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Analysis of the possibility of using the main engine cooling water electric heater as an effective method of reducing fuel consumption

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Abstract. In the modern practice of fleet operation, the policy of stimulating measures to save fuel consumption is actively promoted. As a rule, the shore operator solves the issues of economy occasionally by selecting the mode of operation of the main diesel engine from the condition of approaching the speed mode of the vessel to the “optimal” speed. The issues of reducing fuel consumption by the ship's technical service are not always raised. But there are opportunities for this, especially in connection with the tightening of international requirements for environmental protection and safety of the ship. We carried out the analysis of a relatively economical method of reducing the consumption of diesel fuel on a tanker of AFRAMAX type.

1. Introduction

Currently, the problem of fuel consumption is related to the new stricter regulations on the content of sulfur oxides SOx in the emissions of burned fuel in the areas of the ESA (Emission Control Area), which entered into force on 1 January 2015 in accordance with the provisions of the Convention MARPOL Annex VI, Reg 18. For shipowners and ship operators this means converting shipboard equipment to more expensive diesel fuel with a sulphur content of less than s<0.1% or equipping ships with an exhaust gas treatment system derived from the combustion of heavy fuel with a sulphur content of up to 3.5% (the maximum allowed by the Convention until 2020, Rule 14)[1].

Only expensive modernization of vessels in operation will allow burning heavy fuel in the ESA zones. Such equipment can be installed during factory repair. It should be noted that the modernization, according to conservative estimates, can cost close to $1 million only for the purchase of equipment. The cost of delivery of equipment in several tons to the plant, additional time of the vessel out of operation further increase the cost of the project. Due to the difference in fuel prices to compensate for the cost of installation of equipment to reduce SOx will have more than one year (even if the constant work in the EU zone, which is almost there). At the same time, it should be taken into account that the equipment needs maintenance, it can be energy-intensive, which will also affect the efficiency of its use. Although the advantages of burning heavy fuel, of course, are available.

This article considers another way to reduce fuel costs, which does not require significant modernization costs and at the same time ensures compliance with the requirements of the Convention through more efficient use of diesel fuel with sulfur content s<0.1% when the vessel is parked in the ESA/NAECA zones. In the latter case, in the NAECA (North America Emission Control Area)

harbourage can reach considerable time, from two days to two weeks or more.

2. Analysis of the process of diesel fuel consumption at harbourage

As an example, the tanker "Moscow River" of type AFRAMAX has the following characteristics:

Table 1. The main characteristics of the tanker “Moscow River” type AFRAMAX [2]

IMO Number:	9165542
Shipyard:	NKK, TSU Works, Japan
Built Date:	February 1999
Delivery Date:	25 February 1999
Flag:	LIBERIAN
Tech. class:	Lloyds Register
Notation:	LRS *100 A1 Double Hull Oil Tanker, ESP, ShipRight
Hull number:	184
L.O.A. (m):	243.00
Breadth (m):	42.03
Depth (m):	20.70
Deadweight (t):	106552.00
GRT:	56076.00
NRT:	32748.00
Draught (Loading) (m):	14.75
Speed (knots):	14.70
Technical Management:	SCF Management Services (Dubai) Ltd.
Commercial Management:	Sovcomflot (UK)
P&I Club:	GARD
Hull & Machinery Insurance:	MARSH
The main diesel:	DU-zulzer 6RTA-58T with power of 12 000 kW at 103 rpm.
Diesel generators:	YANMAR 6N-21AL (3 PCs.) power 640 kW at 900 rpm
Steam boiler:	MITSUBISHI (2 PCs.) steam capacity 2x25 t/h.

Let us consider what happens to the diesel fuel consumption in the harbourage during this period, when there is no need to heat the air in the premises. Approximate costs of diesel fuel at normal anchorage are 4.5-5.5 tons per day (Charter rate – 5.9 tons at anchor with the boiler). The main consumers are diesel generator and auxiliary steam boiler. The characteristics of work of these consumers and their elements:

- diesel generator provides electricity to all consumers of marine equipment;
- auxiliary boiler provides steam heating of the main diesel, oil heating of oil separators, settling tank of heavy fuel, heating of water for domestic needs, evaporation of water from sludge;
- the boiler operates in a cyclic "start-stop" mode, performing approximately 50 to 80 cycles per day. If for some reason it is necessary to run the desalination plant, and it is not less than a day, or to put into operation a different heating (not cargo), the number of cycles can reach 80-100 per day;
- the electric motor of the boiler fan has a power of 75 kW, works constantly, providing air supply depending on the opening of the gate valves;
- the second boiler, which is in stand-by mode, is provided with constant steam heating in case of possible emergency or planned shutdown of the boiler in operation;
- the electric motor of the diesel fuel pump of the auxiliary steam boiler with a capacity of 18 kW operates almost constantly, with short stops after reaching the steam pressure and disconnecting the nozzle (the duration of the pump stop depending on the boiler load and steam consumption);

- the electric motor of the small feed pump with a power of 7.5 kW operates continuously, the boiler is powered automatically by a control valve;
- pilot pump pump has low power (about 1 kW), works cyclically, the cost of it can not be taken into account;
- since we are talking about the Parking of the vessel in the emission control zone, the fuel pumps of the main diesel and diesel generator with a total capacity of about 8 kW are stopped. Diesel generator diesel fuel pump of 2.5 kW is in operation.

Ensuring the operation of all the above electric motors is the load on the running diesel generator.

As mentioned above, the main steam consumer is the main engine, the cooling water temperature of which is recommended to be kept below 80°C. This temperature is maintained only by the operation of the boiler, since the heating system of the main diesel engine from the running diesel generator on the ship is absent.

In this situation, it is possible to think about the use of an electric heater for the cooling water of the main diesel. Experience of installation of such heaters exists in shipbuilding. The equipment is quite compact with its own pumping pump, power less than 2 kW. This allows one to switch off the main diesel cooling pump (30 kW). The main consumers of electricity are two-section heaters with a capacity of 18 + 18 kW. They can work separately and in parallel. The thermostat provides water heating up to 95 degrees. When using this device, embedded in the cooling system, the need for steam for the main diesel engine disappears. There is no need to worry about the heating of the fuel system – the main diesel is always ready for start-up, the system is pumped with diesel fuel, as it was 30-40 years ago on old engines when approaching and exiting the port and was considered a common practice [3, 4].

3. The result of the implementation of the heater and cooling water diesel

Advantages of main diesel cooling water heater operation are as follows. It:

- reduces the operating time of the boiler and pumps serving it;
- reduced load on the auxiliary engine, respectively, reduced fuel consumption;
- remains possible to produce fresh water when starting the desalination plant without the operation of an auxiliary steam boiler. There is an experience of obtaining up to 10 tons of water per day, i.e. the issue with water for the crew and boiler water is removed.

However, in this embodiment, there is an additional question – how to warm water for the crew. We suggest to replace a conventional steam heater to paraelectricity. Experience with the installation of such units is also available. The maximum power of the unit is 15 kW.

In connection with the withdrawal from the operation of the steam boiler, there are certain concerns associated with:

- heated sludge tank of heavy fuel;
- the operation of oil separators of the main diesel and diesel generator, where steam heaters are used;
- maintenance of the utilization boiler in a hot condition (water circulation in UK is tied on a steam-water drum of the auxiliary boiler);
- evaporation of water from the sludge in the incinerator tank.

Of course, the standard heating by steam removes all these fears. However, experience shows-preheated, full sludge and consumable fuel tanks have insulation and cool down for several days. The oil separator of the main diesel engine at the Parking can be stopped, switched on only before preparation of the main diesel to work. The oil separator of the diesel generator somehow works sporadically, can be put out of work at short-term riding at anchor, at long riding at anchor it can be started, combining boiler start for a day or two further to return everything to an initial state. The utilization steam boiler does not require heating throughout the riding at anchor lot, it can be heated only before going on a flight after the introduction of the auxiliary boiler. Similarly, all procedures for evaporation of sludge should be postponed for the time of the transition of the vessel due to the "free" steam from the disposal boiler [5, 6].

4. Payback of modernization

Let us consider the issue of payback of the discussed modernization. The cost of a good steam-electric water heater for domestic consumers is about €5300, a heater for cooling water of the main diesel – about €7700 or only €13 000 (about $14 200). In physical terms, it is the equivalent of less than 34 tons of diesel fuel. If we assume that the installation costs are equal to the cost of the equipment (once during installation), the total cost will be the equivalent of 68 tons of diesel fuel. With the significant reduction in fuel consumption, the payback of these heaters, including installation, can take 2.5-3 months. Then there is only the attractiveness of the vessel for potential charterers.

If the vessel has an electric heater of domestic water, as well as a general cooling system of the main and auxiliary engines, which allows you to organize the heating of the main diesel from the diesel generator at the riding at anchor, no cost of modernization is required at all. However, such systems are increasingly rare. To obtain a good economic effect, only organizational measures are needed [7].

5. Conclusion

In total, about 130 kW of the load on the diesel generator is excluded and replaced by its existing reduction. It gives not less than 0,4 t of economy of diesel fuel per day and, respectively, decrease in quantity of emissions in the atmosphere, even if it is low-sulfur fuel. This is saving up to $170 per day at the price of diesel fuel of $420 per ton. Moreover, the auxiliary steam boiler shut-off valve is closed, the boiler is removed from operation. Only one diesel generator remains in operation. The daily fuel consumption for the power plant is reduced to 2.0-2.3 tons instead of 4.5-5.5 tons. Diesel fuel economy is up to 2.5-3.0 tons. You can argue that it is little, and the charterer pays for the fuel. This is true if the ship is chartered. However, reduction of fuel costs is already an advantage of the operator and the ship owner if the vessel is out of charter and it is his expenses.

The overall effect can be found by calculating the duration of the considered modes of operation. Having processed the ship's logbooks for 16 months from the beginning of the entry into force of the new rules (2015, 2016), it was found that during this time in the standby mode the average monthly parking of the ship in the controlled release zones amounted to an average of 9 days. Thus, even taking into account the short-term launches of the auxiliary steam boiler in a month, one can save up to 20-25 tons of diesel fuel, which is equivalent to saving up to $10,000. 200-300 tons per year per vessel is almost one full bunkering, which can be avoided [8].

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