WASHING PROCESS OF CARGO TANKS ON TANKERS FOR TRANSPORTATION OF CRUDE OIL

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ABSTRACT

The paper deals with the system employed for washing cargo tanks that are used aboard ships to transport crude oil. Tankers that are designed for the transportation of crude oil must be in accordance with the regulations of IMO - MARPOL, a system for washing crude oil cargo tanks and slop tanks.

Using the system for cleaning tanks is among the most important operations on ships designed to transport liquid cargo, whether it is crude oil, petroleum products, or various chemical products. The task of the system is the removal of the residues left behind during the change of cargo, maintenance, supervision, and inspection of tanks.

A significant progress in the area of transportation of crude oil has been made by a new development of principles known as "Crude Oil Washing¨ (COW), or [1]cargo tank washing system. The system is based on the principle that the apparatus for washing tanks (jets) uses crude oil, i.e. the cargo being transported. Residues from the tank surface are simply removed by jets of crude oil, and are subsequently pumped out with the rest of the cargo.

The solution of using crude oil in the process of washing tanks on tankers designed for the transportation of crude oil is much more economical than the use of sea water. It has eliminated large amounts of oily water after washing, resulting in a smaller quantity released into the sea, thereby reducing the possibility of environmental contamination.

Keywords: tanks washing, crude oil, jet, sea water

1 INTRODUCTION

The process of washing the cargo tanks by means of crude oil represents a complex set of specific procedures, which depends on the type and design of the ship, the type of cargo transported, as well as the specific requirements of environmental protection. Thus it determines both the medium used for washing and the cleaning system itself. Each system must include the preparation of the medium used for washing, its distribution to the washer, and its management after the washing process. The main operations are pre-wash, rinse, drain, and drying off. If during the washing, different cleaning chemicals are used, the pre-wash operation is performed to remove thick layers of residual cargo on the compartment walls and the tank bottom [1]. The pre-wash is best done immediately after unloading, as it will be far easier to remove the remains before they start to stiffen. Washing removes the residual cargo layers. Rinsing tanks and the entire pipeline, as well as other element within the system, with

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fresh water is necessary after the use of aggressive media, such as chemicals or sea water. The tanks need to be dried by means of ejectors, and the entire system thoroughly dried off by compressed air. The selection of appropriate operation of washing tanks and the preparation of media for washing depends on several important factors, such as the amount and type of cargo that need to be cleaned, a new type of cargo that will be loaded, the number of tanks to be cleaned, the type of coating on the tank surfaces, as well as the available time.

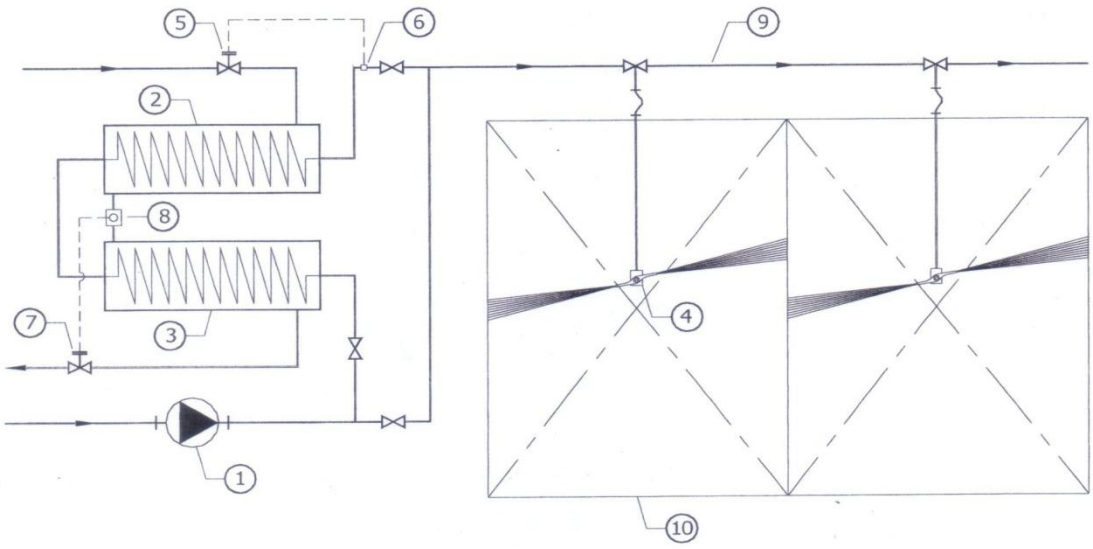
2 MEDIA USED FOR TANK WASHING

As a medium for washing the most frequently used is sea water (hot or cold), sea water with added chemicals, fresh water, and the cargo itself if it is crude oil. Washing by jets of sea water is carried out immediately after unloading of cargo. Sea water can be pre-heated or heated in a special slop tank. If using chemicals, the washing medium is prepared in the slop tank by adding 1 – 2 % of chemicals and circulated in a closed circuit of the slop tank via a device fitted with nozzles and back [2]. Washing by means of cargo is done by a jet of heated crude oil during the unloading of cargo, which dissolves the deposits of crude oil on the tank walls. In this way, there remains only a small part of the deposits, while the major part is pumped out with the rest of the cargo. Systems that are installed on new ships provide the possibility of using all these media and their specific washing operations.

3 STRUCTURAL SCHEME OF THE SYSTEM FOR WASHING TANKS WITH SEAWATER

Figure 1. schematically shows simplified system for cleaning tanks of liquid cargo with equipment for heating the sea water, the pipeline on the deck, and spray devices placed in the tank.

A system for the washing tank is composed of pumps (1), sea water heaters (2),the condensate cooler (3), pipelines and washer nozzle (4). The system also includes the steam control valve (5) located in the steam pipe conducted for heating. The amount of steam for heating is regulated by the output temperature of sea water from the boiler through the sea water temperature sensor (6). Condensate control valve that regulates the state of the condensate through the float set to maintain the level of the exhaust pipe between the heater and condensate cooler. By a pressure pump sea water is supplied to the washing devices placed in each tank, so that by powerful jets cargo residues are removed from the tank surface. Prior to this, sea water is heated up to the required temperature through the condensate cooler and a steam boiler [3].



1. Pump
2. Gastec sea water
3. Condensate cooler
4. Washer nozzle
5. Steam control valve
6. Sea water temperature sensor
7. Condensate control valve
8. Condensate level regulator
9. Pipeline on the deck
10. Cargo tanks

Figure 1: The basic scheme of a system for cleaning tanks with sea water

4 WASHING SYSTEM FOR CRUDE OIL CARIER TANKS

Crude oil carriers must have, in accordance with IMO – MARPOL, a system for washing crude oil cargo tanks. Washing is done simultaneously with the unloading and the system is called the Crude Oil Washing (COW).

Figure 2. shows a ¨COW¨ system mounted aboard a suezmax tanker, built in the shipyard ¨Brodosplit¨, Croatia.

The main elements in the system are the pumps, a Butterworth sea water heater, spray devices in the tank, a drying-off ejector, an oiling control unit, i.e. a Discharge Monitoring, and the pipelines. For supplying crude oil to COW system the cargo pump pressure is used [4]. The supply must provide a sufficient amount and adequate pressure for the proper operation of the majority of devices in simultaneous washing. The cargo pumps are used in the system of sea water as well, by means of closed circuit slop tanks. In the system of washing tanks with heated sea water fire pumps can also be used. The pump has a suction on the ballast system or, if fresh water is used for rinsing, on the fresh water tank.

The pump capacity is by 5 – 10 % higher than the total capacity of all the washer nozzles. The sea water pressure supplied to the system is approximately 15 bar.

The fire pump is connected to the main wash line via a removable pipe section and an irreversible flap. Sea water is through the pump directly conducted to the wash main located on the deck, or may be previously discharged into the sea water heater.

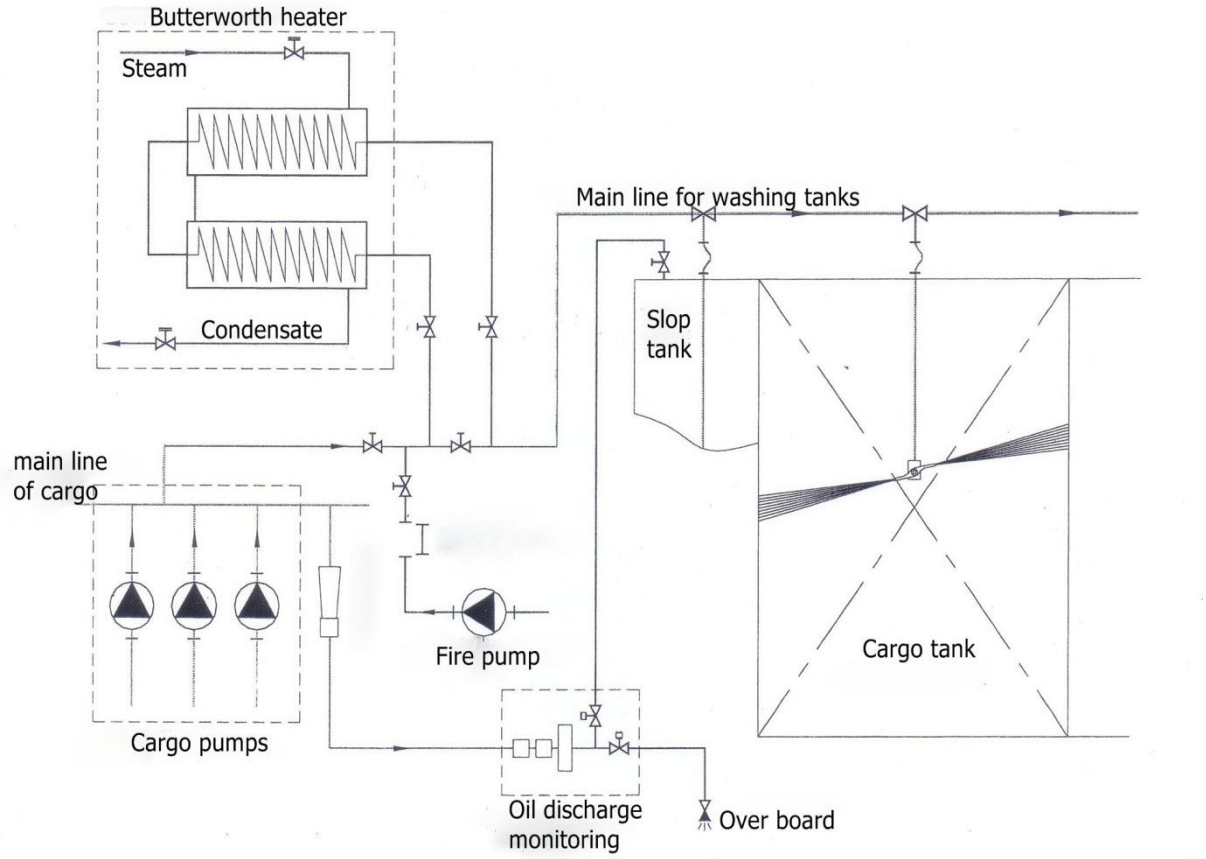


Figure 2: Diagram of the system for cleaning tanks on crude oil carriers

The tank cleaning system has been deigned with the following options for the cycle:

- Crude oil washing system during unloading,
- Wash with warm sea water,
- Rinsing with heated sea water using closed circuit slop tanks,
- Rinsing with heated fresh water.

The primary system is a system of washing of cargo tanks with crude oil, performed simultaneously during the unloading of liquid cargo. The tanks are washed by a jet of crude oil, obtained from the cargo pipeline pressure side. In order to facilitate unloading, the oil is heated at the bottom of the tank near the intake. A stream of heated crude oil dissolves the residual deposits on the structure and the walls above the cargo level, thereby enabling them to be unloaded with along with the rest of the cargo.

By using this system, minor amounts of residual cargo plaque remain in the tank, which are, if necessary, subsequently washed by heated sea water. Tankers are fitted with special slop tanks, most usually two: one clean and the other unclean. Slop tanks are used primarily to accommodate a mixture of oil and sea water that accumulates after washing with heated sea water. While washing with sea water in a closed circuit using a slop tank, a suction pump in the clean slop tank powers the washing mechanism and the ejector draining into the unclean slop tank. Washing with sea water is usually followed by rinsing the tanks, as well as the entire system with fresh water in order to protect it from the aggressive action of salt.

4.1 Sea water heater

Sea water is heated in the Butterworth sea water heaters. The heater capacity usually has to be such that it can heat 120-200 m^3/h of sea water to a temperature 85-90 °C using a

steam pressure of 10-14 bar. For the purpose of heating fresh reduced steam is used, or the steam obtained from the main and auxiliary machinery.

Figure 3. shows a two-stage Butterworth heater which consists of a heater (1) and a condensate cooler (2). The unit also contains a safety valve spring (3), a pressure gauge, a thermometer, and a device for blowing and exhaust.

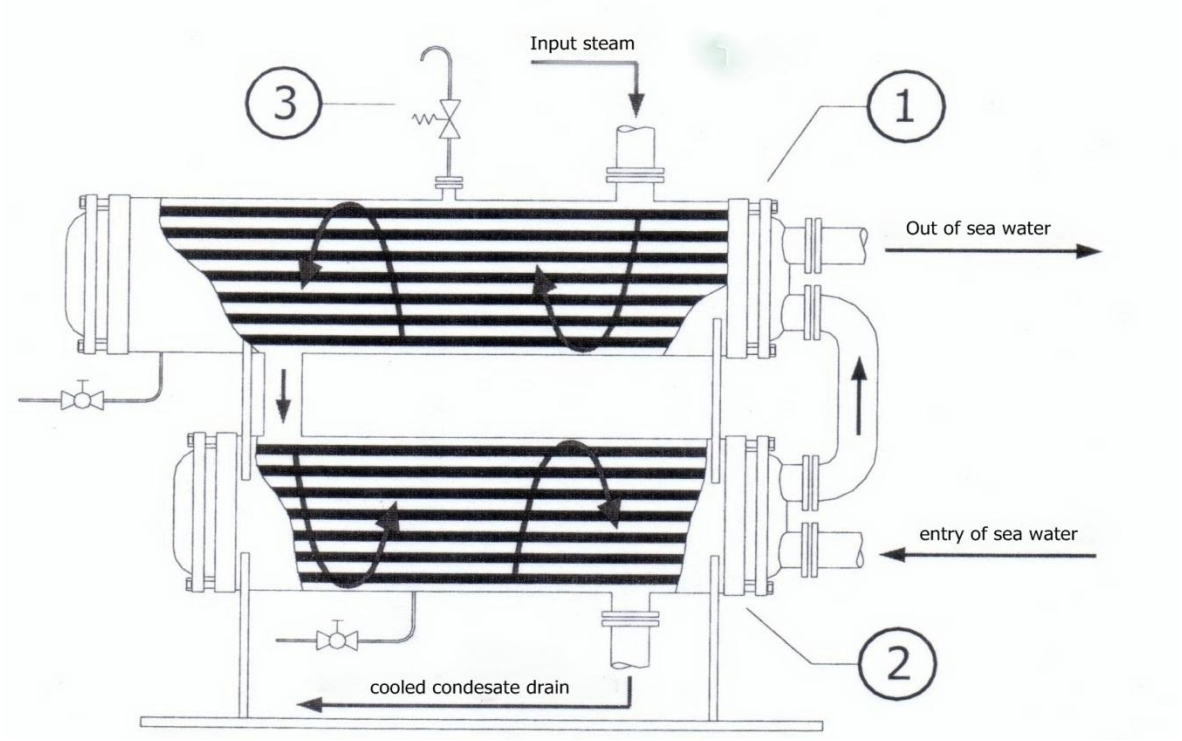


Figure 3: **Butterworth heater**

The steam condensate heater and cooler represent heat exchangers fitted with a jacket and the pipe unit. To ensure the thermal expansion, U pipes are used, inserted into the pipe plate with the inlet chamber. The pipes are designed so that they can be easily cleaned or replaced. The condensate cooler Butterworth design is identical to the heater on the sea water side, while on the steam side it is differently designed in terms of the diaphragm ensuring the stream flow. Sea water is conducted through the pipe unit to avoid the corrosive effect of sea water to the jacket. The heat transfer coefficient is limited by circulating sea water through pipes so that its velocity does not exceed 1.2 m/s.

In order to utilize the advantage of heat, sea water first enters the condensate cooler, where its temperature is increased by the heat transferred from the heated condensate, thereby ensuring at the same time the cooling of the condensate the pre-heating of sea water. The pre-heated sea water the steam heater where its temperature is raised to required final temperature. In recent decades, both the heater and the cooler have come to be designed as a single unit [5].

4.2 Washer nozzle

The heated crude oil or sea water after heating is conducted through the main washing pipeline and supplied to each tank, i.e. to the nozzle-fitted washing device. Each tank should be equipped with a sufficient number of devices, distributed and arranged so that they should enable both horizontal and vertical surfaces to be washed by directly washed by jets, or else be rinsed off by an effective repelling of the jet [6]. The number and position of the washer devices should be such that they create the least amount of shaded areas of the steel structure, which cannot otherwise be effectively washed. The devices can be fixed, i.e. attached to the tank, or portable, lowered into the tank through special openings fitted at its top.

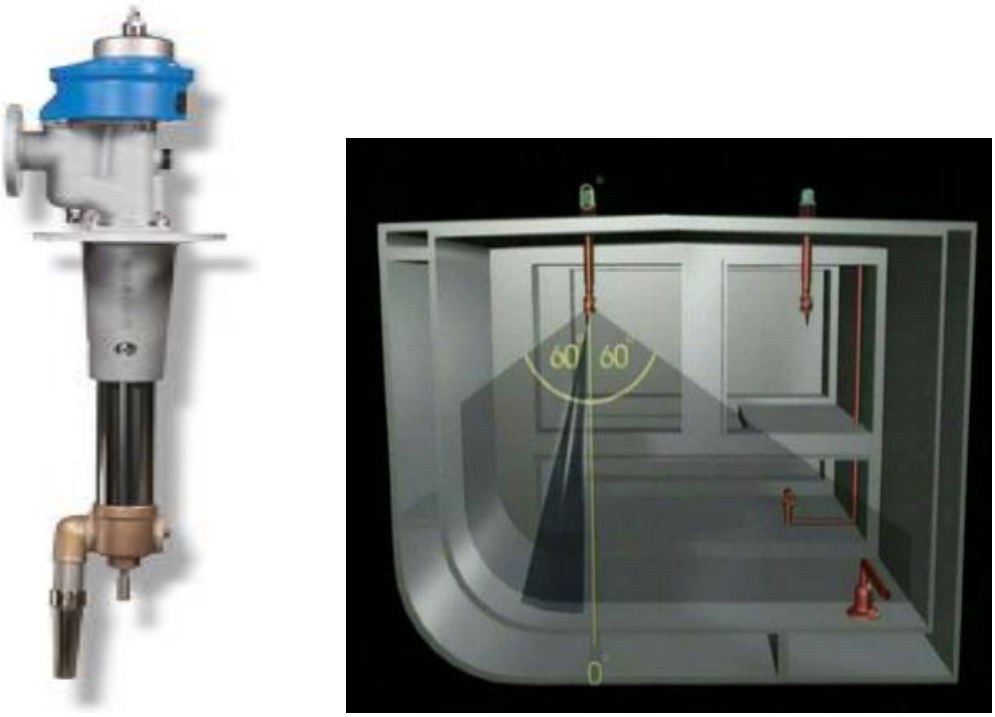


Figure 4: **Fixed washer**

Figure 4. shows a Sweden manufactured ¨SCANJET¨ fixed washer nozzle, mainly used aboard crude oil carriers. It consists of a casing with a driving turbine attached outside the tank and nozzles placed within the tank. The washing medium under pressure enters the casing and drives a turbine which is located on the shaft and continues through the tube to the nozzle into the tank. The bottom part of the shaft features a worm screw and a worm wheel through which the nozzle rotates, both on a horizontal plane and around its own axis.

The device performance is dependent on the washer nozzle diameter, the number of nozzles, the operating pressure, the programmed motion, and time.

Figure 5: Fixed device with parts for the regulation and programming

Figure 5. shows the upper parts of the device with speed control, positioning and jet motion programming.

The nozzle rotation speed around the vertical axis can be adjusted by changing the rotation speed of the driving turbine with speed control bolts located on the bottom of the device. An indicator bar shows the current position of the nozzle. When the rod is in the down position, the nozzle vertically points downwards. To ensure drainage, the nozzle can be brought to this position by turning a crank mounted at the top of the indicator rod.

The nozzle rotation speed around its axis, i.e. the lifting speed, is programmed by using the programming keys located on the top, under the protective cover. By simply pressing the keys the angle of the nozzle per one revolution is determined. By programming the motion as necessary, or by adjusting the speed of rotation in both directions, the washing time, as well as the quality of tank surface washing, can be directly influenced.

5 CONCLUSIONS

Pollution of the sea and the environment in general presents is a serious threat to human health, as well as the entire ecosystem. Large quantities of oil and hazardous substances are released into the sea as a result of standard activities in the exploitation of the ship due to ejection, emission, discharge, spillage, or leakage occurring at liquid cargo handling, cleaning and rinsing tanks and preparing them for the next loading. Earlier, tanks were washed with water which caused a number of problems, raging from separation of oil and water, to corrosion and pollution.

Today, the use of the COW system (Crude Oil Washing) has proved to have a number of advantages. Among other things, it has resulted in a better quality of cargo unloaded, the increased amount of cargo since much less remains on board, the reduction of corrosion and manual cleaning of deposits, and, most importantly, due to a decreased extent of washing, a significant reduction of sea pollution.

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