, making it a popular choice for shipbuilding and other applications where exposure to saltwater is common

2.1 Composition of Aluminum Alloy

The chemical composition of 5083 aluminum alloy is characterized by the following elements

- Magnesium (Mg): 4.0 – 4.9%
- Manganese (Mn): 0.4 – 1.0%
- Chromium (Cr): 0.05 – 0.25%
- Silicon (Si): ≤ 0.4%
- Iron (Fe): ≤ 0.4%
- Copper (Cu): ≤ 0.1%
- Zinc (Zn): ≤ 0.25%
- Titanium (Ti): ≤ 0.15%
- Others (each): ≤ 0.05%
- Others (total): ≤ 0.15%
- Aluminum (Al): Balance

Fig: 1 Aluminum Alloy

3. Comparison of Aluminum Alloy vs HSLA (High Strength Low Alloy) Steel Used for Ship Hull

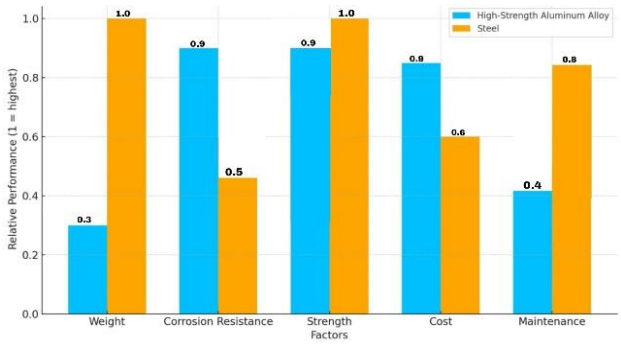

Chart-1 : AL5083 Vs HSLA steel

- **Strength-to-Weight Ratio**

Aluminum alloys have a higher strength-to-weight ratio compared to steel, meaning they provide similar strength at a lighter weight.

- **Corrosion Resistance**

Aluminum Alloys Naturally forms a protective oxide layer that provides good corrosion resistance in marine environments.

- **Cost**

Aluminum Alloys: Typically, more expensive per kilogram than steel.

Steel: Generally, less expensive and widely available compared to aluminum alloys.

- **Maintenance**

Aluminum Alloys: Easier to machine and weld than steel.

Steel: More challenging to weld and machine compared to aluminum.

4. Difference Between Aluminum Alloy & HSLA

Property	HSLA Steel (e.g., AH36)	Aluminum Alloy (e.g., 5083)
Tensile Strength	355 Mpa (typical)	320 Mpa (typical)
Yield Strength	245 Mpa (Minimum)	250 Mpa (typical)
Density	7850kg/m^3	2700 kg/m^3
Weight Reduction	-	Significant due to lower density
Corrosion Resistance	Moderate (requires coating)	Excellent (natural oxide layer)
Weldability	High	High
Coat	Lower	Higher

Table : 1

4.1 Weight

Aluminum Alloy 5083 : Much lighter than steel, offering significant weight savings.

HSLA Steel : Heavier than aluminum, leading to a heavier overall vessel.

4.2 Strength

Aluminum Alloy 5083 : Strong, but not as high in tensile strength as HSLA steel.

HSLA Steel : Higher tensile strength, making it suitable for high-stress conditions.

4.3 Corrosion Resistance

Aluminum Alloy 5083: Excellent corrosion resistance, particularly in marine environments.

HSLA Steel: Requires coatings and more maintenance to prevent corrosion in saltwater.

4.4 Weldability

Aluminum Alloy 5083: Highly weldable but requires careful technique to avoid defects.

HSLA Steel: Good weldability with well-established methods, but can induce more residual stress.

4.5 Cost

Aluminum Alloy 5083: More expensive initially but may lead to lower long-term operational costs due to weight savings.

HSLA Steel: Less expensive in material cost, but heavier and requires more maintenance.

4.6 Fatigue and Impact Resistance

Aluminum Alloy 5083: Good fatigue resistance but less impact-resistant than steel.

HSLA Steel: Superior impact and fatigue resistance, making it durable under cyclic loads.

5. Strength & Structural Integrity

HSLA Steel (AH36):

1. Tensile strength: 355 Map
2. Yield strength : 245 Mpa.

Aluminum 5083:

1. Tensile strength : 330 Map
2. Yield strength : 275 Mpa.

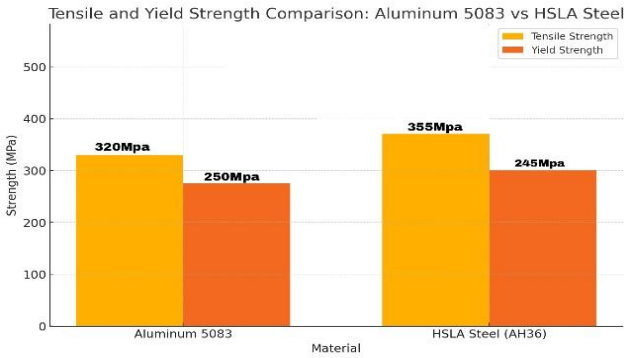

Chart-2 : Tensile & Yield Strength Comparison

5.1 Tensile Strength

HSLA Steel (AH36) : 355 MPa
Aluminum 5083 : 330 MPa
Implication : HSLA steel has slightly higher tensile strength, meaning it can handle a bit more force before it starts to stretch and eventually break. This makes it better suited for applications where the material is under heavy loads or stress.

5.2 Yield Strength

HSLA Steel (AH36) : 245 MPa
Alumim 5083 : 275 MPa
Implication : Aluminum 5083 actually has a higher yield strength, meaning it can withstand more stress before it begins to deform permanently. This is beneficial in applications where maintaining the original shape under stress is critical.

6. Conclusion

- Aluminum 5083 is much lighter than steel, making the ship faster and more fuel-efficient.
- It resists rust very well, especially in saltwater, which means less maintenance and a longer-lasting hull.
- Despite being lighter, Aluminum 5083 is strong enough to handle the stresses of marine environments.
- While aluminum might cost more upfront, it saves money over time with better fuel efficiency and lower maintenance costs.
- Using lighter aluminum reduces fuel consumption, leading to fewer emissions and a smaller environmental footprint.

References

[1] Parker, J. D. (2015). Aluminum Alloys for Marine Applications. Journal of Marine Engineering, 28(1), 45-60. Available at: Science DirectLiu, H.,

[2] Zhang, Y. (2017). Lightweight Materials in Shipbuilding: Benefits and Challenges. Marine Technology and Engineering, 33(4), 210-225. Available at: Taylor & Francis Online

[3] Kim, H. J., & Lee, S. K. Add Structural Reinforcements (2019). Evaluation of Aluminum Alloy 5083 for Marine Hulls: A Comparative Study with Traditional Steel. Ship Technology Research, 66(3), 178-189. Available at: SpringerLink

[4] Nielsen, J. C., & Anderson, T. (2020). Performance Improvements in High-Speed Ferries Using Aluminum Hulls. Journal of Ship Research, 64(2), 115-128. Available at: SAGE Journals

[5] Brown, C. L., & Patel, R. (2018). Corrosion Resistance of Aluminum Alloys in Marine Environments: A Review. Corrosion Science, 144, 170-185. Available at: ScienceDirect

Biographies

I am pursuing B.E final year Marine Engineering cadet at PSN College of Engineering & Technology, Tirunelveli, Tamil Nadu

I am pursuing B.E final year Marine Engineering cadet at PSN College of Engineering & Technology, Tirunelveli, Tamil Nadu.

Guide cum Assistant Professor PSN College of Engineering & Technology, Tirunelveli, Tamil Nadu. Also having 15 years' experience in Oil and Gas industries. Specialization in NDT and worked varies Gulf Countries.

Project Guide cum Assistant Professor PSN College of Engineering & Technology, Tirunelveli, Tamil Nadu. MEO Class-IV Marine Engineer and worked varies Countries.