A TESTING STATION FOR STUDYING THE COMBUSTION OF FUEL WITH MECHANICAL CENTRIFUGAL AND ROTATING CUP BURNERS.

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Abstract:.*The burner of the ship's steam boilers is a device in which air is mixed with fuel with the purpose of burning and supplying heat power. A continuous combustion process of gas and liquid fuels is ensured by means of burners.*

KEYWORDS:*BURNER, COMBUSTION OF FUEL IN BOILERS, ROTATING CUP OIL BURNER, PRIMARY ATOMIZING AIR STREAM, STEAM BLAST JET TYPE FUEL OIL BURNER.*

1. Introduction

A 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.

According to the type of the fuel used burners are classified into:

- fuel oil burners;
- gas burners;
- dual fuel burners

According to how the combustion mixture is formed, the fuel oil burners are classified into:

- mechanical;
- injection;
- rotary cup.

2. Problem discussion

The present paper deals with the issue of bringing the testing station into an operational/ simulation condition in order to exhibit the performance and control of the rotary type burner on the one hand and the two-stage mechanical burner on the other hand. Both types of burners are prevalent in the product range of ship's heat equipment manufacturers due to a number of advantages: the scope of burner control has been considerably increased, the burners are not very sensitive to the fuel viscosity, they are easily atomized, different types of fuel can be used.

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.

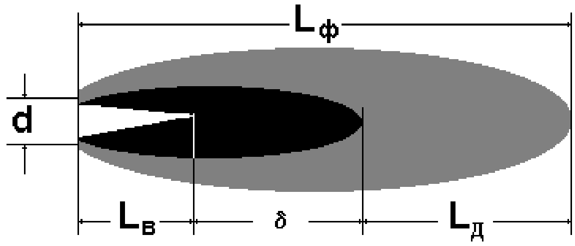

Fig.1 *A scheme of flame combustion*

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. The testing station gives the opportunity of controlling the shape of the flame so that optimum results could be achieved for the specific mode of operation.

The testing station for training purposes is made on a mobile platform and its aim is to illustrate the operation of two types of burners used in shipbuilding. At the one end of the platform there is a rotating cup burner with its service and control systems whereas at the other end there is a mechanical burner type Monarch ("Meteor") manufactured by MP "Spartak" (Burgas) along with its control panel. Both burners are positioned opposite to each other in a "furnace", the upper half is made of transparent Plexiglas to provide for good visibility. When operating the burners use oil from a common tank/ reservoir. Oil is selected as the burning fluid due to safety considerations. The oil drained at the bottom is delivered back to the reservoir by an oil pump. Both burners have an autonomous power supply and they can operate independently – see Fig.2.

Fig. 2 *Testing station for combustion*

The injection burners type „Monarch" are fully automated. Their design has been considered down to the smallest detail and is being kept up-to-date. They meet all requirements for safety, reliability and low cost. The burners have the following characteristics:

– Automatic sequence of operations;
– Stable fan characteristics – good combustion process;

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– Air damper closed on burner shutdown;
– Quiet operation;
– Burner casing hinged to the boiler;
– The design of the burner makes installation, adjustment and servicing easy.

The design, control and operation of the mechanical burner on a testing station are shown in Figures 3, 4 and 5.

Fig. 3 *Burner type „Monarch“*
1.Hinges securing the burner to the furnace;
2. Flame observation port;
3. Asynchronous three-phase motor;
4. Air damper;
5. Pressure gauge for the pump delivery pressure;
6. Pump inlet;
7. High pressure pump;
8.Electromagnetic valves controlling the fuel stream to the burner nozzles

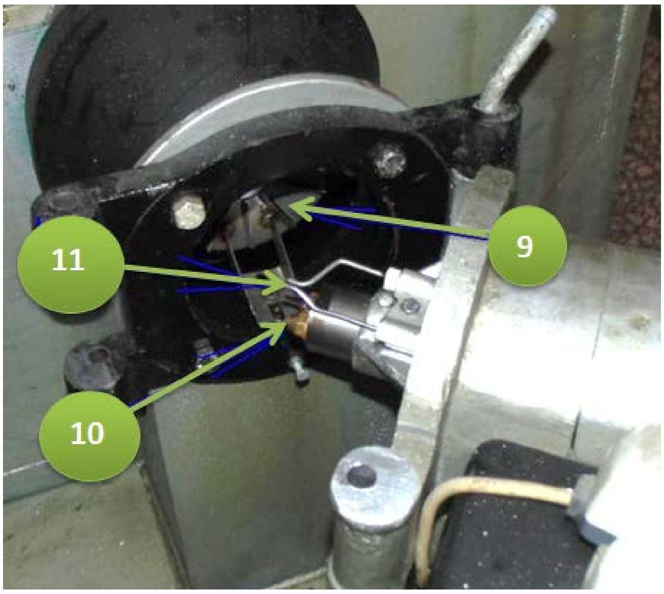

Fig.4 *Burner type „Monarch“*
9. Diffuser;
10. Nozzles;
11. Ignition electrodes

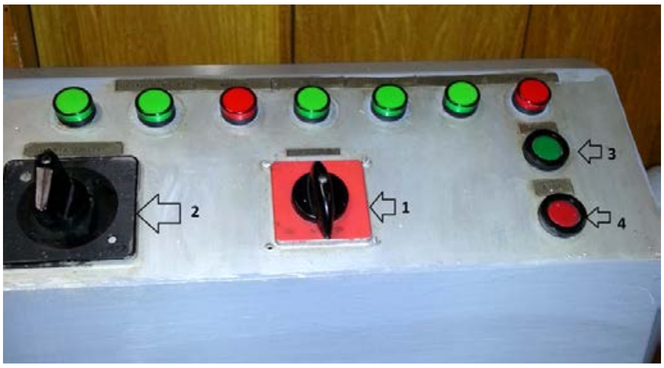

Fig.5 *Burner control panel*

switch 1 – breaking the electrical circuit to the electrical switchboard;

switch 2 –the fluid for the burner to operate on (HFO or diesel oil) is determined;

switch 3 and 4 – start / stop

The electrical switchboard for operation and control of the burner type “Meteor” is fully automated. The switch “1” serves to break the electrical circuit to the electrical switchboard. Switch “2” is used to determine the fluid that the burner will operate on – HFO or diesel oil; this choice is important for the operation of the heater i.e. the electrical heater does not work if the burner operates on diesel oil. When the switch is in position “HFO”, the burner control algorithm activates an electrical heater whose function is to maintain a certain viscosity of the fuel. By switches „3“ and „4“ the burner is started or stopped. Above the control push buttons there are light signals located from left to right as follows:

- Green light „testing station power supply“;
- Green light „cold HFO“- it indicates low temperature of the fuel used;
- Red light „failure“;
- Green light „1st stage“, it indicates that the burner is operating at first stage;
- Green light „2nd stage“, it indicates that the burner is operating at second stage;
- Green light „Heater“, indicates that the electrical heater is operating;
- Red light „overheated HFO“.

When switch “1” is set in position „on“, voltage is supplied to the switchboard and the green light comes on. Voltage passes through three of the fuses and is supplied to a step-down transformer 380V-220V; then to the windings of the seven contactors as well as to the Programmable Time Relay (PTR) and the Motor Time Relay (MTR). After pushing the “Start” button the PTR is activated; as a result of that the asynchronous three-phase electrical motor is activated. As the fan and the fuel pump are connected to the electrical motor axis, both delivery of fuel from the service tank and purging of the furnace start. The time for the furnace purging is measured by the Motor Time Relay (MTR). After the time set expires, the Programmable Time Relay (PTR) supplies voltage to the electromagnetic valve of the first nozzle. Voltage is simultaneously supplied to the ignition electrodes. When the photo relay (PR) registers the presence of a flame, the supply of voltage to the electrodes is suspended and the photo relay starts to measure the presence of the flame. If a satisfactory flame fails to be generated at the first attempt or the flame fails to settle down, the red signal “failure’ appears and an alarm is sounded.

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 [2].

Rotating cup burners are the most sophisticated type of burners at present. Atomization is accomplished by means of a

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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 [3].

Ignition is done by means of a pilot burner on light fuel oil which is automatically extracted from the furnace with certain models of boilers – see Fig.6 and Fig.7.

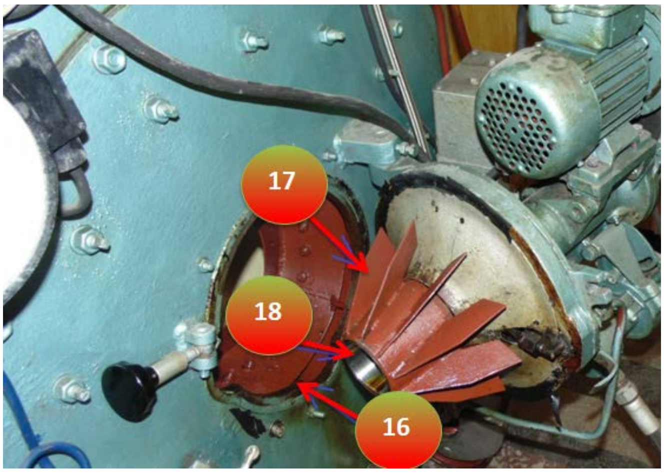

Fig.7 *Rotating cup oil burner*

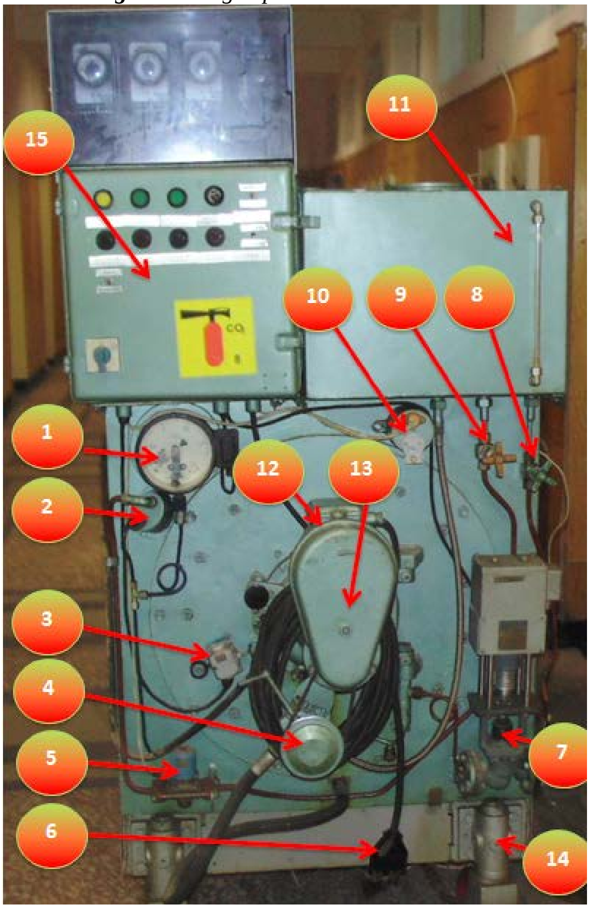

Fig.6 *Rotating cup oil burner*

1. Pressure gauge „U" indicating the fuel pressure in the system after the ignition burner;
2. Ignition torch;
3. End switch "B5"of the main torch;
4. Oil pump;
5. Solenoid valve „S1" for cutting off the fuel to the ignition torch;
6. Power cable;
7. Solenoid valve „S2" for cutting off the fuel to the main burner;
8. Manual shut off valve for the fuel supply of the main rotating burner;
9. Manual shut off valve for the fuel supply of the ignition burner;
10. Lamp imitating the flame „L1" and photo relay measuring the flame;
11. Reservoir;
12. Three- phase asynchronous motor;
13. Rotating cup burner;
14. Wheels;
15. Electrical switchboard;
16. Furnace casing nozzle;
17. Burner casing nozzle;
18. Swirling (rotating) cup;

This part of the testing station for the rotating cup burner is controlled by the electrical switchboard which comprises light signals and push buttons.

4. Conclusion

The method of atomization of the fuel in rotating cup burners and injection (mechanical) burners is an advantage which makes them widely used. They are equally efficient for good quality light and heavy fuel oils which is a particularly important feature for the ship's burners. Some research has proved their high reliability which results in fault-free operation.

The methods and equipment for fuel oil combustion in ship's boilers have been presented in the paper. General description and design of the rotating cup and mechanical burners have been discussed. The electrical circuits for the testing station studying the flame shape and combustion with mechanical and rotating cup burners have been restored and made.

The existing testing station can be used for conducting different experiments in connection with the flame shape as well as with the size of the atomized combustion particles. 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) [4] and they comprise the North Sea, the Baltic Sea, North America and Canada as well as all European Union ports. The present day rotating cup and mechanical burners meet the modern requirements for full automation, potential for unification, high technology, maximum energy efficiency and good degree of environmental protection.

5. Literature

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