CONSTRUCTIVE SOLUTIONS TO REDUCE THE NOx AND SOx IN THE MARINE BOILER BURNERS.

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Abstract:*. The modern world is facing two challenges - firstly, the energy crisis related to fuel the other - environmental degradation, especially in the form of air pollution and its consequences - climate change. The regulations demand specifically a significant reduction of sulphur oxide combinations (SOx), carbon dioxide (CO_2) and nitrogen oxide combinations (NOx).*

Keywords:*burner, combustion of fuel in boilers, reduction of sulphur oxide combinations (SOx), nitrogen oxide combinations (NOx), hook-up control box, heat transfer.*

1. Introduction

The modern world is facing two challenges - firstly, the energy crisis related to fuel the other - environmental pollution, especially in the form of air pollution and its consequences - climate change [1-3].

Fuel represents 3/4 of the transport costs for ships carrying oil (tankers). An international ship trading company uses more than 370 million tons of fuel each year [5], in terms of sustained upward trend in the prices of heavy fuel used in the operation of main marine diesel engines.

High oil prices leads to a spiraling increase in the prices of many goods and services production chain associated with an increase in the prices of maritime transport.

A boiler burner is a device in which fuel and air are mixed in order to provide efficient combustion and to generate heat power. A continuous combustion process of gas and liquid fuels is ensured by means of burners. Modern fuel oil burners are complex devices consisting of many components. These burners comprise different types of control and adjustment systems. Fuel oil burners are manufactured as separate modules that can be fitted to different types of burners [4].

2. Problem discussion

There are several technically and economically acceptable techniques for reducing emissions. In economic terms, these techniques are much more efficient than previous methods of reducing emissions. Methods to reduce emissions of sulfur dioxide are switching from fuels with high sulfur content to those with low sulfur content and the introduction of technology to purify.

3. Objective and research methodologies

A lot of parameters affect the quality of the combustion process and the resulting emissions. These include burner adjustment, geometry of the furnace, fuel pressure, maximum values of the temperature and the pressure in the combustion chamber (furnace space), values of the air temperature and pressure [1]. The fuel atomization can be optimized further in the operational process through analysis of the burner flame by means of the testing station.

Flame combustion is accomplished by means of burners. It is widely spread. This is the oldest method for fuel burning. It is used in boilers, furnaces, technological equipment and engines. With this type of combustion the flame is a stable flame in a regular shape. The shape of the flame depends on;

- type (form and design) of the burner;
- the degree of mixing of fuel and oxidant;
- the stream of the burning mixture.

The front of the flame is the boundary between the core and the ignition area. The core is an area where the main ignition parameters are formed. The shape and the size are determined by the intensity of the mixing of the fuel and the oxidant.

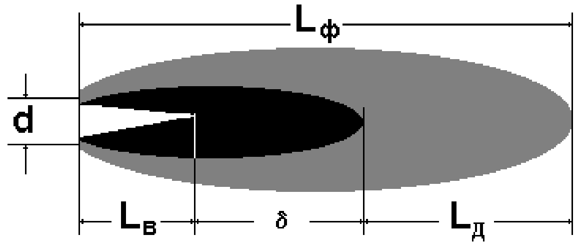

Fig.1 A scheme of flame combustion

L_B - ignition area
D – combustion front, has thickness less than L_B and $L_ф$
L_L – forcing area; has an elliptical shape
$L_ф$ – length of flame as a whole; has an elliptical shape

The flame is externally seen as one dark cone with a light elliptical area. The efficiency of combustion is determined by the total length of the flame [4].

The German manufacturer, SAACKE recently unveiled their low NOx boiler ship FMB-VF, specially designed to reduce NOx emission [6] – see Fig.2.

The boiler have the following characteristics:

– Vertical two-pass fired boiler;
– Design allows very high operational reliability;
– Designed to incorporate proven low NO_X Combustion Systems;
– Flue gas recirculation enables compliance with current and known future emission regulations;
– Optional water injection possible.

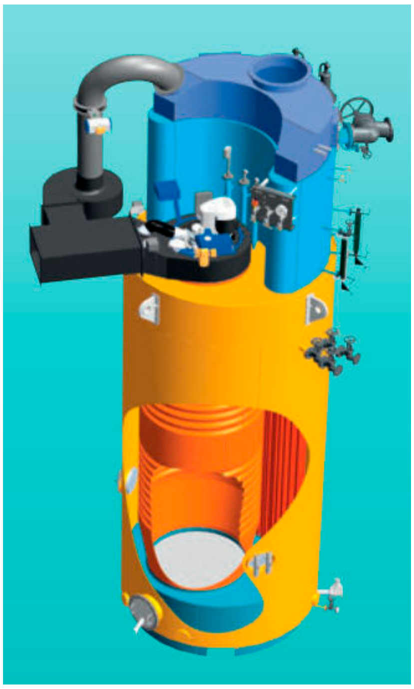

Fig. 2 Fired Marine Boiler SAACKE FMB-VF

The FMB-VF-LONOX is a vertical two-pass fired boiler. Heat transfer is performed through the corrugated or plain flame tube furnace and a number of plain smoke tubes. The design of the flame tube entrance for burner mounting allows a minimum of burner refractory which significantly enhances operational reliability.

The FMB-VF-LONOX boiler is designed to incorporate proven Low NOX Combustion Systems. In order to meet lowest emission levels the boiler package is equipped with flue gas recirculation. Flue gas recirculation, in conjunction with Marine Gas Oil (MGO) fuels, enables compliance with current and known future emission regulations and will allow boiler operation in ports worldwide. For Heavy Fuel Oil (HFO) firing the combustion system can be equipped with water injection to improve solid particle emission levels.

The burner has a rotary type, it can work with more types of fuel, and gas. Rotating cup burners have been developed as a result of the efforts to eliminate the usage of steam (air) when atomizing HFO and to ensure efficient performance for all modes of operation. With the rotating cup burners the fuel is atomized centrifugally. Various designs of this type of burners exist [4].

Rotating cup burners are the most sophisticated type of burners at present. Atomization is accomplished by means of a conical cup rotating at a speed of 4500÷8000 rev/min. They have the following characteristics:

- reliable, not sensitive to the degree of purity of fuel due to the lack of narrow channels;
- there are no high-pressure and high temperature pipelines that involve risks and dangers;
- depth adjustment d=18÷20;
- fully automated;
- complex design; hard to repair;
- efficiency depends on the change in the orifice section of the fuel channel;
- the primary atomizing air stream can be supplied by the main fan but more often it comes from a fan mounted on a common axis with the rotary cup and moving along with it – fig 3.

SAACKE Marine System has designed a system for delivering fuel and improvements in settings it is possible to adapt to all types of marine boilers. Design etc. "hook-up control box" is made in such a way that each type of boiler control panels can be revamped to safely and reliably burning light fuel without modification of existing PLC programs.

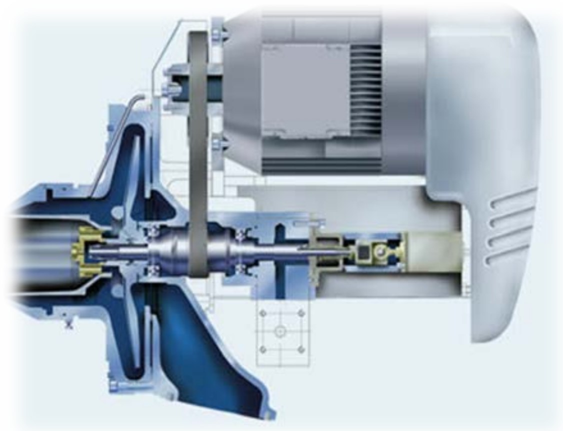

Fig.3 Rotating cup burner

All necessary additional control, signal and safety loops that are necessary for reliable and safelight fuel oil combustion are contained inside the hook-up control box. The interaction between the hook-up control box and the original boiler/burner control panel is solely made by hard-wired signal transfer from/to already existing (or duplicated) input/output terminals of the original boiler/burner controls.

In this way, any modification of the existing approved burner sequence controls and/or PLC programs is avoided, so that the already given approval of the original system is not invalidated by the modification.

Additonal safety shut-downs required in light fuel oil combustion mode are implemented into the existing hard-wired safety circuit by adding the corresponding number of relays, triggered by signals from the hook-up control box. The function of those can be easily confirmed during the function test in presence of classification surveyor after completion of the modification works [6].

Summary of features of the SAACKE Marine Systems solution:

- Complete separation of LSFO (MGO) and HSFO systems and 100% protection of the LSFO storage and service tanks from contamination with HSFO.
- Very short change-over time to LSFO (MGO) without the need to drain the FO circulation piping.
- Very short change-over time back to HSFO. The independent pipeline layout allows for permanent circulation and heating of the HSFO ring line. HSFO pumps to be kept in operation for circulating during LSFO (MGO) mode operation.
- Completely independent and redundant controls for the LSFO (MGO) operation mode. Any failure in the light fuel oil operation mode has no influence on the standard fuel oil operation mode controlled exclusively by the original boiler panel.
- Minimized downtime during system conversion. Due to the completely independent LSFO (MGO) supply system installation, the boiler can be used normally during 90% of the

conversion job duration being supplied by the existing fuel oil system.

- Minimized risk of operator mistakes. Due to the comprehensive but simple automation in the hook-up controls, Operator's tasks to change-over from one operation mode to the other is limited to the activation of one single selector switch.

The SAACKE Marine System upgrade kit for Ultra Low Sulphur Diesel Oil (ULSDO) – MGO combustion consists basically of the following mechanical components, some of which are optional items fig.4:

GO 001 ULSDO (MGO) double pump station. Specially designed for operation on low viscosity fuel

GO 004 ULSDO (MGO) suction thermometer

GO 006 Stand-by / low pressure alarm switch

GO 007 Pressure switch/gauge root valve

GO 015 Burner inlet automatic change-over valve with electro-pneumatic drive

GO 016 Burner outlet automatic change-over valve with electro-pneumatic drive

GO 020 ULSDO (MGO) non-return valve

GO 023 ULSDO (MGO) safety valve

GO 025 ULSDO (MGO) temperature transmitter

GO 028 ULSDO (MGO) radiation cooler

GO 030 Control air filter regulator

GO 033 Control air pressure monitor

GO 050 ULSDO (MGO) adjustable overflow pressure limiting/control valve

GO 058 Shut-off / By-pass valve for GO 050

GO 060 ULSDO (MGO) suction line shut-off valve

GO 062 ULSDO (MGO) pump station isolating valve

The SAACKE MARINE SYSTEMS upgrade kit for ULSDO (MGO) combustion also includes the following electrical components:

CGO 010 Hook-up control box for ULSDO (MGO) combustion mode control including MGO pump motor starters

CGO 118 Remote indication display with alarm output for MGO temperature

CGO 131 Local manual stop/repair switch for ULSDO (MGO) pumps

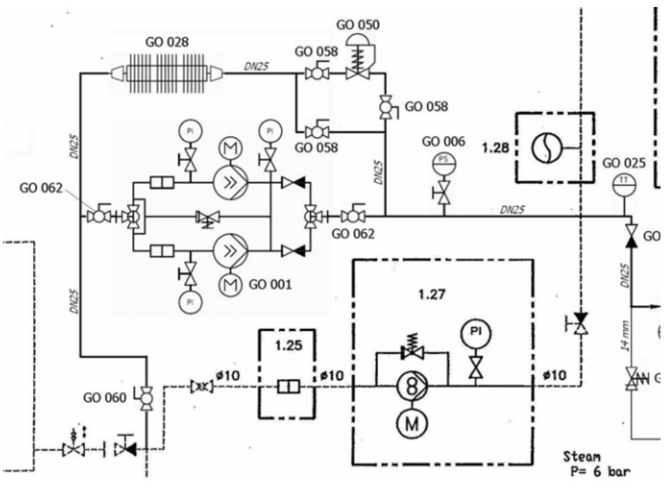

Fig.4 The SAACKE Marine System upgrade kit for ULSDO (MGO)

Upgrade SAACKE Marine System LSFO to provide a separate supply system for low-sulfur content fuel with low viscosity from storage to combustion devices. Initially, the system draws fuel from the reserve tank for light fuel using a pump. Usually the delivery of low-sulfur content fuel with low viscosity is done by screw pump specifically designed and designated for such types of fuels. The fuel passes through the valve GO 060, then through GO 062 and enters the suction side of the pump, wherein there is a filter. From there, the fuel passes through the pump. At the outlet from the pump passes through the tap GO 062. There are 2 loops. The fuel reaches the non-return valve GO 020, which dropped from white to black. This valve is designed to prevent the entry of another type of fuel. The device temperature GO 025 shows the current temperature of the fuel in the pipeline. PSL GO 006/7 is a device for pressure, which maintains the pressure in the system within certain limits. If the pressure falls below a certain value, PSL signal to the computer. The pressure regulator GO 050 is a valve that regulates the pressure of the system (running from 2.1 to 2.5 bar). It is a valve with a spring, which means that if the pressure drop - the valve is opened, and if the pressure rises - the valve is slightly closed. Thus, to maintain constant pressure in the system. This valve connects the suction GO 050 with the discharge side of the pump. The valve GO 058 is a bypass in case you need to repair GO 050 (pressure regulator). The cooler fuel GO 020 serves to maintain the fuel temperature within certain limits.

Boiler run on automatic mode. First goes the fan to purge the furnace. With the departure of fan and pump starts. While the boiler makes blowing, fuel burner valves are closed. Then we have to fuel changeover valve GO 015. Solenoid valves GO 015 definitions if the system running on fuel oil or gas oil. The system is filled with fuel and valve GO 050 maintains a constant pressure, because there is still no fuel. Fuel stop at GO 015 - the valves on the boiler. Once the pressure reached 2.5 bar the three-way valves are opened. When the valve of the boiler is opened, is obtained differential pressure with the pressure regulator GO 050 opens to compensate for the pressure loss.

While the pressure in the system reaches 2.5 bar, the fuel is rotated in the small circle. It maintains a constant temperature of the fuel. The cooler GO 028 is fuel-air type, it passes inside a fuel from outside and is blown from the air. GO 023 is a safety valve. Adjust the pressure slightly higher than what is set pressure regulator GO 050. In the event that becomes a system crash or GO 050 blocks, system pressure will increase and the valve GO 023 will open. Then Gas system will connect to the Fuel Oil System. This will unload system. GO valve 023 will remain open until the system pressure drops below a set point-in which is set.

4. Conclusion

Requirements regarding the purity of exhaust gases from the burners of the ship's boilers will continue to rise. The tendency to introduce increasingly strict limits on greenhouse gas emissions is a result of measures taken to reduce their destructive effect on the environment. The modern statutory requirements for environmental protection include strict restrictions in relation with sulphur admixtures in different types of fuels such as F.O., light fuel oil, heavy fuel oil, and diesel oil. These sulphur limits are already in force for the sea areas defined as SECA (Sulfur Emission Control Area) and they comprise the North Sea, the Baltic Sea, North America and Canada as well as all European Union ports.

5. Literature

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