

Influence of Implementation of Composite Materials in Maritime Industry on CO₂ Emission's Reduction

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Abstract

The future of the composites market looks attractive with opportunities in the transportation, construction, wind energy, pipe & tank, marine, consumer goods, electrical and electronics, aerospace, and others. The composite materials market is expected to reach an estimated \$40.2 billion by 2024 and it is forecast to grow at a CAGR of 3.3% from 2019 to 2024. The composite materials that have started to be used in the production of tourist boats, especially those of the yacht type, have proved in practice the designers' expectations for the great advantages they have brought compared to steel. The performance of the new generation ships of this millennium, will require the ever-increasing use of new and innovative materials, to meet the also growing demands of potential buyers of these vehicles. On the other hand, based on the already sanctioned principles of the European Community for the observance of the norms set for CO₂ emissions from maritime transport - (Green shipping) in respect of the Kyoto Protocol on Climate Change, it becomes more necessary to produce marine vehicles that significantly reduce the weight of marine vessels, consequently engine power and fuel consumption by significantly reducing CO₂ emissions. This study aims to bring a specific analysis of the impact of composite materials to the CO₂ emission's reduction.

Keywords: composite materials and composite market, performance of marine vessels, climate change, CO₂ emission's reduction, software simulation.

Introduction

As an incentive for this article, was the study carried out by the I Care Consulting Company in collaboration with the partners of the PASSAGE Project - Interreg Europe Program on CO₂ Emissions in the European Maritime Strait, including the Otranto Strait.

This study identified the source of CO₂ contamination by Otranto, considering several factors: economic activity, maritime transport, inland transport, and human activity.

Straits have unique geographies, and are characterised by diversified and specific economic activities, including transportation, industrial activities, tourism, services, and manufacturing. Straits are important centres of communication, commerce, and culture.

Straits include cities with an important population living on coastlines, and thus particularly vulnerable to global environmental change, such as rising sea levels and coastal storms. Additionally, all these economic activities may be a significant, and growing, sources of energy consumption and account for a significant percentage of greenhouse gas (GHG) emissions. [1]

This may include not only GHG emissions from “land based” activities (ports, industries, cities, tourism), but also “sea based” activities, such as domestic or international maritime transportation. Therefore, straits may play an important role in tackling climate change and responding to climate impacts, bringing an integrated management approach, considering marine areas and hinterlands, on both sides of the strait.[2]

As for cities, strait’s ability to take effective action on mitigating climate change and monitoring progress, begins with developing a GHG inventory; a “carbon study”. Such an inventory will first enable straits to understand the main emissions contribution of different activities taking place at strait level. It may then allow straits to determine where to best direct mitigation efforts, where to best consolidate partnerships with key stakeholders, and finally create a strategy to reduce GHG emissions. [3]

The clear definition of the concept of maritime straights helps to analyze the impact that maritime transport brings to the level of CO2 emissions.

Defining a strait: perimeter, activities

From a geographical point of view, a strait is a narrow stretch of water between two landmasses joining two marine expanses. Unlike cities, for which we can generally base studies on administrative boundaries, a strait is a complex area comprising a maritime space and a terrestrial interface, with a spatial dimension that can be subject to discussion and interpretation depending on the purpose of this definition. Moreover, there is no administrative boundary for a strait (although there are different administrative boundaries within a strait), and thus it is necessary to take into consideration functions and activities of a strait to be able to propose and justify a specific boundary. [4]

From a functional point of view, a strait is the crossing-point where the crossing is the shortest possible. It is thus a core node of transport and communication, with a "bridge effect" stepping up maritime connections (ferries, container transport, ro-ro ferries etc.) or fixed links (bridges and tunnels). A strait be a transportation hub organized around the main ports on both side of the strait, involving longitudinal (between the main ports of the strait) and transit flows of goods and people through the maritime corridor. Economic activities, as well as in-land transportation are then

induced by these flows through the maritime corridor [5]

Main GHG emission sources at strait level

Calculation of CO₂ emissions in the maritime strait considers the major activities that are developed in the strait according to the concept defined for it, as described in the table No1

Ports operation: including energy consumption of the buildings in the port and of the ships in the port areas.

Maritime transport: including local, international (with calls to the strait's ports) and transit maritime cruise. This emission source was included in most of the inventories, depending on the local availability of data. The local maritime cruise data was collected from the ports and/or the local maritime companies. The international maritime cruise data was collected from the ports, and the transit maritime cruise was collected from the coastguards

Table 1: Technical and economic activities in the Strait

Ports	<ul style="list-style-type: none">• Port operations: port-owned and leased vehicles, buildings, port-owned and operated cargo-handling equipment, port purchased electricity for port administration-owned buildings, lighting and operations• Ships in port areas: In fairway channel, at anchor, in port basin, maneuvering, at berth
Sea-based	<ul style="list-style-type: none">• Local maritime cruise: traffic between port-to-port inside the strait (Ferry, fishing)• International maritime cruise: emissions due to ships arriving / departing from the port located in the strait• Transit maritime traffic: emissions « inside » the strait without calls at straits' ports
Land-based	<ul style="list-style-type: none">• Road-railway-fluvial traffic: origin/destination of goods handled in the ports' area• Tunnel• Induced economical activities (ex: fishing, tourism, etc...)

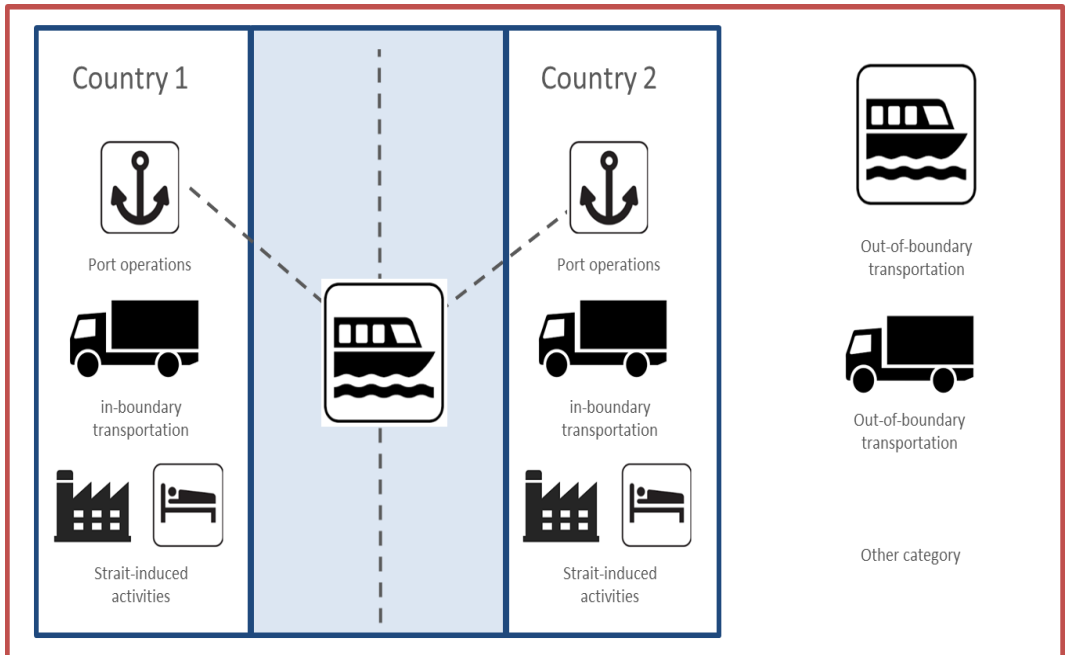
In-land traffic: including road, railway, waterways transport from and to the ports and tunnel transport if appropriate. This emission source was included in all the inventories based on local and national statistics on the quantity of merchandise transported, the number of passengers passing through the ports, the mode of transport and the distance travelled. This emission source represents between 3% and 20% of the emissions within the strait.

Induced economical activities: including industries and residential and commercial

activities. This emission source was included in all the inventories based on European data on the emissions from industries (in the EU-ETS database), and on the emissions from residential and commercial activities per capital.

The analysis methodology includes the collection of statistical data regarding the number and typology of economic enterprises operating in the coastal area at the perimeter of the straight, the number of vessels anchored in the port of Vlora, the number of vessels transiting the Strait of Otranto, the number of Port shipyards, as well as the processing duration, the number of land transport vehicles to the Port, statistics on the number of people around the straight as is described in the Fig No1.

Fig No 1 – Diagram of technical and economic activity in the straight



Otranto straight CO₂ Emissions

The Strait of Otranto (Albanian: Kanali i Otrantos; Italian: Canale d'Otranto) connects the Adriatic Sea with the Ionian Sea and separates Italy from Albania. Its width from Kepi I Gjuhes, Karaburun, Albania to Punta Palascia, east of Salento is less than 72 kilometres (45 mi). The strait is named after the Italian city of Otranto. The strait of Otranto has a very strategic position and for centuries has been a key to control all traffic flow from Mediterranean to Adriatic seas.

Fig 2 – Strait of Otranto

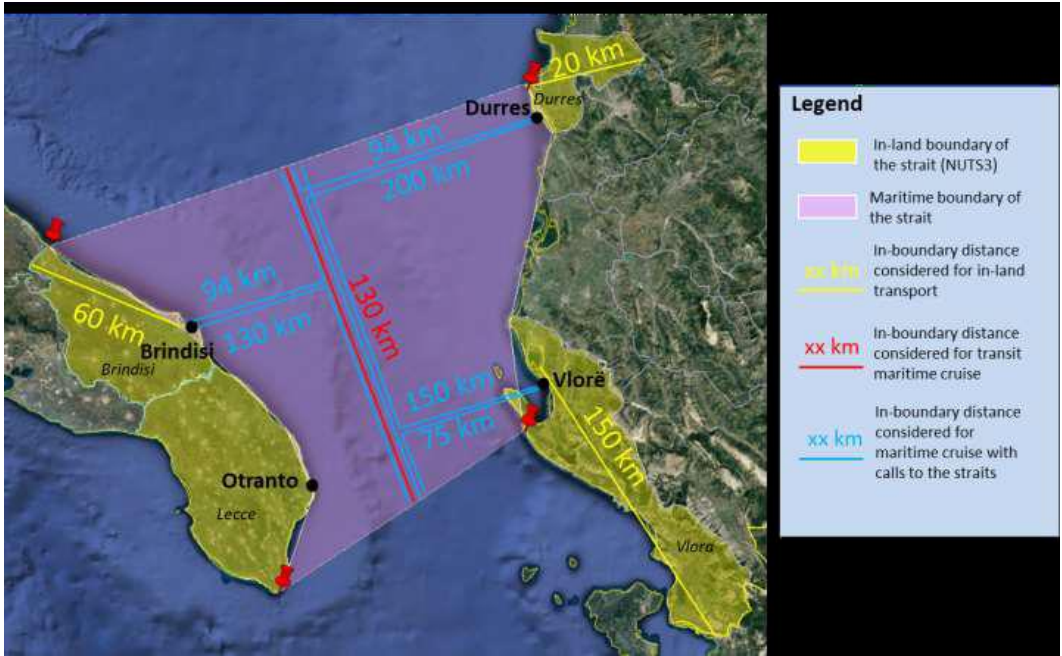
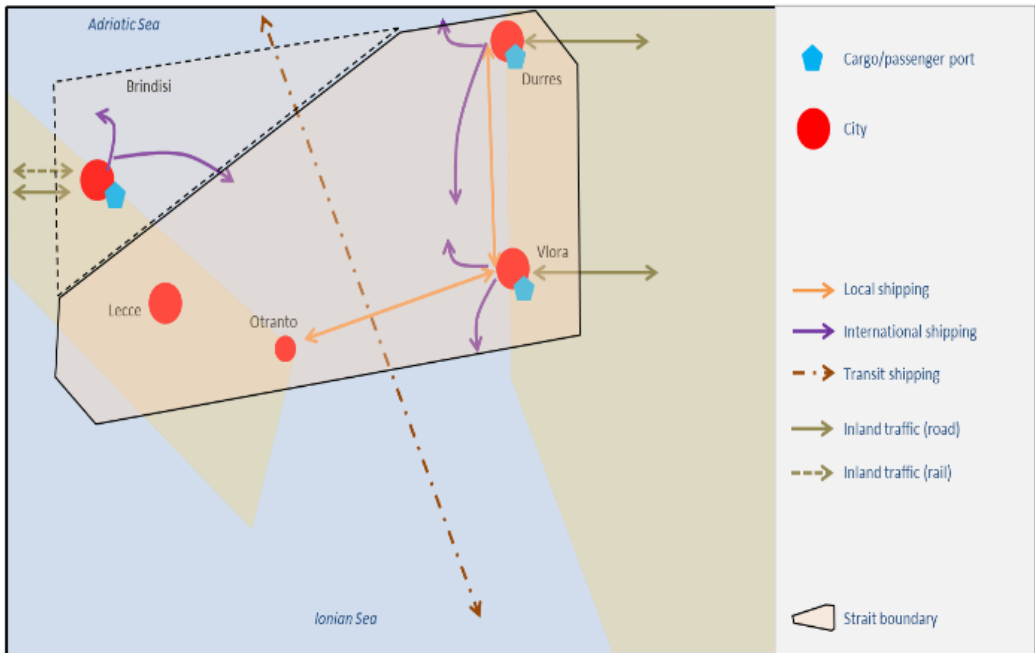


Fig 3 – Diagram of maritime transport activities



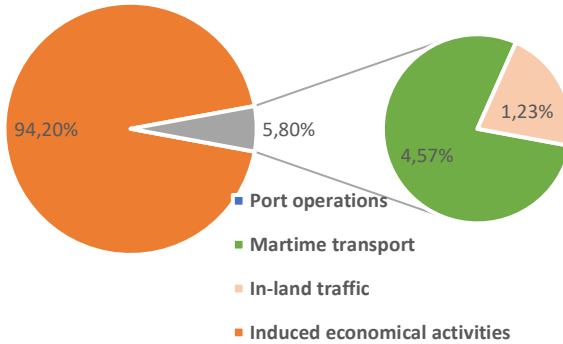
From the analysis of the data for the variables defined in the diagram the calculation of CO2 emissions resulted: 94% of the emissions in the strait are generated by

economic activity, 5 % by sea transport and 1% by land.

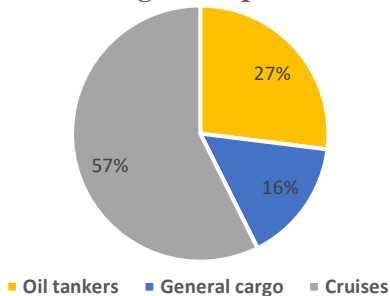
If we will go more in details for the maritime transport Co2 emissions define by category of vessels 57% of in boundary emissions are generated from the cruises, 27 % from oil tankers activity and 16 % from cargo activity.

Graph 1 – Emissions in the Otranto Strait

Emissions of the Strait of Otranto

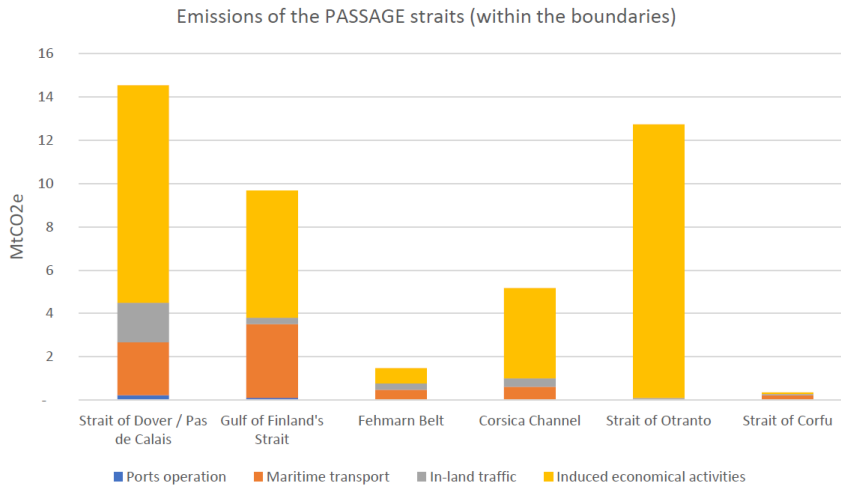


In-boundary emissions from the vessels calling at the port of Vlörë



If we compare the level of CO2 emissions in the Strait of Otranto with those of other European Straits, we find that the total level of emissions in the Strait of Otranto is 12.5 M Ton. 95% of CO2 emissions in this strait are attributed to economic activities.






Graph 2 – Emissions of the Passage Straights



At the strait level, the application of the national objectives (disaggregated by sector) results in a reduction of the emissions by 36% by 2030, compared to 2016.

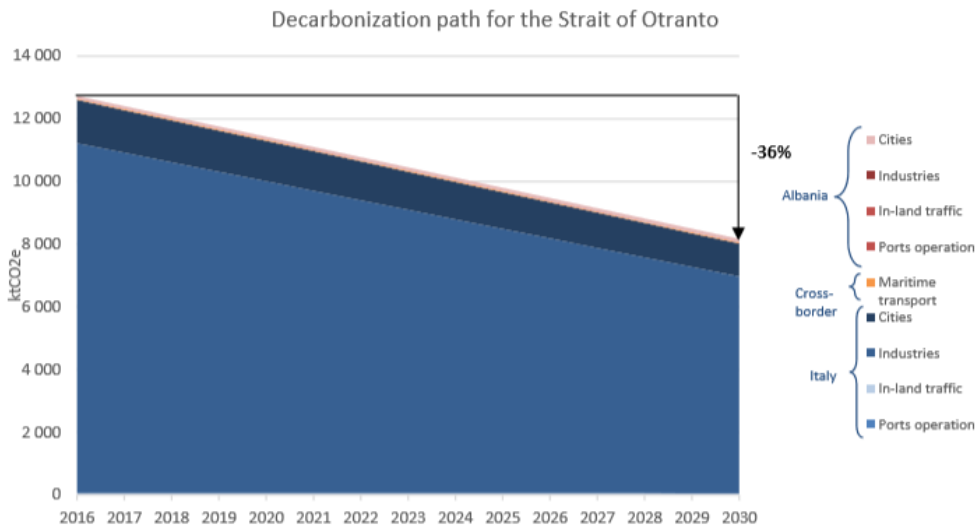
The following table presents the main hypothesis made to estimate the decarbonization path of the Strait of Otranto.

Table No2 – Table of hypothesis for decarbonisation in the Strait of Otranto

Emission source (within the strait's boundary)	Source of hypothesis	% of reduction	Emissions 2016 (tCO ₂ e)	Emissions 2030 (tCO ₂ e)
Port operations 	European Commission's target on CO ₂ emissions from maritime transport	-40% between 2005 and 2050 (corresponding to -12.3% between 2016 and 2030)	NC	NC
Maritime transport 	European Commission's target on CO ₂ emissions from maritime transport	-40% between 2005 and 2050 (corresponding to -12.3% between 2016 and 2030)	31 432	27 566
In-land traffic 	Transport target in Italian National Energy Strategy and Albania's Target in INDC	IT: -16% between 2016 and 2030 AL: +47% between 2009 and 2030 (corresponding to +30.6% between 2016 and 2030)	64 157	58 380
Industries 	Industry target in Italian National Energy Strategy and Albania's Target in INDC	IT: -38% between 2016 and 2030 AL: +47% between 2009 and 2030 (corresponding to +30.6% between 2016 and 2030)	11 163 390	6 921 302
Buildings 	Building sector target in Italian National Energy Strategy and Albania's Target in INDC	IT: -24% between 2016 and 2030 AL: +47% between 2009 and 2030 (corresponding to +30.6% between 2016 and 2030)	1 468 585	1 161 873
TOTAL			12 727 564	8 169 120




This reduction is due to the actions implemented at all the levels (national, regional, local) and corresponds to the path that is being taken with the actual strategies. The emissions can also be reduced by implementing new actions specifically on the strait's boundary.

Graph. No 2 – Decarbonisation paths for the Strait of Otranto



Based on the decarbonisation paths for the Strait of Otranto 2016-2030 the action plan for Albania will be focused on three main thematic axes.

Table No 3 – Action Plan for decarbonisation in the Strait of Otranto

Thematic axes	Cross-border
Port operations 	<ul style="list-style-type: none"> Energy efficiency certificate for the port buildings
Maritime traffic 	<ul style="list-style-type: none"> Energy efficiency on maritime transport vessels – Green shipping
Induced economical activities 	<ul style="list-style-type: none"> Local government supporting climate change mitigation Green certificate for tourism

Composite materials and their performance

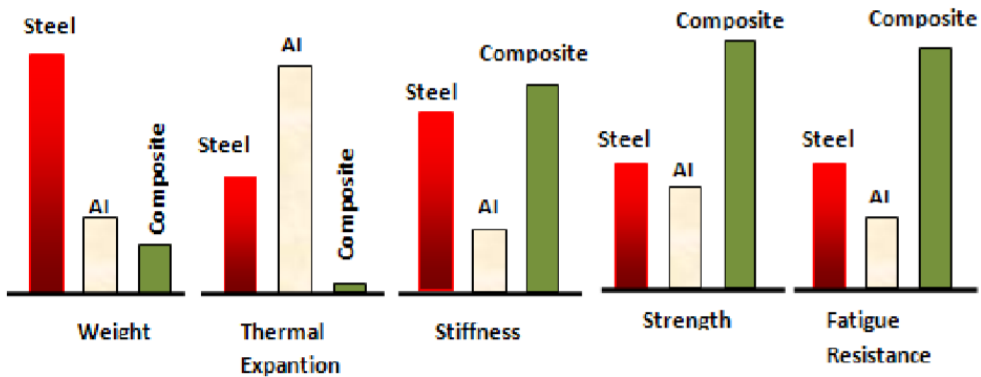
As described above, maritime transport is one of the relevant polluters in the Otranto Straits. Energy Efficiency in Shipping is proposed in the Decarbonization Action Plan. From this point of view, the reduction of the motor power of the marine means is one

of the directions of interference. The design and construction trends of ships are those of realizing the final product with a total dislocation as small as possible.

As is known from Archimedes' law, minimal deployment means the minimum diving volume of the vehicle, which, on the other hand, contributes to a lower resistance to movement, better hydrodynamic characteristics with a reduction of the surface of the vessel (in the case of yachts with sail) or motor power installed in the case of motor yachts; a better ride comfort, lower cost of construction and vehicle utilization, increased navigation autonomy, especially in the case of large sized cruise vehicles.

If we take in consideration the physical and mechanical parameters (fig. No 4) the composite material has very good performance for the weight comparing to the metallic materials.

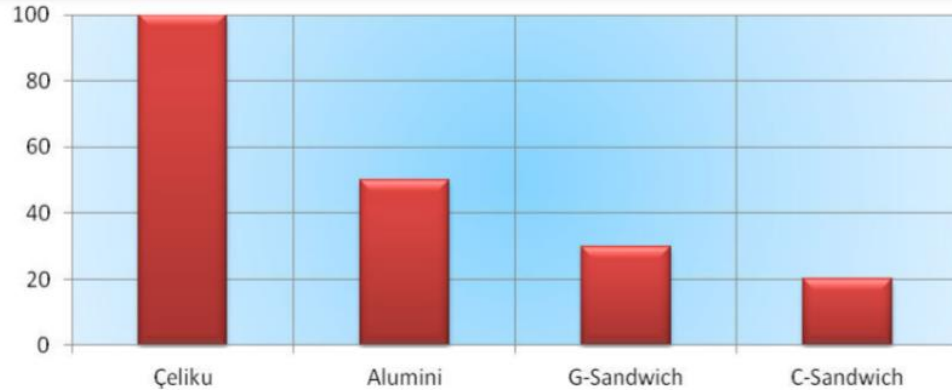
Fig. No 4 – Physical and mechanical parameters for vessels materials



The designers of these ships always face the constant challenges of creating more and more efficient structures, while facing higher demands on national and international safety standards and norms. Saving weight in many naval structures has long been considered one of the most important problems by attracting the attention of researchers and naval projectors.

An approximate weight factor estimate in marine structures is shown in Figure 35 (Based on the recommendations given in Ref.86). Thus, aluminium structures are about 50% lighter, compared to those of steel. Glass fibre reinforced plastic (FRP) sandwiches are 30-50% lighter than light alloy structures (aluminium). Carbon FRP sandwiches are 30% lighter than glass FRP sandwiches.

Fig – Saving weight for vessels based on the material



A marine material with composite material can be constructed with a weight much easier than other materials (steel) and, consequently, this tool requires an installed power of up to 25% less for the same vehicle performance. This enables the choice of an easier engine, creating better opportunities for its maintenance and repair. A smaller weight of the engine means even more access to other board accessories, thus increasing the degree of comfort.

A smaller installed power means less fuel consumption and, consequently, a lower cost of storing this vehicle from their owners. Understandably, the cost also depends on the cruise times of the vehicle. The greater the time it is to use, the greater is the saving of monetary values.

Steel and aluminium structures can guarantee an almost constant maintenance cost up to the first 15 years of service. Then its chart begins to grow very rapidly, because of steel corrosion and the appearance of cracks due to aluminium fatigue. Current manufacturing technologies with composite materials have eliminated the osmosis phenomenon, making the tools maintain the aesthetic side, not exhibit structural degradation, and maintain the maintenance cost constant up to 20 years or more of the lifecycle of the product.

To quantitatively assess this phenomenon, let's take a simple case of a vessel calculation.

Thus, a steel patrol vessel, depending on its use profile, can spend carriages up to an equivalent of \$ 800,000 a year. A reduction in installed power (due to the use of composite materials) of 25%, means an engine with 25% lower power, 25% less fuel consumes, 25% less CO₂ emissions, in total means a saving of \$ 200,000 a year.

Conclusions

So, to achieve the second objective energy efficiency in marine vessels the best solution will be the use of composite materials to produce the marine vessels.

The use of composite material in the production of marine vehicles reduces their weight, creates the possibility of installing a fewer motor power than the floating memories produced with metallic material, creates opportunities for a higher standard of comfort, adding accessories to interior design.

The use of composite materials creates possibility of installing a fewer motor power and for consequence less fuel consume, less carbon emissions.

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