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Maintenance and Repair of Appendixes Afloat on Ships Fast Ferries

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ABSTRACT

In this article, we will study the possibilities of changing different appendices of high speed ships, without the need for the ship having to go into a shipyard. This way, we can reduce the costs of fuel, moving to the shipyard where we perform the repairs, reduce the times of entry, the arrival and departure of the ship in the shipyard, as well as saving on the hiring of shipyard personnel, etc. To do this, we must have staff that is prepared in advance, either the ship's own crew or external personnel, for example, experienced divers in this type of work.

1. Introduction

Since 1841, the ferry service has been a crucial link in the United Kingdom, its surrounding islands and the ports of call of America, Europe and Oceania.

As the rate of demand increased for passenger and commercial ferrying, so has the demand for speedier ships. The need to reach ports and countries faster and more securely has motivated the ferry industry to reach new levels of innovation, and the result is a new generation of "Fast Ferry" which has faced the challenge of matching the pace of our modern world.

In relation to the Canary Islands, the appearance in the inter-island trade of "Fast Ferr", has meant that there is a before and after in the islands commerce, since any person or merchandise, can be transported in a period of time less than three hours, (See Fig. 1,) with its vehicle, without the need for the entrance and exit of airports, customs control, and always near the city center.

Figure 1: Canarias inter-island routes by Fast Ferry.

Source: `https://www.fredolsen.es/es/rutas`

As the main objectives of this project, we will focus on the study of all the maintenance and repair work whilst afloat, without having to enter a shipyard, taking into account the appendices of the chosen model vessel. In this case we have opted for a Fast Ferry Trimaran Vessel of the inter-island Canarian route.

Due to the ship's breadth of 30.5 meters, each time any one of the ship's appendages breaks down, it is necessary, to have it changed, to move the ship to a shipyard that admits its size entry, if any, the nearest on is located about 1000 miles from its place of work, this implies an additional expense in fuel, substitute boat, personnel, entrance, arrival and exit of the shipyard, etc. Using an average for this type of ship entering a shipyard every two years, for maintenance and repair of the appendages, as presented in this paper, allowing the entry to the shipyard could increase the time spent up to three or four years.

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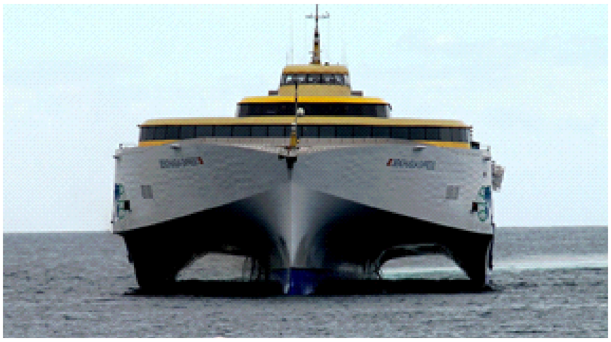
For the presentation of this article it has been structured in such a way that in section two, which describes the vessel that has been used as a model for this study, in the third section, which has been presented, as an example, using two field results that have served as basis of the complete study which was carried out and finally the conclusions will be presented.

2. Model Ship

The model ship in this study, we will be using a fast-ferry, high-speed trimaran with an average of 10 daily port in and out maneuvers operating in the Canary Islands, with an approximate journey time of two hours. The hull is made of aluminum, its sole purpose is to save weight and to make the ferry crossing as fast as possible. The most significant data are: 127 meters in length, with 8,973 gross tons (GRT) and 1,000 deadweight tons, 30,40 meters in length and 4,20 meter maximum draft., with a capacity for 1300 passengers and 341 cars or 450 meters of lanes for trucks and 123 cars.

Figure 2: Model Ship.



Source: Authors

The ship has four engines MTU 20V 8000 diesel, with a power of 9100 kW each, located in two engine rooms. The two engines in the aft engine room are coupled to a Rolls-Royce steering-type Kamewa 125 SII water-jet, while the two engines in the bow engine room are connected to a fixed water-jet propulsion type Kamewa 180 BII.

The movements of the ship are controlled by three types of stabilizers; A stabilizer of the T-foil type is placed in the bow; About two-thirds of the length, there are two Roll-Fin stabilizers and finally; Two interceptors in the stern. It is also fitted with two small rudders made of nickel aluminum bronze, in the central hull at the stern, with a turning radius of 15 ° to each band when the ship exceeds 25 knots of speed.

The vessel has a transverse metacentric height similar to a conventional hull vessel and is therefore equipped with a ballast system in the stern which consists of two ballast tanks and two anchor control tanks. Both sets of tanks are designed to be filled when the boat enters port. The ballast tanks have been designed to cause parallel lowering of the two lateral and central hulls increasing the area of flotation and therefore transversal stability. Each control tank is connected to two transfer pumps, with which water can quickly be pumped from one tank to another. The pumps are run from a variable speed drive, which in turn receives signals from a PLC-based control system.

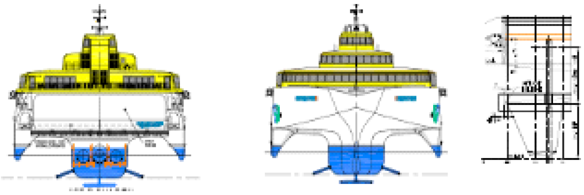
The personnel dedicated to the maintenance and repair, belonging to the vessel, is engineering, which during navigation, are three people and another three while the vessel is in the home port.

The mooring time in port, during the night, is of eight hours, time when all the work of disassembly-repair and assembly can be carried out. For the main engines, the shipping company has a contract for four operators who carry out maintenance. It has another contract for two divers who carry out periodic inspections and are prepared to carry out any work that has to be done while the vessel is afloat. It has three types of subcontracted workshops that perform the different types of welding repairs (with welding equipment for aluminum that can vary according to demand, which can vary from 2 to 8 workers and in larger jobs, up to 16 operators).

2.1. Main Appendices of the Model Vessel.

As we have commented previously, the appendices of the vessel are auxiliary elements to the hull and essential for navigation. Among them, we highlight the stabilizer system in T; The stern bar interceptors that serve to correct the pitching motion, and the Roll-Fin side flap system, which allows the list to be corrected during navigation. In addition to these, we also have the rudders that are an aid to navigation, since they allow the three water-jets to be fixed, and possible changes of course are executed through them.

Figure 3: Different trimaran appendixes, stern and outrigger stabilizers.



Source: Ship manuals

Figure 4 shows the auxiliary ship associated with the model vessel, which is indispensable for repair and maintenance work on the appendices with the vessel afloat. This auxiliary ship is located in the base port and comes with a crane for support, because it has no propulsion, it is helped into place in the water near the area to be repaired. It can be immersed and joined under the hull thanks to ballast tanks which, when filled, can be attached to the bottom of the vessel's propeller system, being able to carry out the maintenance and repair work, through sealing joints, undertaking the sealing and later emptying by use of the same submersible pumps, to be able to gain access to the area of the vessel that needs to be repaired, such as the system of rudders or propulsion.

Figure 4: Auxiliary vessel of the Austral trimaran.

Source: Authors

3. Background

The stabilizers serve to compensate the swing and keep the boat in a position as stable as possible and thus improve the comfort of passengers and crew. There are various circumstances in which it is desired to improve the stability of the vessel and each of the methods which can be used for this have their advantages and disadvantages. The stabilizers are divided into: active, when they require an independent source of energy for their operation, and in passive, when they act by taking advantage of the energy generated by the ship's own oscillatory movement. Although there are various devices, they can all be classified into the following:

3.1 Balance Keels.
They are stabilizing devices of the passive type, consisting of keels made of steel sheet that protrude from the bottom at the height of the bilge and which are oriented longitudinally.

3.2 Adjustable stabilizing fins.
They are stabilizers of an active type, constituted by one or more pairs of steerable rudders, around its horizontal axis, and which project from the sides of the bottom part.

3.3 Passive anti-balance tanks.
They essentially consist of two tanks placed symmetrically with respect to the diametrical plane of the vessel, joined by upper and lower ducts. Both tanks are partially filled with water, which can pass from one to the other through the lower duct, while the upper duct allows the passage and transfer of air. When the vessel comes into balance, the liquid level begins to oscillate inside the tanks, at the expense of the energy supplied by the balance itself, this way exerting a compensation action between the two.

3.4 Active anti-balance tanks.
This is a development of the previous system, in which the oscillatory movement of the liquid inside the tanks is induced by the placing of air under pressure, controlled by servo motors that receive the information about the balance parameters.

3.5 Active swing-stabilizers.
They are based on the mechanical properties of gyroscopes, based on the tendency to resist the change of position. Such an installation comprises of one or more rotating stabilizers in the rest position on the vertical axis of rotation and a small gyro control which rotates about the transversal plane of the vessel.

3.6 Spin-stabilizers passive.
As in the actives, the passives are based on the properties of the gyro, and present huge analogies except in some technical differences of the devices. They have hardly been developed, being replaced by the active gyro-stabilizers.

3.7 Rudders.
In this study, we will contemplate the dismantling of some of the ship's rudders, which are used, for navigation when it reaches its cruising speed.

Figure 5: Hanging trimaran rudders to aid navigation.

Source: Authors

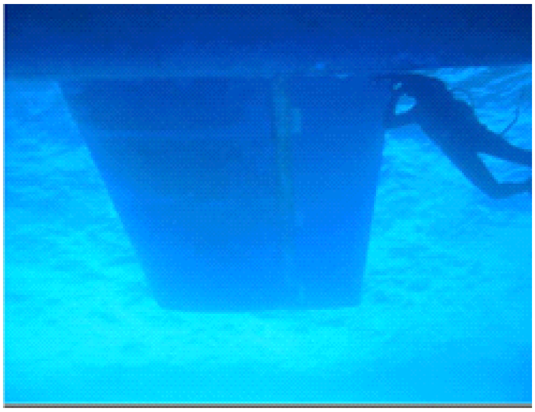
4. Results

The following describes the procedures and results of the various repair and maintenance work carried out on the appendices of the model vessel:

4.1. Roll-Fin Operations

These are stabilizers of the active type, constituted by one or more pairs of steerable rudders, on its horizontal axis, and that they project from the bottom of the vessel. The control surfaces consist of two components, which move, flaps and the main surface which is attached to the hull. The movement of the flaps generates the necessary force upwards or downwards to counteract the effect of the movement of the ship.

Figure 6: Diver working on a roll-fin stabilizer.

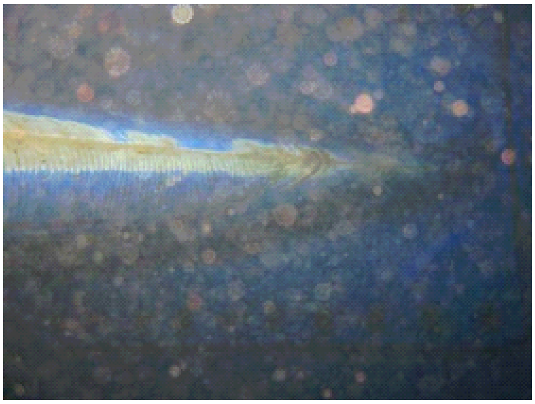


Source: Authors

The roll-fin bearing is mounted on the inner side of the hull and can be seen from inside the vessel. The drive shaft is supported on the bearing passing through it connected with a guide which rotates by means of a pair of hydraulic cylinders.

In the inspection of the Roll-Fin on the model vessel, two circumstances are observed: the first one, due to friction there is a loss of paint, an incidence due to the water during navigation (Fig. 7).

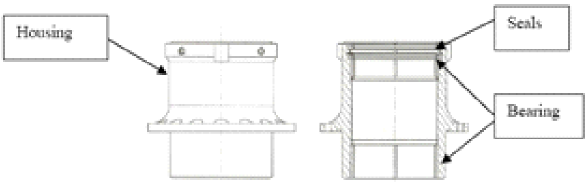
Figure 7: Paint loss on roll-fin stabilizer.



Source: Authors

The second circumstance is that there is a loss of water through the seals, despite checking that the grease is used correctly.

Figure 8: Bearing housing with seals.



Source: Manuals ship

These facts imply the dismantling of the bearings mounted on the inner side of the flaps with two lip seals. To ensure the lubrication and tightness of the area during movement, fast couplings are fitted with patch cords.

At first it is thought that the loss of water must come from a break in the seals, these can be changed without dismantling the yoke that supports the hydraulics. In the following picture you can see that the seals are broken even though the grease has done good lubrication.

Figure 9: A break in the seals.

Source: Authors

When the seal is changed the loss of water starts again, this means that it is possible that the gap between the bearings and the shaft is too large. Before changing the housing is decided, with the supporting bearings afloat.

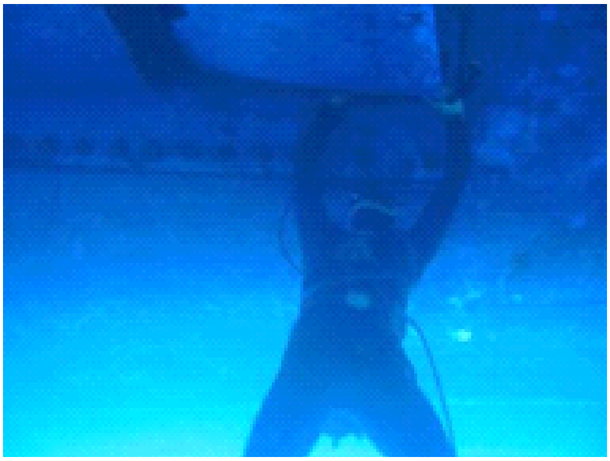
The roll-fin has a completely sealed space in such a way that it allows a total water tightness of the area.

Figure 10: Roll-fin cofferdam.

Source: Authors

As soon as the dismantling begins, two divers on the outside work to place two sectors between the hull and the axis of the roll-end, to make it watertight and that water getting in is at a minimal, or that it is to say, to be taken care of by the bilge pump system. Divers need to be immersed inside the vessel in the confined space, so it has to be well cleaned because when it is flooded and the diver enters, there can be no oil residue as they need to see, to access the elements and to perform their work.

Figure 11: Diver placing sealing sectors.



Source: Authors

Once the dismantling of the hydraulic system has been completed, they start with the proper extraction of the bearing housing. An extractor is used for such work by using two hydraulic jacks powered by a hand pump.

Figure 12: Dismantling of the bearing system of the Roll-fin.

Source: Authors

All the parts are disassembled and all the elements are cleaned and the housing is replaced with the new bearings.

Looking carefully at the first verified circumstance in which the stabilizer blade damage was observed (Fig. 7), it is dismantled and transported to the surface by means of balloons, then hoisting it with a crane, which then is transported to the corresponding workshop to make the necessary repairs.

Figure 13: Hoisting the roll-fin, rudder system with balloons and crane.

Source: Authors

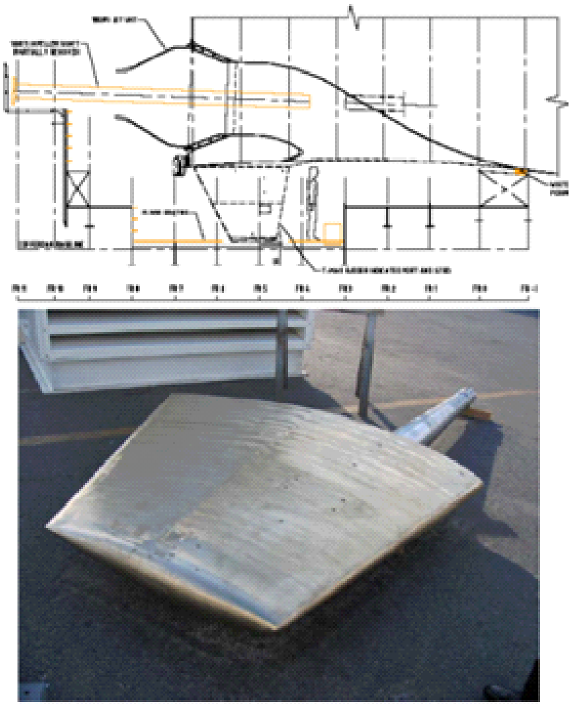
Finally, it is checked that the entire system is perfectly watertight, and then after having it done, it is tested.

4.1.1. Personal Necessary personnel / working time: For this operation, it took two of the vessel's operators own crew, with a time of 4 hours, two divers and a support boat, with a working time between 4-6 hours and a crane to hoist the blade. These hours are computed since the work is done both outdoors and indoors. The length of time the vessel is in port at night is usually 8 hours, if the operation needs only 6 hours, it can be done in the stopover port, sailing without a stabilizer having the ship cruising at moderate to 75% of its normal speed, and making the assembly the following night, as long as there are no malfunctions in the stabilizer blade.

4.2. Changing a Hung Rudder because of Cracks

As previously mentioned, the trimaran vessel under study has two small rudders hanging from the central hull to maneuver during cruising speed of the vessel.

Figure 14: The hanging rudder of the trimaran.



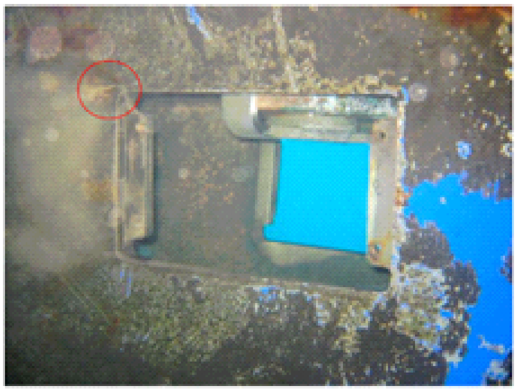
Source: Authors

A fault occurs on one of the hanging rudders due to breaks, with cracks in the covering where the rudder arm is held, as well as on the double hull fastening of the rudder.

Damage can occur during maneuvers, when the vessel is needed to go in the reverse direction, the flow of water is contrary to the design of the hanging rudders, producing enormous cavitations and vibrations. If we consider that many of these ships carry out an average of 8 to 10 maneuvers per day in which the maneuver lasts in the region of 5 to 10 minutes each, and in which the ship goes backwards for half that time. By extrapolation, we can say that this maneuver occurs 40 minutes per day, which is then 20 hours per month.

In the following picture you can see marked with a red circle, the crack produced in the observation window of the rudder.

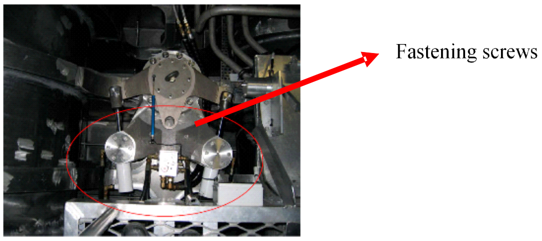
Figure 15: A crack in the hanging rudder.



Source: Authors

The rudder is only attached to the hydraulic drive system by the screws marked in Fig. 16, whereby the cylinders transmit the torque directly to the aforementioned screws.

Figure 16: The Rudder's hydraulic drive system.



Source: Authors

The hanging rudder is dismantled by two divers on the outside and three operators on the inside, with a crane and balloons to hold the rudder in the sea and then the subsequent hoisting by means of the crane, which will be then carried by means of a transport vehicle to the corresponding workshop where the repair welding of the housing cover of the rudder's arm is undertaken. The painting is also done with.

Figure 17: Repair of the crack and painting of the rudder.

Source: Authors

Parallel to the whole situation, the repair of the crack produced in the rudder housing in the central hull of the vessel is carried out.

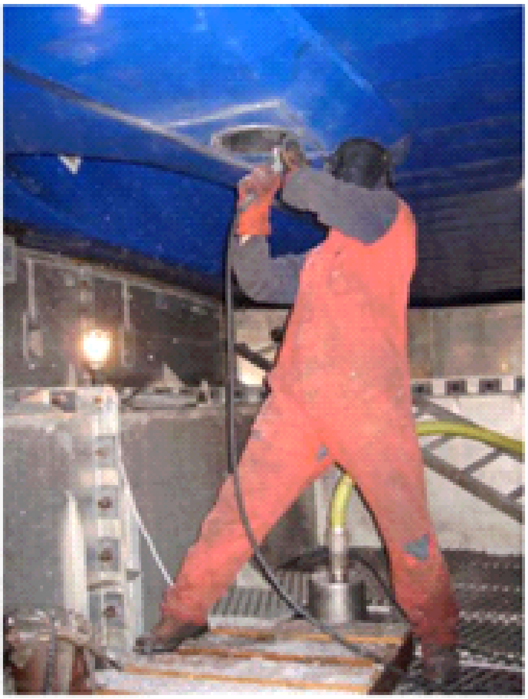
This procedure would be normal, if the vessel was in a shipyard, but the method becomes special, because the procedure occurs with the vessel being afloat. In such a way that the model vessel, thanks to the implanted auxiliary systems, permits the revision of rudders as well as water jets whilst being afloat.

Figure 18: A crack in the hull.

Source: Authors

In order to repair the buried crack, the auxiliary vessel, described in section 2.1 of this article, is used, so that once it has coupled to the central hull, it is possible for work to be made on the crack.

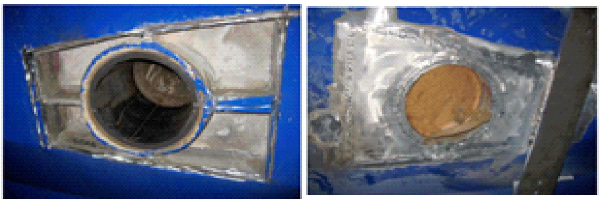
Figure 19: An operator working on the double hull.



Source: Authors

Once the vessel has been coupled and the auxiliary vessel has been emptied, a cut is made first in the double hull, and then the welding is performed, as can be seen in the following photographs.

Figure 20: Cutting and welding on the double hull.



Source: Authors

One of the major problems is the alignment of the rudder housing, because when a new double bottom welding occurs, the housing must be rectified to position the rudder cap for the rudder arm.

Figure 21: Rectification and rudder cap housing.

Source: Authors

4.2.1 Necessary personnel / working time: For this operation, three operators of the ship's own crew were needed, with a time of 6 hours, two divers and a support boat, with a working time of 4-6 hours. The use of the auxiliary vessel with its corresponding crane. The average working time, due in this case to the crack produced in the hull of the model vessel, has increased to 12 hours, so in this case unlike the previous one presented in this article, the model vessel has had to be taken out of service for two days, in the event that there were no cracks in the hull and it was only necessary to change the rudder bushing, work would have been done during the night stop, as during the day the ship could have sailed with a single 5% decrease in speed since the system of the two lateral jet-ports can assume any deviation in course.

4.3. *Differences between Float and Shipyard Operations*

If any of these repairs had been carried out in the yard, it would have been necessary, in addition to the above:

a) Vessel being taken out of service and without freight

b) A substitution vessel if it has a regular line

c) The moving of the ship to the shipyard, however, in the Canary Islands there is no shipyard that can raise the ship in dry dock, due to the width of the vessel.

d) At an average speed of 27.5 knots (economic speed), with a consumption of 3325 litres per hour or a consumption of 121 litres per navigated mile, it represents 79800 litres of fuel per day.

e) Entrance mooring and departure of the shipyard, personnel, scaffolding, workshops.

f) Equipment that is not generated by the ship itself such as water, light, hotels for crew, etc.

5. Conclusions

1) This type of vessel, with its auxiliary vessel, allows numerous inspection, repair and maintenance to be made of its pushing and maneuvering system without having to place the ship in dry dock.

2) With experienced divers in ship systems, you can save a lot of time on staff and work times.

3) There is significant fuel savings with the afloat system.

4) There is a significant travel saving of specialized technicians, since an initial assessment can be made of the studied types of faults.

5) Uninterrupted operation of the ship, or a small stop, until the work is completed.

6) An increase in the time of the scheduled dry dock inspections, since the majority can be done while afloat.

7) More time to study and execute the possible modification, which generates the fault, and correct it once the vessel is in dry dock

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References

- Benchijigua Express Stabilization System Manuals
- Manuals of the Auxiliary Ship to Benichijigua Express
- Technical reports of the Austal shipyard.