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"THE STERN TUBE OIL POLLUTION IN OCEAN AND USE OF COMPOSITE MATERIAL TO REDUCE IT -A REVIEW"

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ABSTRACT

This paper explains the causes of the stern tube oil pollution in ocean. Paper gives idea to reduce the oil pollution in the ocean, and explains the methods to reduce it. The idea about composite material which can be used for the stern tube bearings is explained in this paper.

Keywords*: - *Stern Tube oil pollution; water lubricated bearings; stern tube bearings; propeller shaft bearings; ship source pollution.

I. INRODUCTION

The pollution of the world's oceans has increased considerably from last few decades. The norm and international regulations are becoming more and more stringent for any kind of ship source pollution it must be zero tolerance. If the shipping companies found guilty of polluting US waters almost US $140m in criminal fines have been levied by US Courts against them. The stern tube oil will flow out into the sea due to seal damaged by simple fishing net or rope caught on ships rotating shaft. There is proven advanced technology which will avoid the oil spill into seawater. The seawater is pumped and used for the lubrication of the stern tube. No oil is required to lubricate the stern tube bearings. Mild steel bearings require the protection against the corrosion from the salt water. [3]

Now days epoxy resin composite materials are used for those stern tube bearings. Herbal base bio resigns composite materials can be used for the stern tube bearings as an advanced technology.

II. PROBLEM STATEMENT-

2.1 Stern Tube Lubricating oil is an issue [1]

Currently, the majority of commercial ocean-going ships operate with a propulsion system using a propeller shaft typically supported by oil lubricated white bearings with the oil contained in the stern

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tube by shaft seals. This sealed stern tube system is filled with mineral oil and sealed typically with a forward aft lip type seal at each end as shown in figure 1. Typical stern tube contain 1500L (396 US gal) of mineral oil. The white metal stern tube bearing in a sealed system provide for predictable and controlled wear life of shaft bearings. This system has been in use since the 1950's when it replaced sea water lubricated lignum wood bearings where wooden bearings wear life was unpredictable and corrosion presentation was an issue.

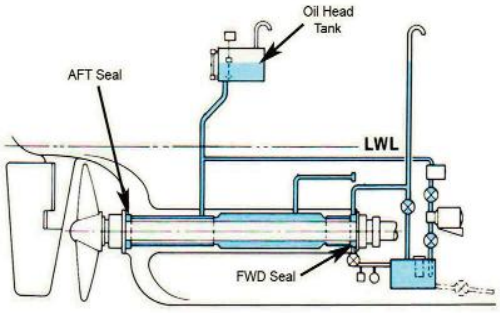

Figure-1: Typical oil lubricated stern tube bearing system [1]

However there are some issues with oil lubricated stern tube bearing system and the issued have become much more prevalent today with concern over any ship source pollution.

Following is the pie chart showing the ocean pollution due to different reasons.

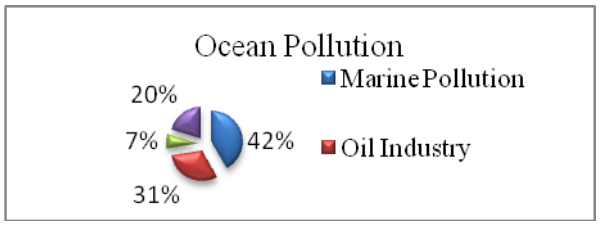

Figure-2: Ocean oil pollution [1]

2.2 Stern Tube is having following types.

2.2.1 Operational (Normal Consumption)

In stern tube bearings, the radial movement of the shaft is considerably larger than that of bearings of general industrial application. In addition, external disturbances such as rough sea and vibrations are considerable. It is practically impossible to seal the stern tube perfectly. Therefore one of environmental issues in medium and large commercial vessels is stern tube oil leakage. [11]

Environmental legislation can only get tougher, but even will maintained and managed ships will still leak oil [12]

Calculation of amount of oil spill in the ocean by ships due to propeller shaft bearing lubrication-STOP (Stern tube oil pollution)

If 45,000 commercial ships are working in the whole world from that 90% operate ships are working with oil stern tube system.

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The avg. oil leakage for each ship is 6 liters/ day.

If we consider one ship will works 330 days for a year.

45,000 × 0.9 × 6 × 330 = 80190000 liters of oil is escaped in the ocean as oil pollution.

The above calculation shows that about 130 to 244 million liters of oil is being mixed in the sea water from the ports and harbors [13]

2.2.2 Accidental-

Typical causes of increased oil leakage from stern tube seal damage

1. Fishing nets or rope caught in the propeller
2. Propeller shaft misalignment or bent shafts
3. Aged or worn lip seals
4. Propeller contact

The propeller shaft of the ships working all over the world, come in contact with fishing line, net, rope, garbage, ice and even damage to a propeller by hitting the bottom. A ship will operate 6000 – 8000 hours per year and dry dock the ship 2.5 to 5 years for seal maintenance. A ship will operate 6000 – 8000 hours per year and dry dock the ship 2.5 to 5 years for seal maintenance. The record from the Lloyd's Register, "Defect statistics over the last 20 years indicate that the aft stern bush represents 10% of shaft line failures, with the forward stern bush representing 4% of total failures. Interestingly, the aft stern gland (seal) and forward stern gland (seal) represent 43% and 24% of failures respectively. [14] The sea oil pollution cannot be properly monitored so still it is a big issue, increasing the pollution.

Figure 3.Fishing net or rope caught on ships rotating shaft.

Oil pollution from seal damage is a big issue due to following reasons.

a) Costly to repair seals
b) Criminal fines or jail terms for ship crew, manager, and owner.
c) Loss of contracts or permits.
d) Bad public relations or insurance problems.
e) There is proven alternative to avoid the oil pollution.
f) Sea water lubricated composite material bearings.

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g) Eliminate stern tube oil and pollution risk

h) Viable alternative to oil lubricated white metal propeller shaft bearings

Seals on the propeller shaft prevent the water to enter into ships shell. The lubrication is provided to the bearings on the shaft. The lubricant serves to lower friction resistance and cools the bearing housings and gaskets, keeps water out and stops corrosion. Subject of increasing international concerns, Zero tolerance for any kind of ship source pollution is now becoming the rule and international regulations are becoming tougher. Provision of heavy penalties such as large fines or jail terms, loss of government contracts or permits is done by government for the violation of the pollution rules. These penalties can be applicable to any company or individual such as the master, the chief engineer, the owner, the operator, the charterer of the ship and the Classification Society. Penalties can be applicable to any company or individual those will violate the rules. Composite bearings are the only alternative to overcome this difficulty. The composite materials need not the oil lubrication and it gives good performance to the seawater lubrication. Now days the research is going on to successfully use the epoxy resin composite bearings for the propeller shafts. Also some researchers are doing their research to find out the bio or herbal base resins. These resins can be used to make the propeller shaft bearings. The herbal resin composite bearings are having self lubrication properties which will reduce the oil pollution considerably.

The composite bearings are having following advantages

Long wear life and lower maintenance costs mean predictable, lower life-cycle costs

• Global availability provides superior customer service and quick turnaround

During the last few decades, the pollution of the world's oceans has become a to demonstrate to commercial ship owners that modern seawater lubricated propeller shaft bearing systems do offer wear life predictability, reduced operating costs and elimination of stern tube oil pollution risks,[1]

In recent years can be met ships whose propeller shaft polymer bearings are lubricated with water. It results from simplicity and associated low cost of such solution which is also environmentally friendly as no risk of pollution is involved. However the solution is not free of disadvantages. The main problem is intensive wear of bush material, occurring in certain cases. It very often results from errors of improper design and machining and mounting operations. [4]

2.3 Problems due to the metallic stern tube bearings.

Following figures shows the problems due to the metallic stern tube bearings. Figure no 4 shows the completely damaged oil lubricated slide bearings and sealing of ship propeller shaft.

In figure no 5 the corroded cantilever open bearing propeller shaft is shown. In figure no 6 Damage of a composite bush, resulting from edge thrust resulting from skew position of shaft axis (up); is shown, during repair the damaged edge was grinded to avoid cracks and de-lamination of the composite (down)

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Figure 4.Completely damaged oil-lubricated slide bearing and sealing of ship propeller shaft [4]

Figure 5.Cantilever open bearing of yacht's propeller shaft [4]

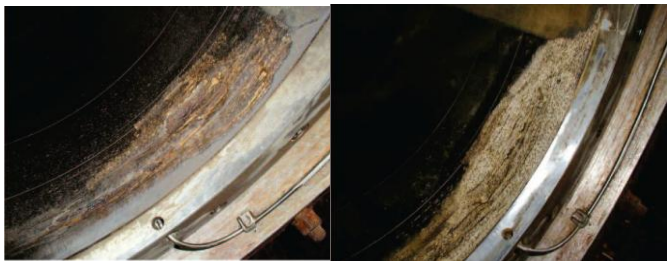

Figure 6.Damage of a composite bush, resulting from edge thrust resulting from skew position of shaft axis (up); during repair the damaged edge was grinded to avoid cracks and de-lamination of the composite (down) [4]

Fig. 7.Oil Lubricated aft stern tube seal

III. THEORY-

3.1 The penalty Of Stern Tube Lubricating Oil Discharges for Ship Owners and Operators [2]

A growing number of new environmental rules are being considered as laws by a number of countries, particularly the United States, Canada and the European Union.

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3.1.1 U.S.A.-

Clean Water Act

The Clean Water Act requires that any discharge that results in shine on the navigable waters in the adjacent zone i.e. 24 nautical miles from baseline of the United States be immediately reported to the National Response Center by telephone.

Oil Pollution Act of 1990 (OPA '90)

Cleanup costs are taken as liabilities from the rule violating parties as well as the strict liability provision is there, for the simple negligence under united state laws for the oil pollution in water. This is true even when the spill is small or the resulting environmental damage is minor.

Polluters pay.

The polluter i.e. owner, operator or charterer of a vessel must pay for the cleanup within certain liability. Parties that fail to notify the proper system of a spill are now subject to greater fines and longer prison terms. Penalties for the civil parties have also been toughened, with the owner of a vessel or facility hat discharges oil or a hazardous substance liable for up to 37,500 USD a day in fines.

3.1.2 Canada

When an oil spill is detected within the Canadian 200-mile exclusive economic zone and a ship is supposed of being the source of the oil spill, oil polluters can be charged under the Canada Shipping Act (CSA), the Migratory Bird Convention Act (MBCA), the Canadian Environmental Protection Act (CEPA), and the Fisheries Act (FA).

The Canadian Enforcement officers and pollution prevention officers are empowered by new authorities. Through the new Bill C-15 the maximum fines are charged for illegal releases of harmful substances into areas frequented by migratory birds from $100 000 to $300 000 for a summary conviction and from $250,000 to$1,000,000 for an indictable offence.

3.1.3 European Union

International laws require enforcement:

1) MARPOL ANNEX 1

MARPOL 73/78 is the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978. MARPOL 73/78 is one of the most important international marine environmental conventions. It was developed by the international maritime origination in an effort to minimize pollution of the oceans and seas, including dumping, oil and air pollution

2) The European Union Directive on "Ship Source Pollution" [EU/2005/35]

❖ OSPAR Convention is the current legislative instrument modifiable international cooperation on environmental protection in the north-East Atlantic. It combines and updates the 1972 Oslo

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convention on dumping waste at sea and the1974 Paris convention on land based sources of marine pollution.

❖ The claim granted by a European parliament, "To achieve or maintain good environmental status in the marine environment, that member states shall take the necessary measures by the year 2020 at the latest"

❖ The fifteen Governments (Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom) of the western coasts and catchments of Europe, together with the European Community, cooperate and form the mechanism called OSPAR by which to protect the marine environment of the North-East Atlantic. The principle paid by the polluter(included in the 1992 OSPAR Convention) is mainly implemented by means of command-and control approaches but can also be applied via market-based mechanisms, e.g. for the development and introduction of environmentally sound technologies and products.

3.2 Environmental penalty of Marine Oil Spills [2]

The oil spills has the short term and long term impact on coastal and marine environments. The damage caused by an oil spill event depends primarily upon the quantity of oil spilt, the chemistry and properties of the oil and the sensitivity of the biological resources impacted. The smothering and physical contamination or the toxicity of the chemical components of the oil effects on sea birds and other marine life by an oil spill. The form and exposure of the coastline e.g. protected mangroves and salt marshes are extremely sensitive to oil spills yet rocky exposed coastlines naturally self clean and are less sensitive to oil spills heavily impacts on oil spill.[2]

3.3 Elimination of Stern Tube Lubricating Oil Discharge [1]

3.3.1 Zero Pollution Risk

The stern tube oil elimination is reduced by composite seawater lubricated stern tube bearing system. There is no rear seal, no storage of oil, no sampling of oil, no disposal of stern tube oil and no worry of ingression seawater contaminating the oil. This composite bearing system ensures ship owners/operators that there will be no environmental violations resulting from stern tube oil leakage.

3.3.2 Proven Available Technology to Eliminate Stern Tube Oil Pollution [3]

Stern tube oil pollution can be eliminated by using a proven, available technology from the world's oceans and seas. Two "conventional" alternatives currently in use maintain to, been environmentally friendly:

1) The more sophisticated multi lip seals which reduce the amount of oil that escapes are developed by Seal manufacturers but shaft seals can still be damaged, and oil can still escape into the sea.

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2) Biodegradable oils are also available, but they are treated as pollution. Now days the metallic and white metal bearings can be replaced by herbal base resin composite material bearings which can reduce the oil spill to zero. The seawater is pumped for the water lubrication to the propeller shaft bearings. The aft seal, as well as the storage, sampling and disposal of oil are eliminated by using the seawater lubricated composite bearings. The potential impact of stern tube oil pollution is zero.

Figure 8.Composite material seawater lubricated stern tube bearings –no oil required [1]

The benefits of water lubricated propeller shaft bearings is noted by the Research presented at the 2007 RINA (Royal Institute of Naval Architects) conference. The statement by the presenters from Fincantieri, a large shipyard in Italy, is traditionally, the shaft line is oil lubricated, and located inside the tube case with a diameter larger than the shaft itself. As the risk of oil leakage is avoided it is called as green solution because the water lubricated shaft line is practically maintenance free. Protection of bearing from the corrosion from seawater is the additional design consideration. The shaft is made by steel which will corrode in (salt) seawater. Bronze or stainless steel liners are generally placed over the shaft in way of the bearings to prevent from the corrosion. Herbal resin Bearings can be developed to complement seawater lubricated propeller shaft bearing systems with the objective of providing corrosion protection for maximum period for service. The shaft withdrawals periods are not beyond five years for if the current shaft coating systems are used. Currently there are over 500 commercial ships operating with composite material seawater lubricated propeller shaft bearings with the first commercial installation in 1983. Following are the some references.

- Carnival Corp. (U.S.A.) - 9 cruise ships (108,000 to 115,000GT) first delivered in 1998; 5 on order
- Gypsum Transportation (U.S.A.) - Gypsum Centennial bulker (50,000 DWT) since 2001 and sister ship on order
- New York City Staten Island Ferries (U.S.A.) - 3 ships (5,900GT) since 2004
- COSCO - China Ocean Shipping Group (China) - 4 car carriers (56,000 GT) and 1 bulker (32,000 DWT) on order

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The composite seawater lubricated stern tube bearings currently installed on nine ships with five more on order by the world's largest cruise ship operator, Carnival Corporation through its operator Princess Cruises The statement by Mr. Chris Joly, Principal Manager, Marine Engineering for Carnival Corporation is, "Seawater lubricated bearings are the present for many of our ships; I would like to see them for all of our future ships.

3 SCOPE-

3.2 All types of the bearings can be made by this material and method.

3.3 With further research propeller shafts can be made with these materials.

IV. CONCLUSIONS

The operational and accidental stern tube oil pollution while reducing ship owner maintenance costs and saving money over the service life of the ship is eliminated by the ship trading companies in the world. New composite Bearings have resulted in seawater lubricated stern tube bearings offering improved wear life, fitting and monitoring methods to meet Class Society approvals which are the proven bearing design. The performance of seawater lubricated composite bearings to date has been comparable to oil lubricated white metal stern tube bearings. Any risk of criminal, civil and administrative penalties and other adverse reactions such as bad public relations for the ship owner that may occur from oil leaking from the stern tube is eliminated by the composite bearing technique. [3]

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