

# Startup Boiler for Supplying Steam to Main Boilers in Thermal Power Plants

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## Abstract

In some steam power plants, there is what is called the primary boiler or start up boiler (STUB) or small capacity boiler which is mechanical installation of pipes, pumps and valves uses for exceptional purposes. In case of stoppage of all other power plants in an isolated area or region from the others or in case of war and complete stoppage of the generating units and absence of an electrical resource for operation of plant and its parts, therefore we resort to operating the start-up boiler to generate steam and send it to the large steam boilers of the units in order to operate them and connect the units to electrical grid. After the steam unit generates the load, the start-up boiler should be stopped. This device is available in the south of Iraq in nassiriyahthermal power station.

**Keywords:** STUB, Main Boiler, 13kg / cm<sup>2</sup> Line, Steam Unit.

## I. INTRODUCTION

The main part of thermal power plant is a boiler. The boiler is a closed vessel in which water is heated, steam is generated or superheated under pressure by application of heated resulted from the combustion of fuel.[1]. Chemical energy of fuel in the boiler is transferred to potential energy of steam that supplied to turbine. An electric power station is an industrial plant for generation of electrical energy. A steam boiler is a combination of heating surfaces in which steam is generated from continuously feed water by utilizing the heat liberated on the combustion of organic fuel which is fed into the boiler furnace together with the air required for combustion, the water supplied into steam boiler is called feed water ,feed water is preheated to the saturation temperature and vaporizes and the saturation steam is formed is further superheated.[2].when the steam generating units stop working, for example ( total shutdown ) for any reason and disconnected from the grid, after removing the defect that cause the stoppage, we need electrical resource (voltage) for starting the units from zero or in case of the war in a region and there is no electricity to start the units , we use the STUB to send steam to main boilersand generate steam under pressure of 13kg/cm<sup>2</sup>, it is important line that connects the STUB and main boilers, the advantage of this line for sending steam to boiler drum and fuel for starting the operation of the units . the main boiler drum is used for

separation steam and water and sending it to the turbine. as we said before. the STUB is used for provision of steam knowing that the main boiler for 210 MW has a pressure of 130 kg/cm<sup>2</sup> and the flow rate of the boiler is equal to 670t/hr while the STUB pressure is 14kg/cm<sup>2</sup> and steam flow is equal to 50 t/ hr [3].The founding fathers of contemporary boiler design were George Babcock and Steven Wilox, they patented boiler systems as early as 1867 and in 1891in New York and tubes technology continued to improve through the late twentieth century. Boiler technology continue to evolve, also conventional atmospheric burners which use air from atmosphere in combustion process are being replaced by power fan that force air into the boiler burners by fans and another fan for removing burnt gases from the boiler through the chimney.

## II. DESCRIPTION OF STUB

STUB consists of boiler tubes, air heater, economizer, steam air heater, forced draft fan, induced draft fan, four burners. Dearator, feed water heaters. We will explainthe above terms with figures. The principle of operation of the STUB is to supply steam to the main boilers of the station at a pressure of 13 kg/cm<sup>2</sup> in case of complete shutdown of the station for any reason and we want to restartthe station again. this can be seen in figure 1.

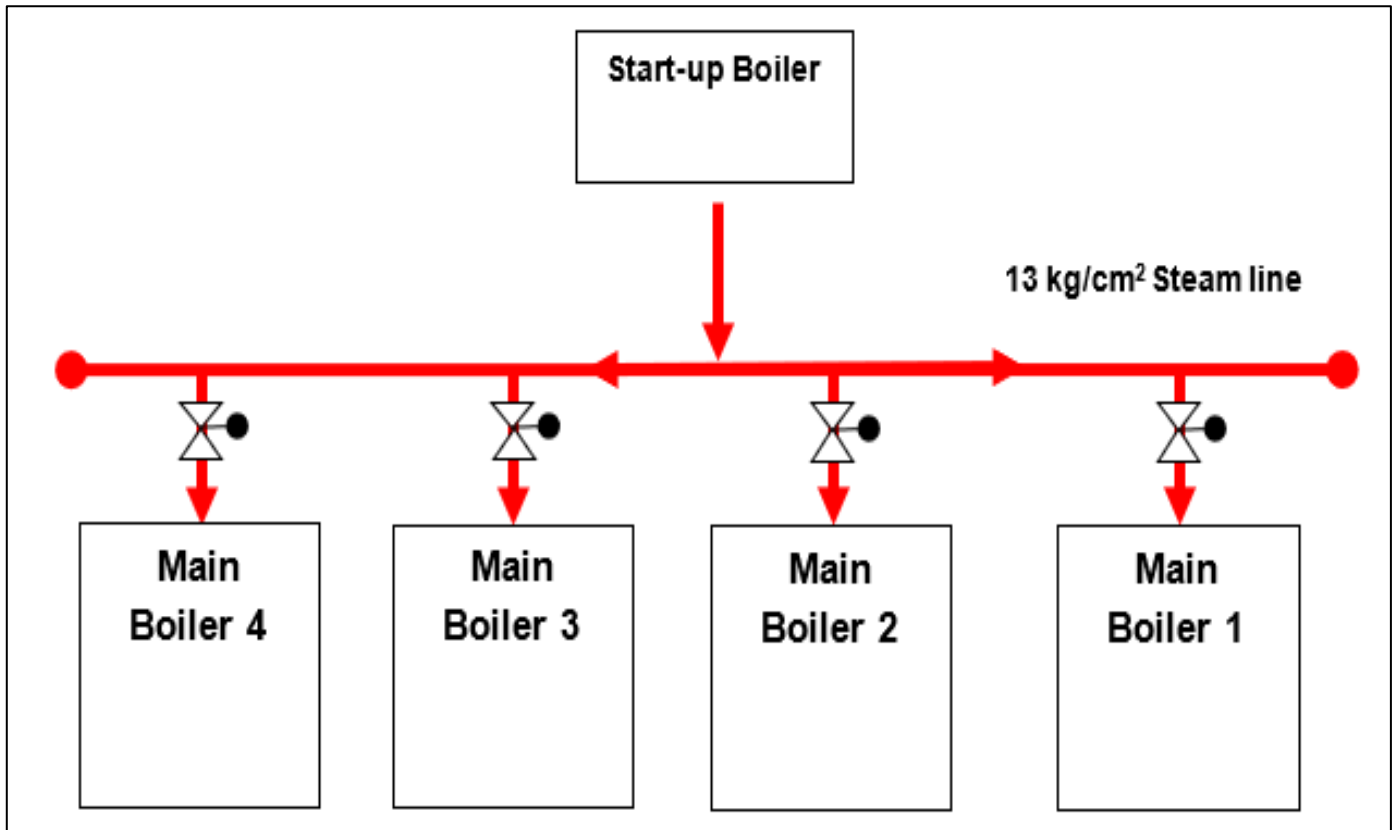


Fig 1 Main Boilers and STUB

➤ *Specification of STUB*

T - 50 / 14 - 250 type with two drum natural circulation firing by gas or fuel oil.

Steam capacity = 50 t / hr

Pressure in the drum = 16 kg / cm<sup>2</sup>

Superheated steam pressure at the output = 14 kg / cm<sup>2</sup>

Superheated steam temperature = 250 °C

Feed water temperature = 100 °C. (specification in details are shown in table no.1)

Table 1 Specifications of STUB.

Denomination of value	No. of operating fuel oil burners					
	1	2	2	3	3	3
1- Steam flow t /hr	10	25	30	40	45	50
2- Steam temperature °C	220	230	235	240	245	250
3- Pressure in drum	13 to 15					
4- Flow of feed water t / hr	66					
5- Temperature of feed water °C	100 °C					
6- Pressure of feed water kg / cm <sup>2</sup>	25					
6- Pressure of suction from dearator kg / cm <sup>2</sup>	1.2					
6 - Automatic changeover of feed water kg / cm <sup>2</sup> .	19					
6- Pressure of mazut before STUB kg / cm <sup>2</sup>	20	20	25	20	25	30
7- Temperature of mazut °C	105 to 115					
8- Air pressure after airheater kg/cm <sup>2</sup>	150	150	170	150	170	185
9- Air temp. before airheater after SAH °C	80 to 85					

• *13 kg / cm<sup>2</sup> steam line*

Steam line 13 kg / cm<sup>2</sup> is considered one of the important lines in power plants. It is a common line for all thermal units and its benefits are as follows;

✓ For giving steam to the main units, in the beginning of the operation of the steam units in order to heat the boiler drum.

- ✓ For cleaning of the furnace's burners in the beginning of operation of the boiler.
- ✓ For heating fuel oil (cold mazut) to 110°C.
- ✓ For making vacuum in the main turbine by supplying the ejector by the steam.
- ✓ For working of gland ejector.
- ✓ For firefighting system.
- ✓ For chemical treatment plant in the power station.
- ✓ For gas receiving station.

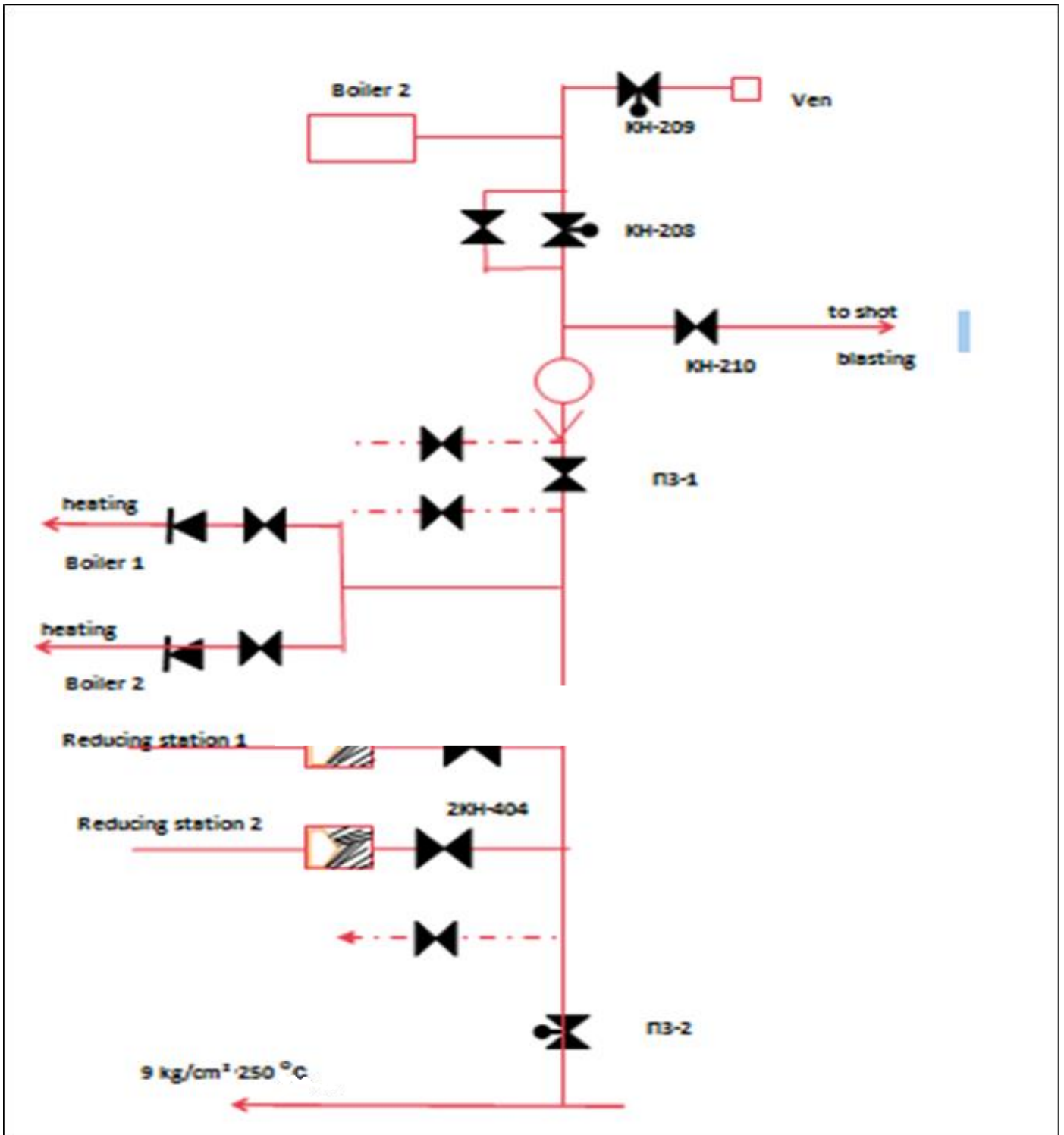


Fig 2 Steam Line of 13 kg/cm<sup>2</sup>

➤ *STUB Structure*

The STUB is a II - shaped design which consist of a fully screened furnace and suspended convective chamber inside in which superheater and reheater are mounted. The economizer is an independent design mounted outside of convective chamber with two-way flue gas circulation. The top and bottom drum are connected with tube forming the water heating system. Inside the bottom drum there is a boiler heating up steam tube loops. The furnace is equipped with four natural gas and fuel oil burners arranged symmetrically in two rows along the side walls of combustion chamber. Those burners are designed so

that they can work either on natural gas or on fuel oil. The natural gas fired burner capacity is 1050 m<sup>3</sup> / hr. The fuel oil fired burner capacity is 1000kg / hr at 35 kg / cm<sup>2</sup> fuel oil pressure. The fuel oil fired burners work on steam blown through the burner at 6 kg / cm<sup>2</sup> pressure. The STUB unit consist of two drum steam generator with gravity circulation, radiation heating surfaces cover the steam chamber walls forming front back, side screens, convective surface as boiler bank, steam superheater, airheater, and water economizer. We will explain what was discussed above in the figure 3 detailed below.

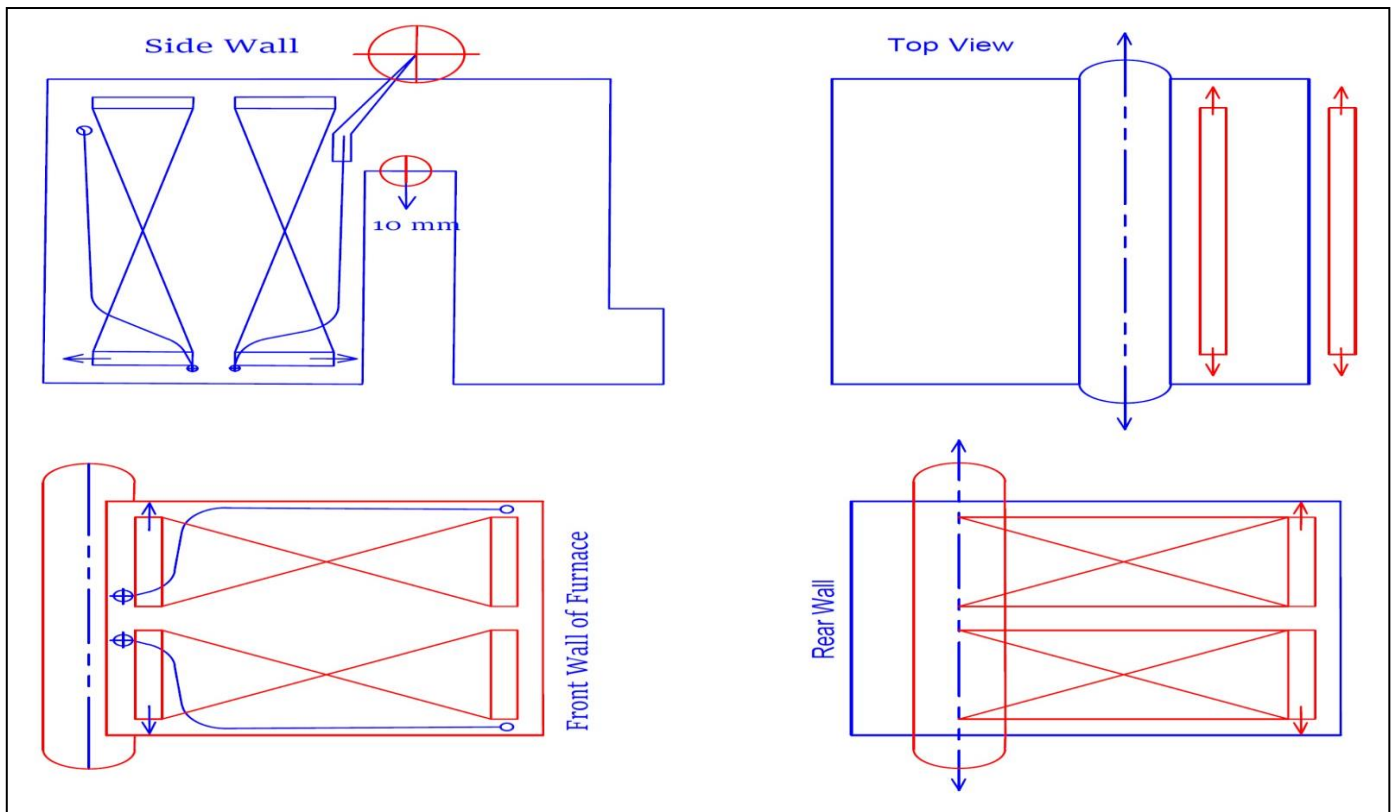


Fig 3 STUB Side, Front, Rear Walls, Top View of Superheater and Upper Drum

➤ *STUB Bank*

The STUB bank comprises upper drum 1476 mm x 36 mm and lower drum 988mm x 22mm (20K Russian metal Gost) and tubes connecting the two drum. The middle row of 16 tubes dia.215 mm and two rows of 14 face tube dia.133mm each present down comers, the

two rows of the face tube dia 133mm are set into lining. The rest 60mm x 3 mm dia. Tubes are riser tubes diameter of 219 mm and 133mm tubes are welded to lower and upper drum which 60mm x 3mm are expanded. This is illustrated in figure 4.

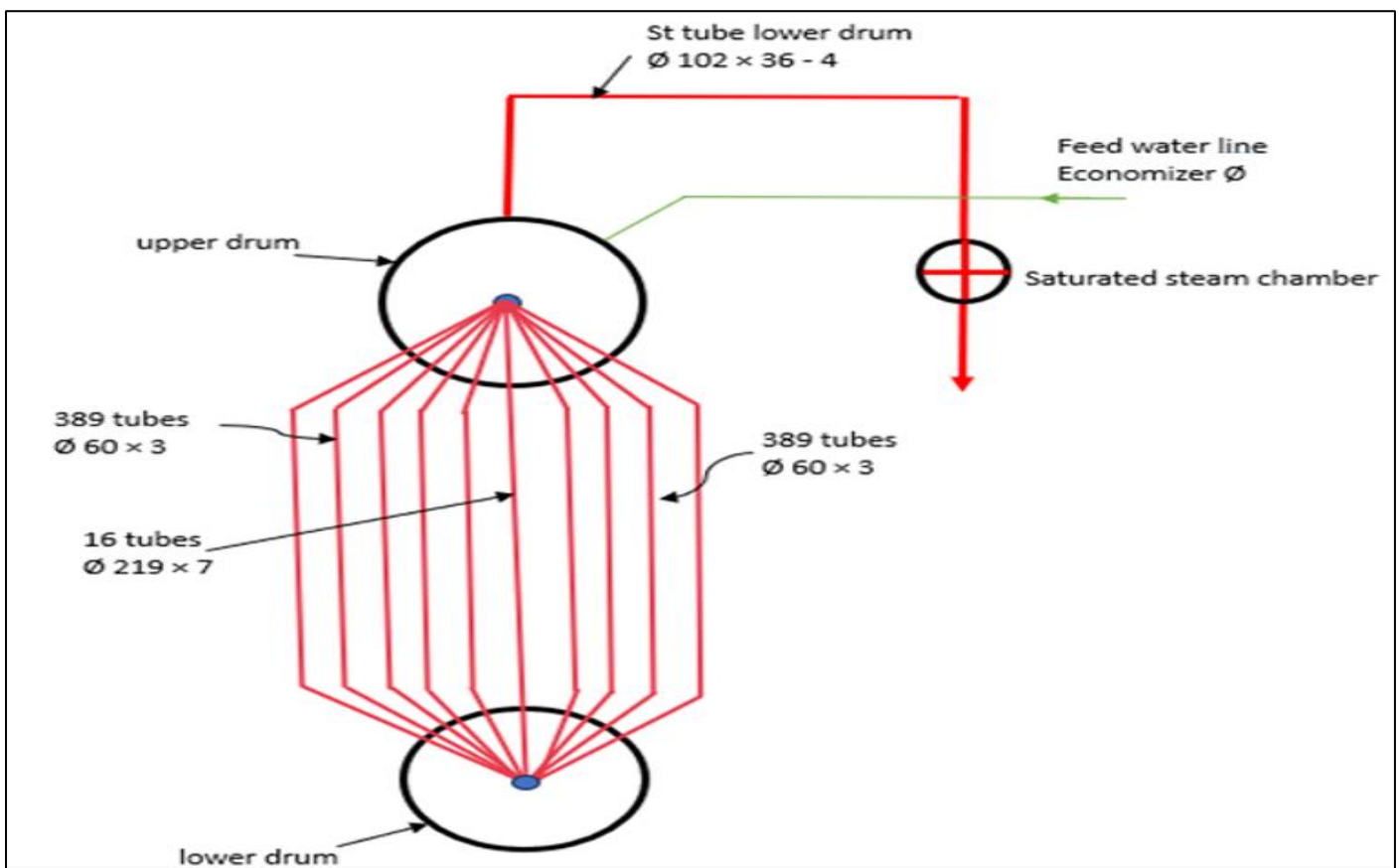


Fig 4 STUB Bank

➤ *Drum Structure*

The upper drum is mounted on two roller supports which allow it to move horizontally when thermal expansion occurs, in order to prevent it to move vertically, drum weld with support. The separation devices are installed inside the drum, the lower drum is hanged on the boiler bank tubes which allow to move both horizontally and vertically if thermal expansion occurs. In the lower drum there is a heating device consist of diameter 57mm steam supply tube and two diffusers connected with tube by reducers ( steam supply for heating is from outer sources). There are three stage of evaporation (1) Ist stage clean compartment (2) II stage salt compartment, include drum volume on both its face. (III) salt compartment, outer

cyclone. The clean compartment is equipped with reflector in the place of water supply mixture ceiling louver and perforated plates. Eight inner drum cyclone are installed into the salt compartment (4 cyclone in each compartment). Clean compartment is divided from salt ones by baffles. The steam is conducted from the outer cyclones to receiving chamber of salt compartment, separated in inner drum cyclones and then passes through the slots in the baffles when it is mixed with steam of clean compartment, further the steam is separated while passing through the ceiling louver and perforated plate from the upper drum, the steam is conducted to steam superheater. As it is seen in figures 5 and 6.

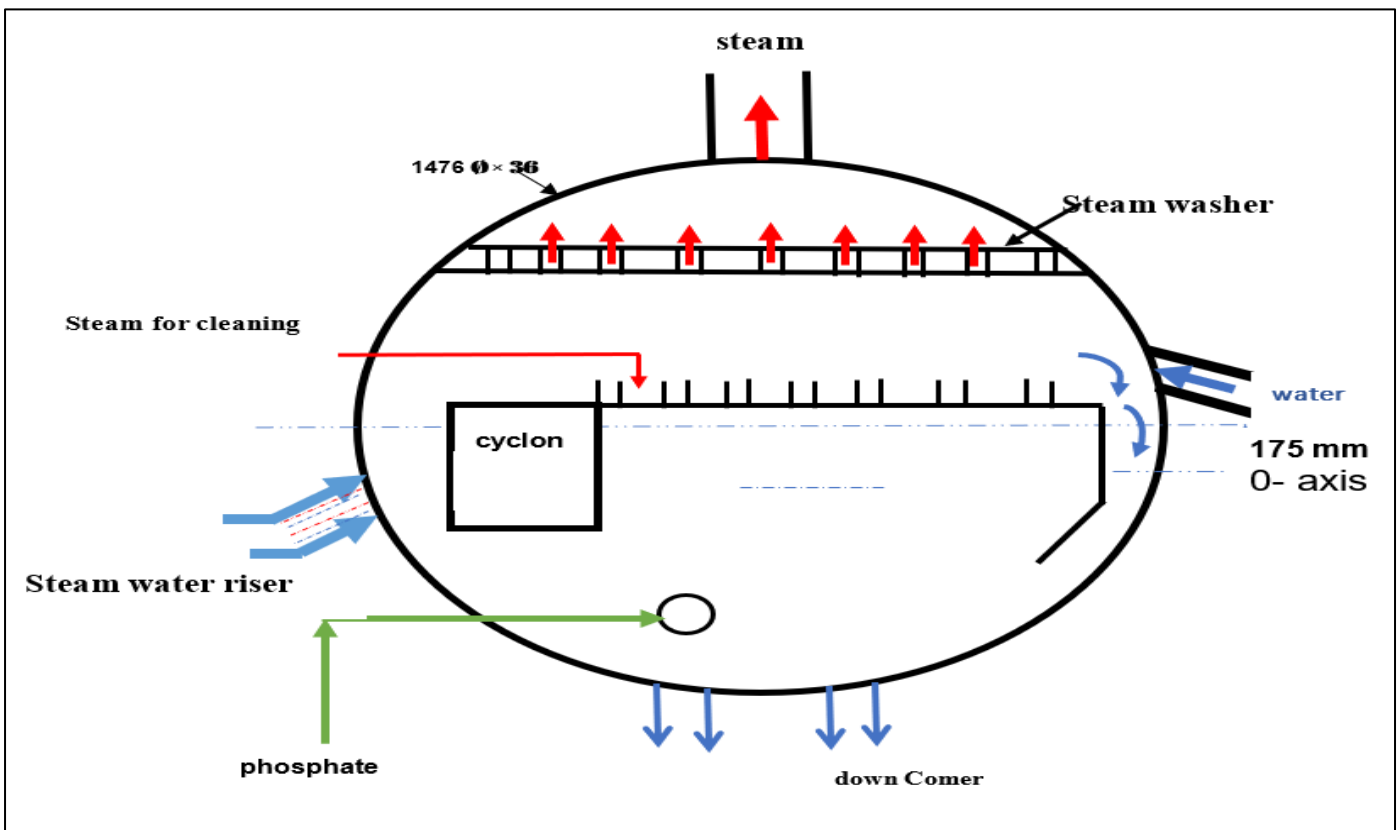


Fig 5 Upper Drum

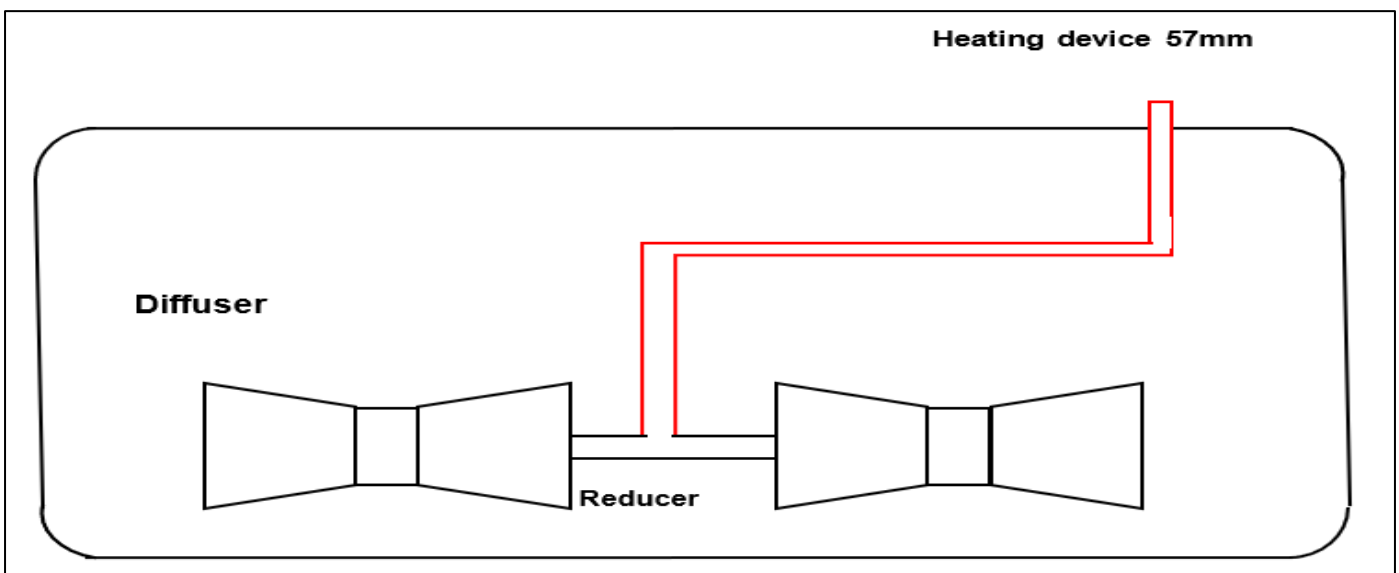


Fig 6 Lower Drum

➤ *Steam Superheater*

The steam comes out from the upper drum to the diameter of 219x7mm saturated steam chamber through 4 pipes dia.102 x 3.5 mm. then steam from dia.32x3mm tubes through 133 coils to dia. 273x11 mm superheat steam chamber then the steam enter the main steam line

through the main steam valve .The steam superheated coils are extended horizontally in convective shaft.On the header 273 x 11 mm there is three valves work gradually when pressure increase 13.4 ,13.6,13.8 kg / cm<sup>2</sup>respectively This is illustrated in figure 7.

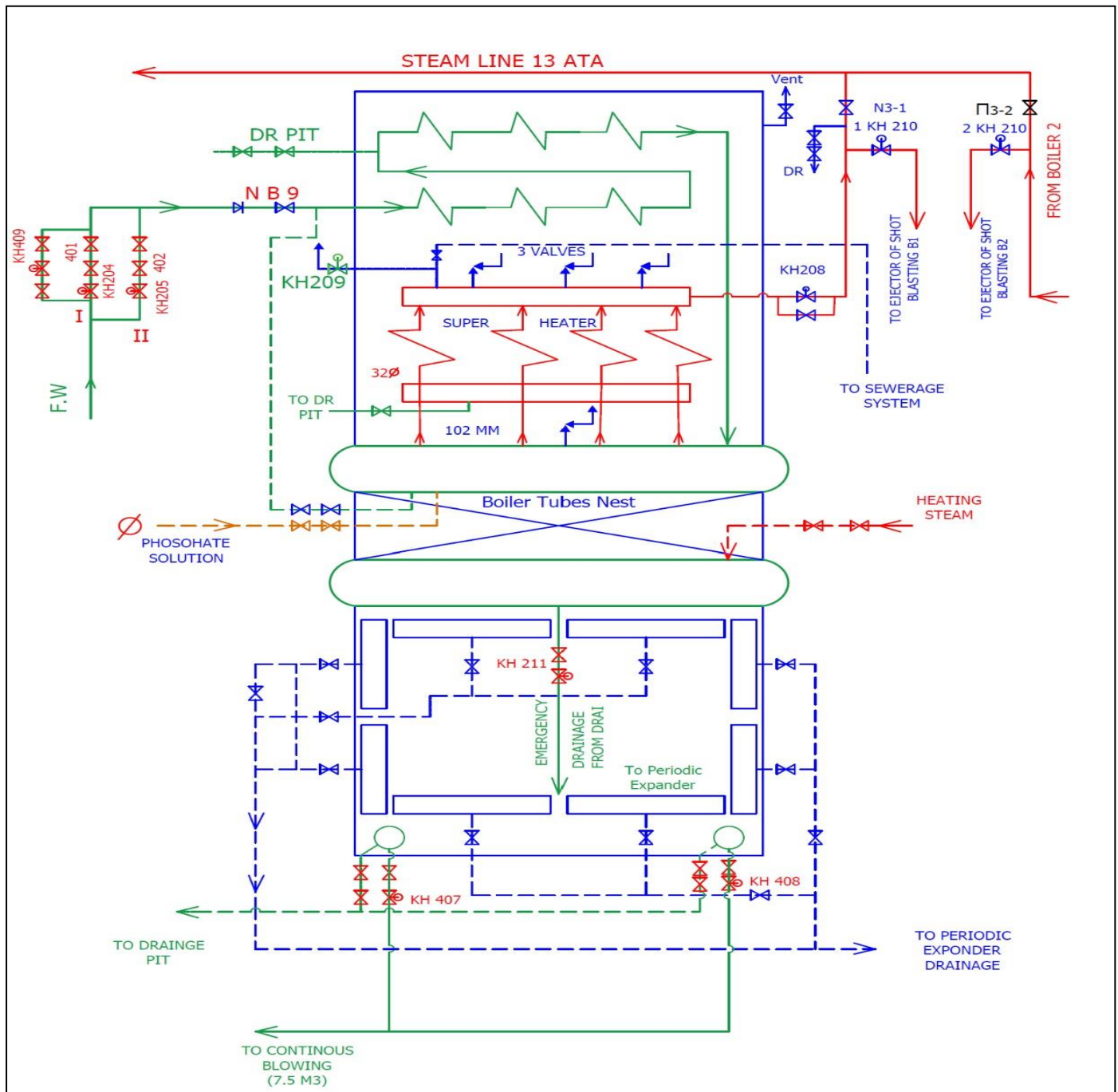


Fig 7 Section of Steam Superheater, Economizer, Wall Furnace

➤ *Water Economizer*

The cast iron water economizer consists of four blocks, lower and upper left ones and lower and upper right ones. The manual blasting instruments are fitted on the economizer. chimney gases are brought up to the water economizer lower (1 stage) through gas duct, pass upwards through the upper right block (I stage) then take a turn in the upper gas box and pass from top to the bottom through the upper lift and lower lift blocks (I stage). Feed water is

supplied to the (II stage) lower part, passes upwards through the grilled tubes, then the water is sent from the upper part of II stage to the lower part of the I stage through four diameter 60 x3 mm tubes. from the upper part of the (I stage) of the economizer. The water is conducted to upper drum through four 60x3 mm tubes. There is a recirculation tube which connects the lower part of the II stage with boiler upper drum. see the pervious. This is illustrated in figure 8.

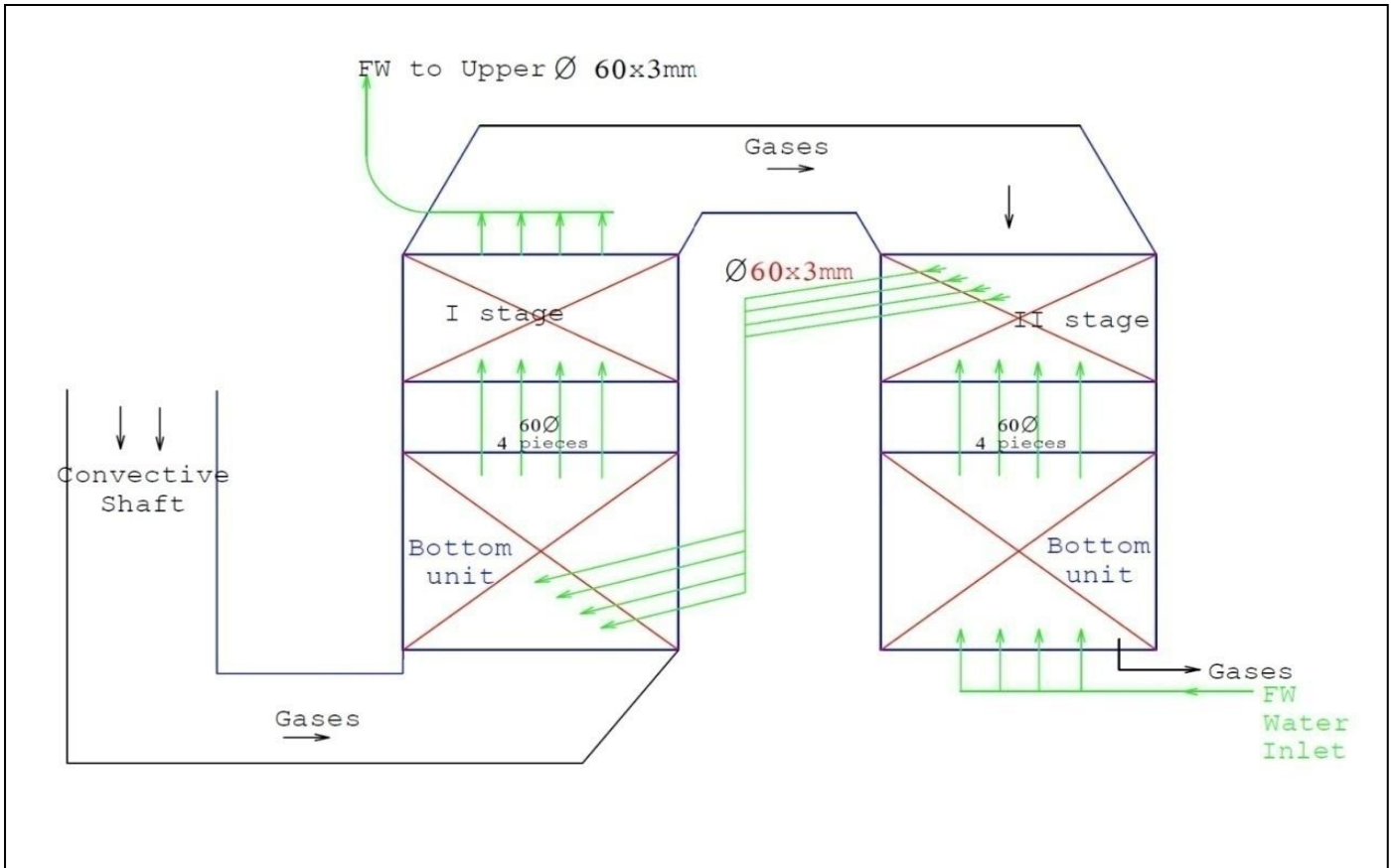


Fig 8 Flow of Gases and Feed Water Through Economizer

In case of boiler wanted to be drained temperature must be 70 - 80°C of water drained through water stream, economizer, drain line with air release cock is opened as in figure 7 vent of economizer. In figure 9 in case of starting of STUB for removing scale and obtain uniform

heating of all circulation loops of STUB first when the pressure of steam is raised 3 - 4 kg / cm<sup>2</sup>, second when drum pressure is raised to 10 kg / cm<sup>2</sup> by opening manual valves to drainage .as illustrated in figure 9.

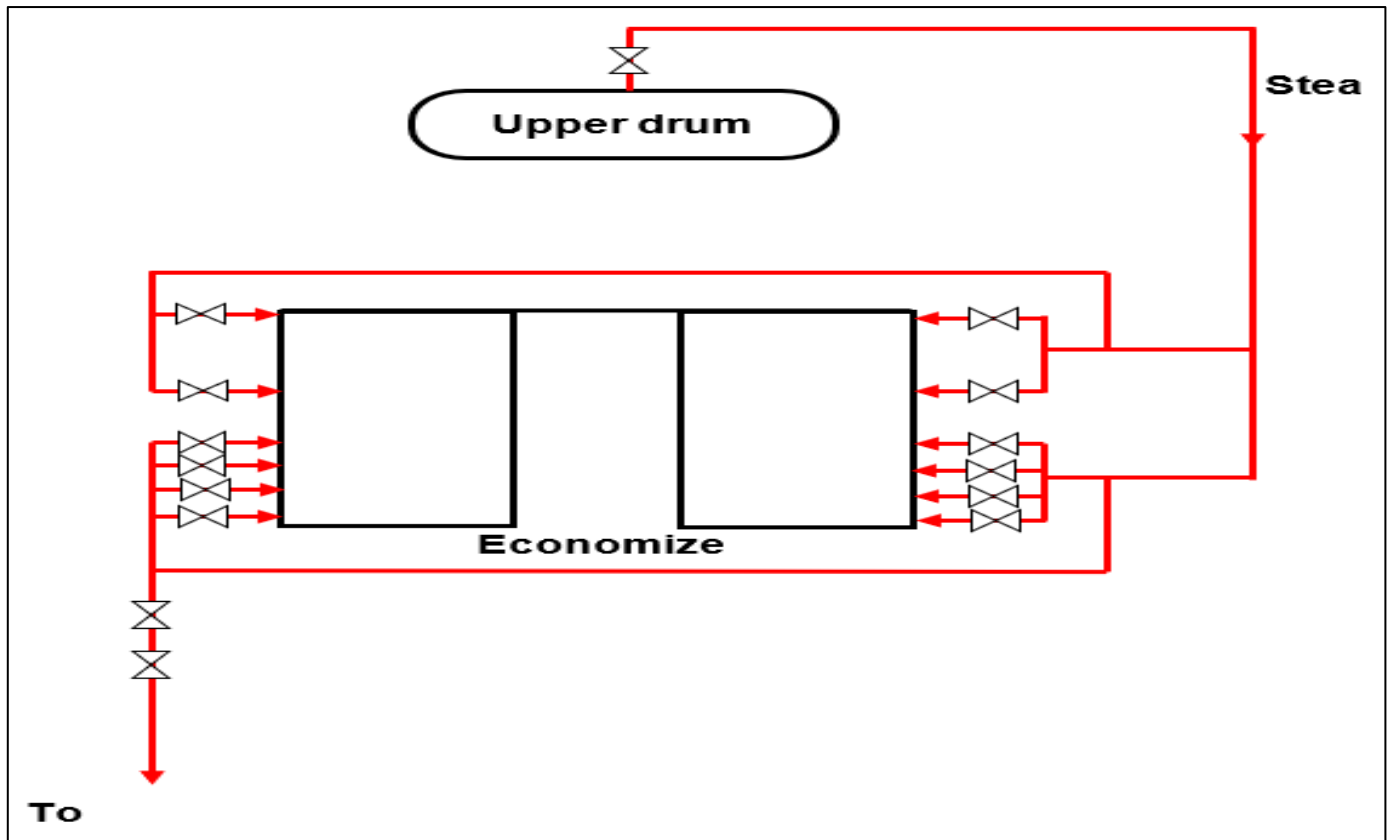
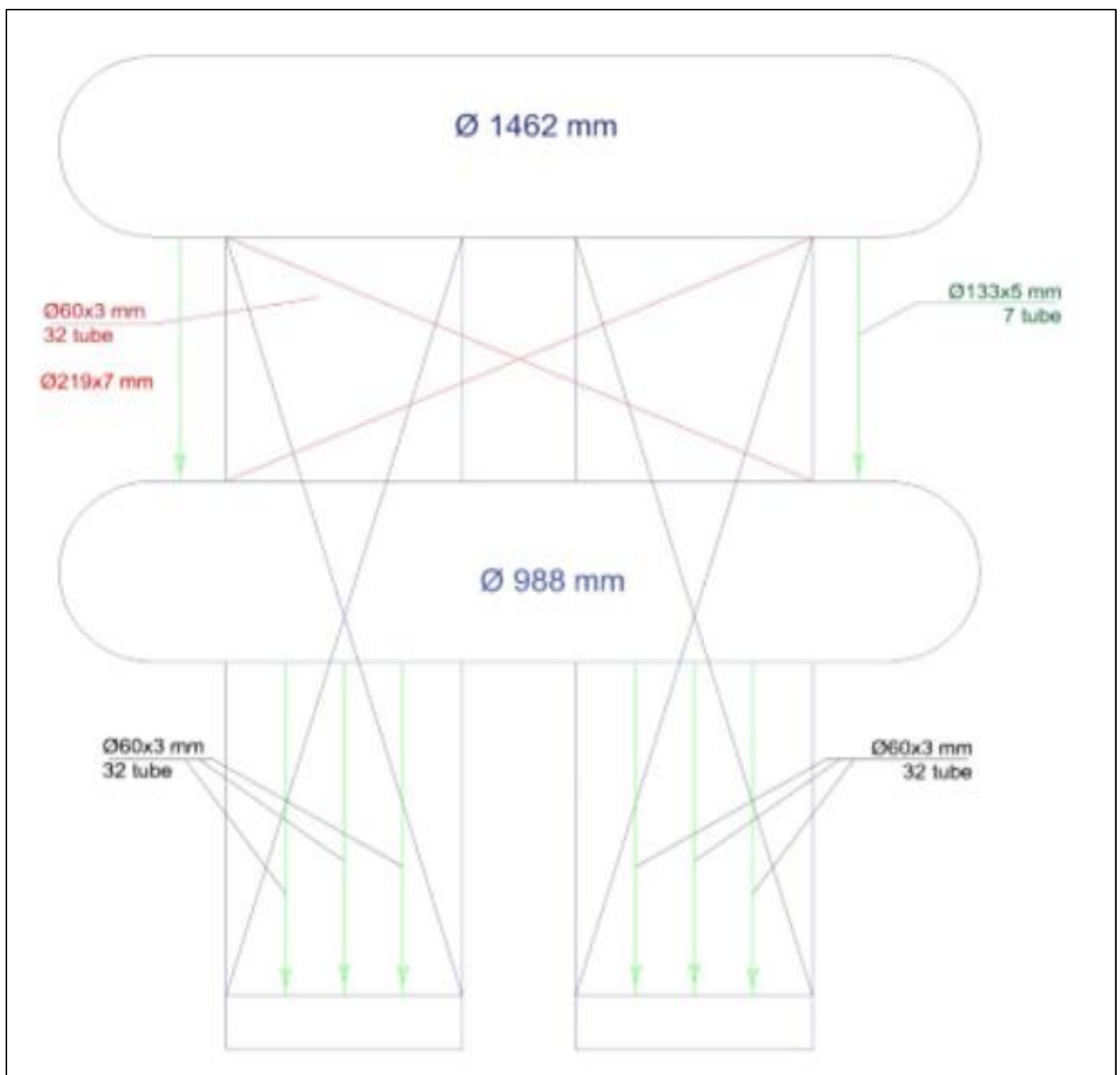


Fig 9 Manual Blower Steam for Cleaning Economizer

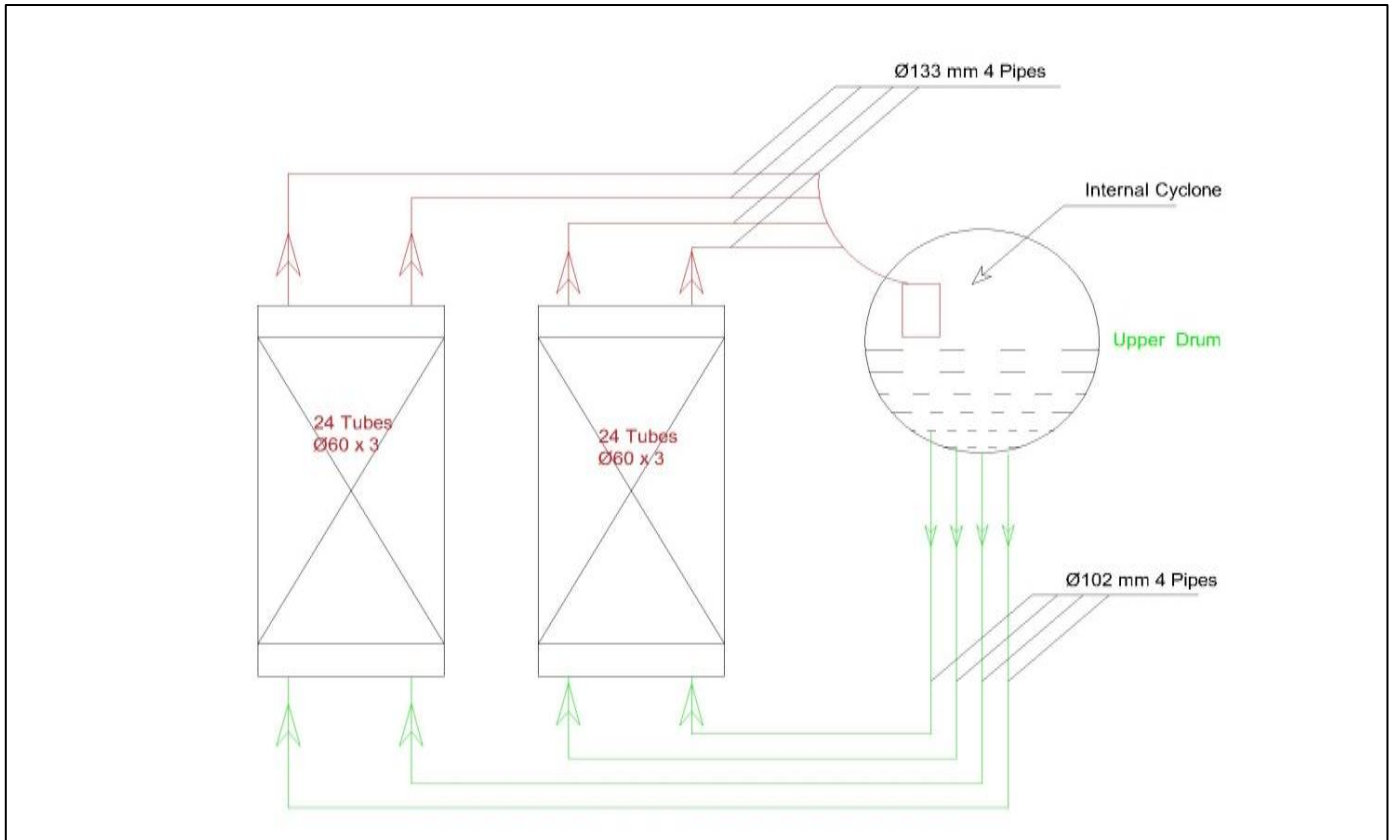
➤ *STUB Contours*

There are nine circulation contours in STUB system, the furnace is divided into eight independent contours, the ninth is STUB bank. The third evaporation stage (salt compartment) should include two furnace front wall panels. Supplying of this panels is carried out from three diameter tube 102 mm tube each to lower panel chamber. The steam water mixture from each upper chamber of front panel enters the outer cyclones through three diameter 133mm tube. supplying the feed water from the upper drum to the outer cyclone is carried out through diameter 76mm tubes, the steam water mixture from the outer cyclone enters upper drum (clean compartment) through two diameter 133 mm tube. The second evaporation stage (salt compartment) includes four furnace chamber side wall panels. The STUB water is supplied to each panel from the upper drum salt compartment four tubes 102 mm

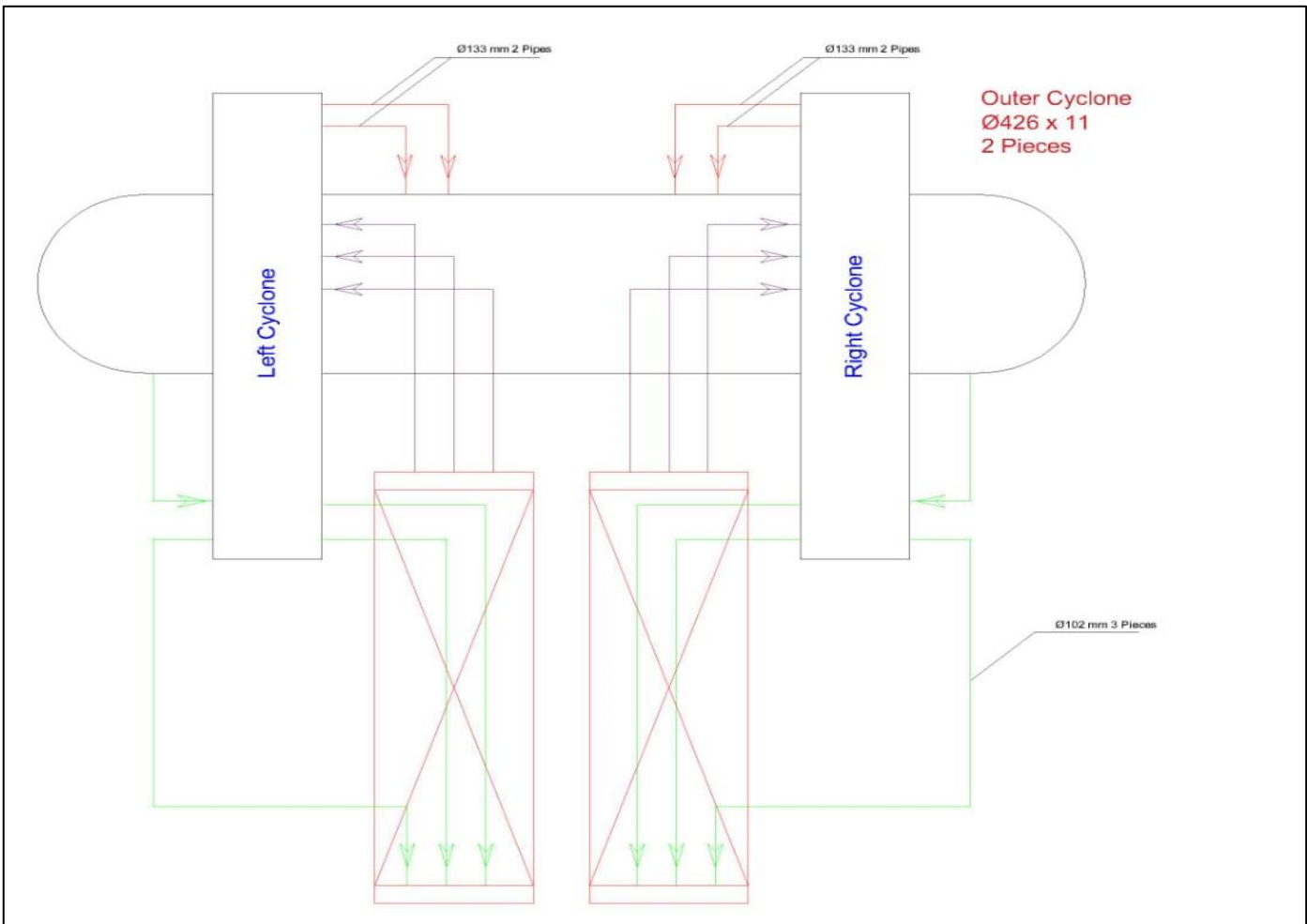
diameter. The steam water mixture from each side panel upper chamber enters the upper drum salt compartment through four tubes diameter 133mm. The first evaporation stage (clean compartment) includes two furnace chamber back wall panels and boiler bank wall panels. The boiler water is supplied from the lower drum to each panel through three diameter 102 mm tubes. The steam water mixture from evaporation surfaces enters directly the upper drum clean compartment. the ninth contour is boiler bank. The feed water from water economizer enters upper drum ( clean compartment) through four tube diameter 60 X3mm. The water comes down from the upper drum to the lower one through 16 diameter 219 mm tubes and through 14 diameter, 133 mm tubes .The steam water mixture having been formed in diameter 60X3mm evaporating tubes of boiler bank comes up to the upper drum ( clean compartment ).As shown in figure 10 below.



1 Stage of Evaporation



2 Stage of Evaporation



3 Stage of Evaporation

Fig 10 STUB contours 1, 2, 3

### III. MAIN EQUIPMENT OF STUB

#### ➤ STUB Chimney Gas and Draft Air Ducts

STUB need mechanical draft for movement of air; it consists of FDF and IDF. The pressure of air through the system is above atmospheric pressure and air is forced to flow through the system. The burnt gases are sucked out of STUB reducing the pressure inside the furnace to less than atmospheric (balance draft). The flue gases are sucked through the chimney by IDF. Flue gases coming out of the STUB carry a lot of heat, an economizer extracts apart of this heat from flue gases and uses it for heating feed water. The use of economizer results in saving fuel consumption and higher boiler efficiency, further heat can be extracted from the gases and used to heat the incoming air for combustion, cooling the flue gases by 20°C (by extracting their heat).

Air heater (calorifier) is of tubular type, the gases flow inside the tubes and the air over the tube exteriors. A calorifier is heated the atmospheric air to 70 °C.

#### ➤ Air Heater

Air heater type KφБ- 12Π is installed in the charging duct of FDF to heat air that going to the boiler. Tubular vertical airheater is mounted on the boiler diameter 40 x 1.6 mm tubes, cold air is supplied through the boxes of two stream, passes between the tubes and then is drawn from airheater to burners chimney, gases flow from the top to bottom and are directed to the economizer through the box.

#### ➤ Chimney Gases and Draft Air Duct

The process of taking the air from atmosphere and charging it into boiler furnace for combustion is done by forced draft fan (FDF) where the air passes through SAH to heat it with steam and raise its temperature to 70 °C then passes through airheater to four burners of the furnace two on the left the other on the right for combustion. The outlet temperature of gases from economizer to IDF depending on fuel type (either NG or mazut the burnt gases from furnace is taken by IDF to the chimney.

IDF capacity is  $79.9 \times 10^3 \text{ m}^3 / \text{hr}$

FDF capacity is  $50.2 \times 10^3 \text{ m}^3 / \text{hr}$

All the above are illustrated in figure 11 below.

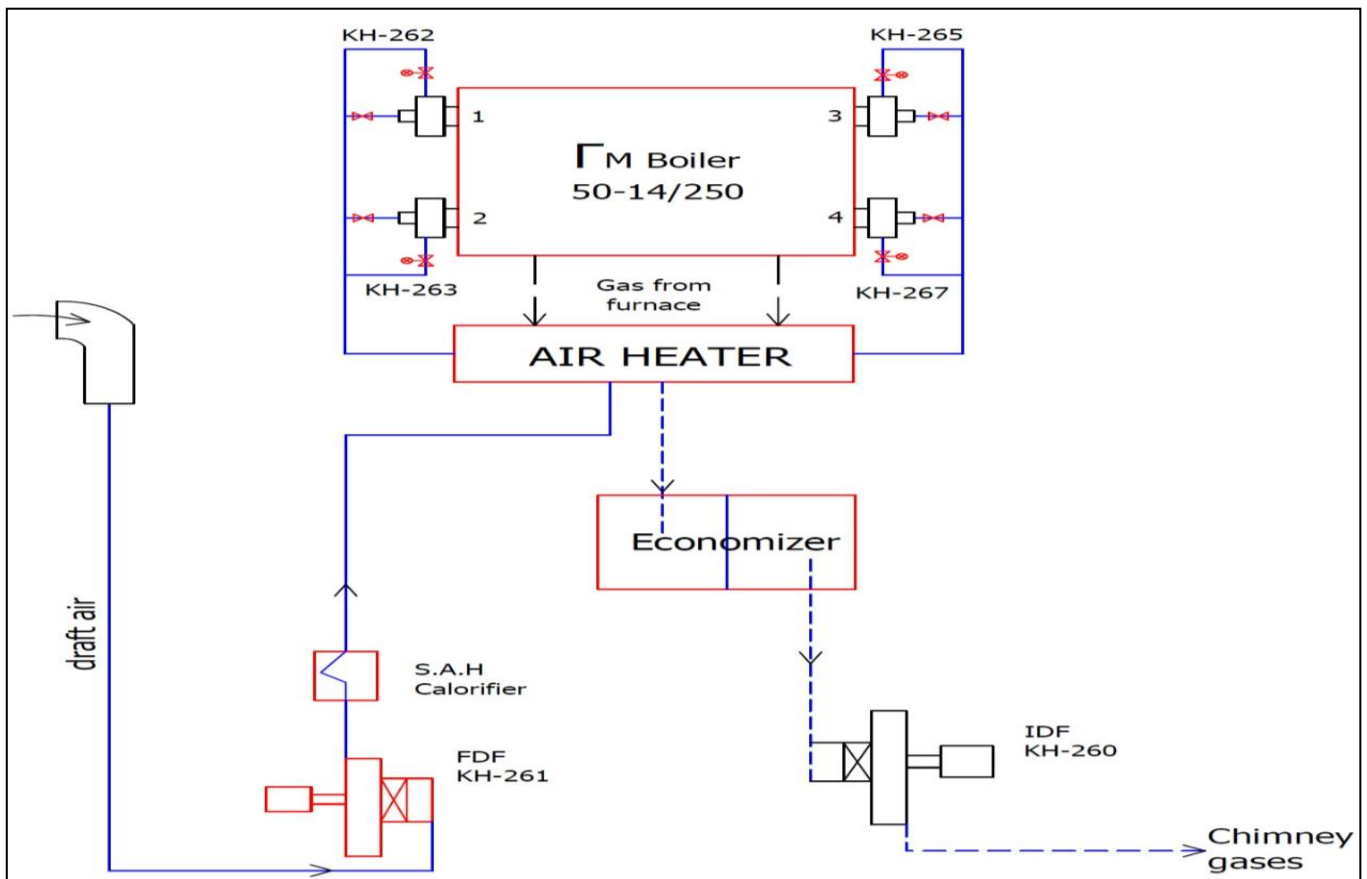


Fig 11 STUB Chimney Gas and Draft Air Duct

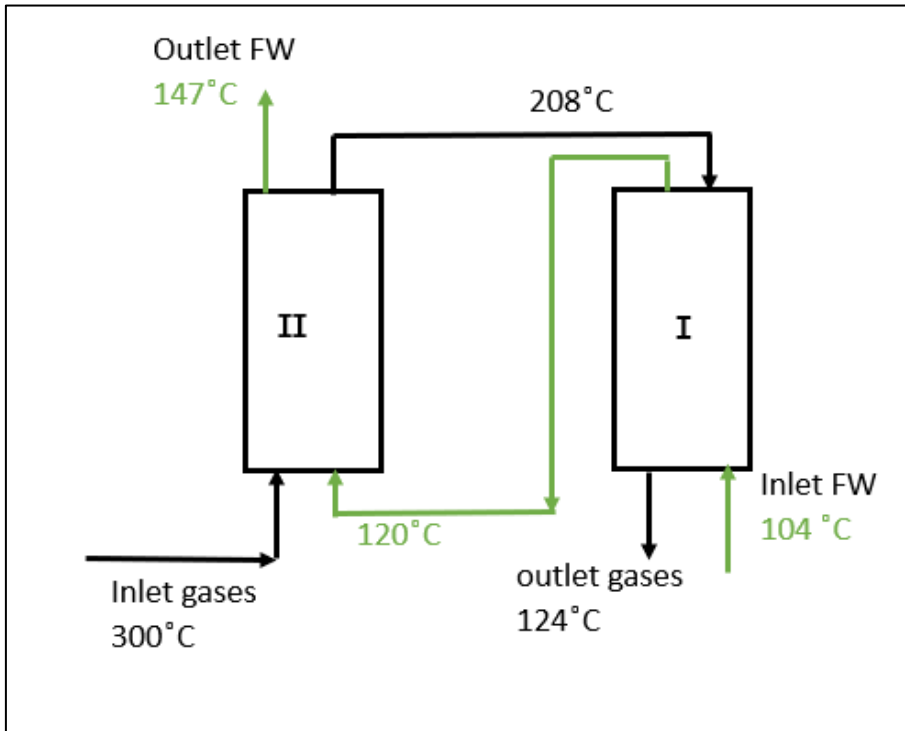
#### ➤ Different Parameters Between Gas and Fuel Oil

When natural gas is burned, it produces 45 percent less carbon dioxide than fuel oil. NG is considered to be clean fuel .NG flame color is blue refers to complete combustion burns at temperature of 1350 °C. the NG flame occurs yellow in color when there is incomplete

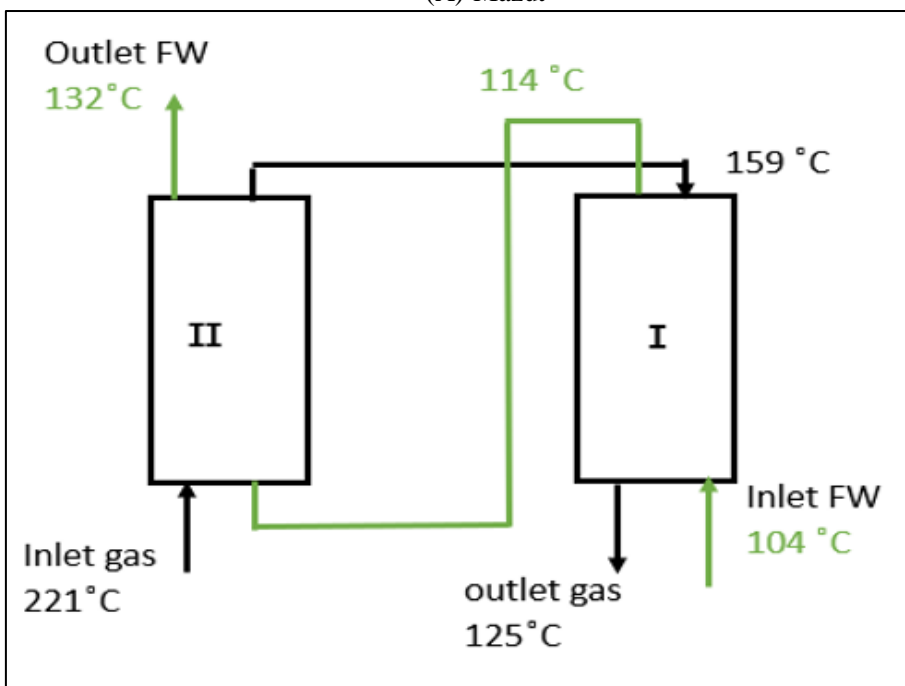
combustion. NG flame is brighter than Fuel flame. fuel flame is less bright surrounded with smoke of un burnt gases. So, fuel oil is more polluted than NG. burning of fuels creates air pollution and generates toxic emissions. Different parameters of burning fuel oil and NG are shown in table no2.

Table 2 Different Parameters Between Gas and Fuel Oil Combustion

	Fuel oil	Natural gas
Furnace temp. °C	1076	1135
Top of the furnace temp. °C	1029	1035
Superheater gases temp. °C	537	416
Inlet to airheater gas temp °C	414	318
Outlet temperature of air from airheater °C	147	139
Inlet gases temp to II stage economizer °C	300	221
Inlet gases temp. to I stage economizer °C.	208	159
Outlet gases temperature from I stage economizer °C	124	125
Inlet water temp. to I stage economizer °C	104	104
Inlet water temp. to II stage economizer °C	120	114
Water temp. to boiler drum °C	147	132



(A) Mazut



(B) Gas

Fig 12 Inlet and Outlet for Gas and Water in Fuel Oil and Gas

In figure 12, we can see the inlet of feed water and gas temperature to air heater for fuel oil and NG fuel.

➤ *Feed Water to STUB*

There are three feed water pumps, each one has 60 m<sup>3</sup> / hr flow capacity, the process of charging water is carried out by the pumps from the dearator (35 m<sup>3</sup> capacity) at pressure of 1.2 kg / cm<sup>2</sup> to the STUB through the first and second stage of the economizer then to upper cylinder of STUB at a pressure of 25 kg / cm<sup>2</sup> with inlet pipe diameter 100mm and outlet diameter 80 mm. The circulation line to dearator is located at discharge line and after non return. It is an alternative line that ensures the flow of water inside the pump, and thus it is a cooling line for the pump because working without it or with a small amount of water leads to an increase in temperature and thus its malfunction. When the pressure of feed water decreases to 19 kg / cm<sup>2</sup>. automatic changeover will work to start the reserve pump. Feed water pump consists of six stages and balance disc. Due to the forces of rotor this will push towards, so small quantity of water go to this disc causes force equal to the pushing of rotor. As shown in figure 13

➤ *Dearator*

The removal of oxygen, carbon dioxide or other gases from a liquid or semi liquid substance is done by the dearator (volume 35 m<sup>3</sup>). It is a horizontal container containing a perforated tray inside, where is pumped to the upper part called dearator column and the steam rises from bottom to the top and the washing process is completed. The dissolved gases reject to the atmosphere through dearator column. Filling up the STUB by FW for this prepare all the fittings and start FW pump that suck from dearator with suction pressure is equal to 1.2 kg / cm<sup>2</sup> (pressure of dearator) and discharge pressure of feed water which is 25 kg / cm<sup>2</sup>. There are three FW pumps supplying water to STUB drum depending on pressure and flow rate. The dearator is located at sufficient height from the basement where the pumps are installed so that pressure at suction does not fall below saturation pressure. Dearator is supplied steam from main line 13kg / cm<sup>2</sup> through reducing stations RS1 and RS2 (one in operation another is stand by) see figure 2, valves 1KH405 and 1KH406, also water is feed to dearator from watertreatment plant through valve 1KH404 as shown in figure 13.

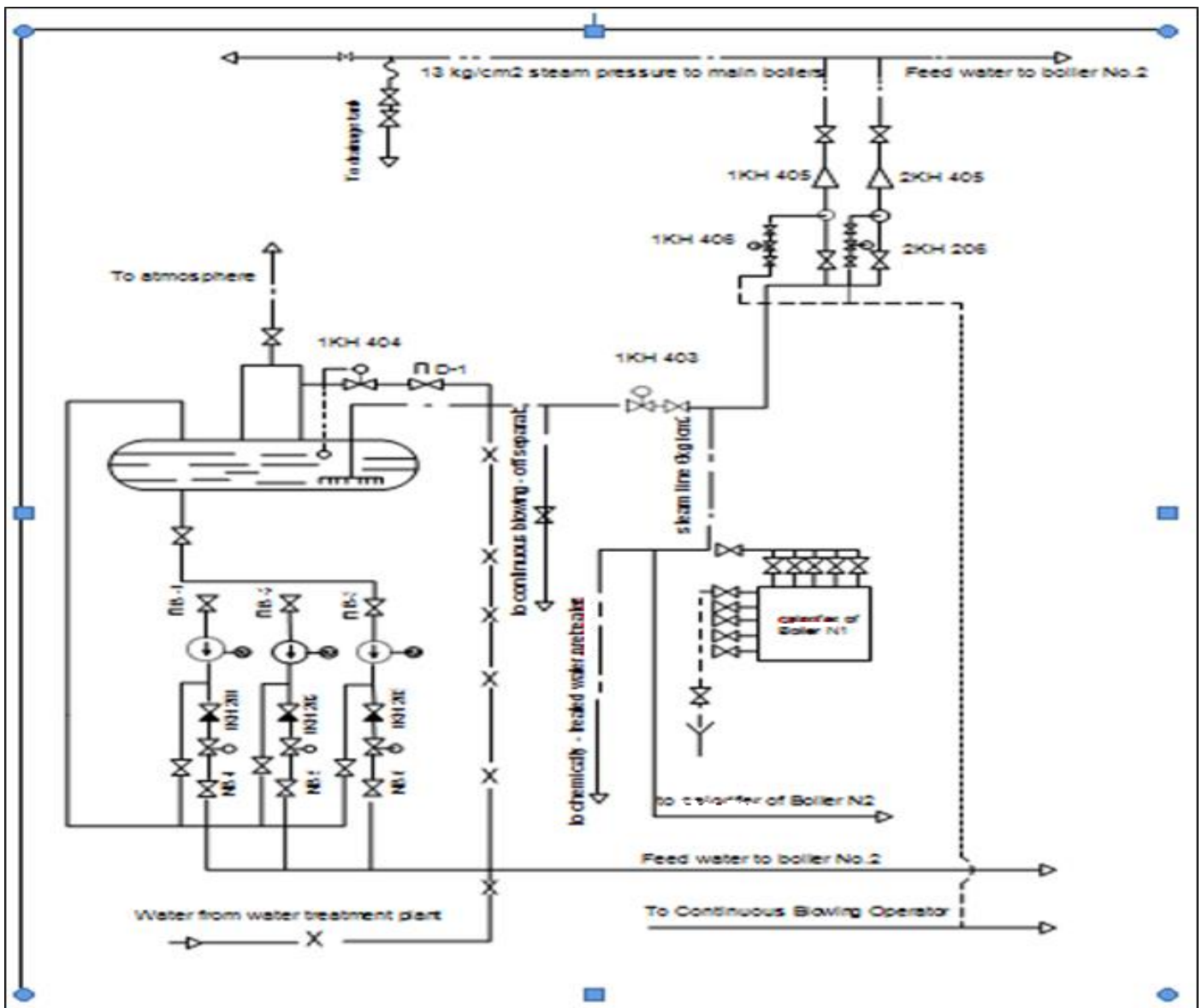


Fig 13 Supplying of Feed Water to Dearator

➤ *Combustion of Natural gas in STUB*

Natural gas produces less pollution than its counterparts, four gas burners are arranged in two rows (two in each row) and belong to class of burners with partial internal mixing since complete intermixing of gas and air is not affected in the burner proper, but it is attained in the furnace space. Among the advantages of combined gas - fuel oil burners is that the change from one fuel to another can be done quite easy. The air channels in such a burner are common for both fuels, and each type of burner is arranged so as to ensure quick and thorough intermixing of fuel and air. If the STUB is to be fired on gas, prepare gas and air lines to burners for firing as follow;

- Make sure that all manually operated valves and control valve (KH242, KH243, KH244, KH245) on gas supply line are closed tightly.
- Open manual valves for purging gas to atmosphere (six valves on each gas line entering the burners) and purging is done by compressed air.
- Remove plugs from the valves KH247 on supply gas line to STUB and control KH415 and open them.
- Make sure that all quick acting valves (KH249A & B and KH250A and B) on pilot line on each burner are opened.
- Take analysis of oxygen in gases not less than 1%. After that the gas line is filled with gas raise gas pressure to burners up to 80kg /cm<sup>2</sup> after that close all the vents and start firing burners no.2 and 4 symmetrically.

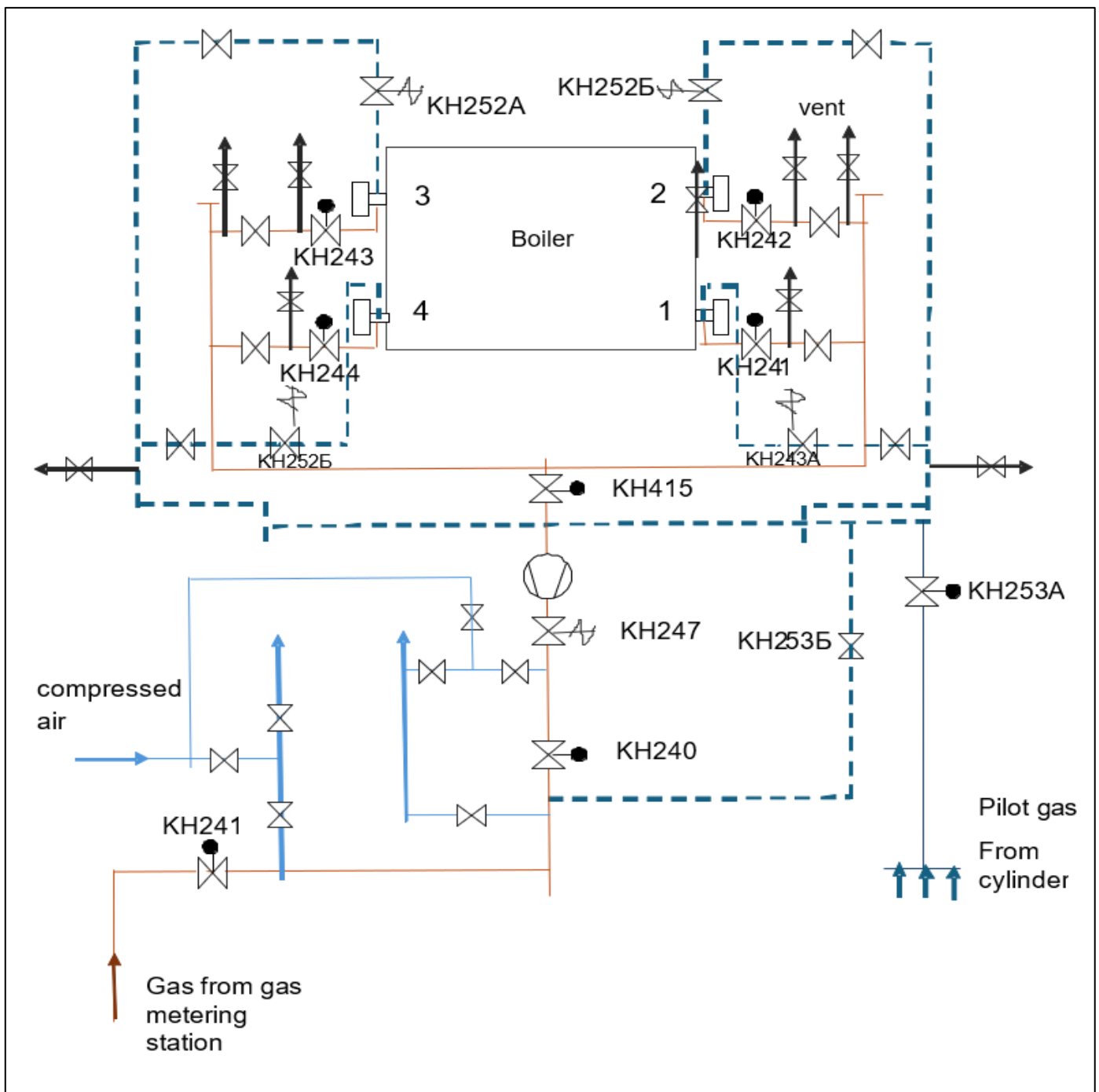


Fig 14 Natural Gas Supply Line Layout

➤ *STUB Heating up Schedule from Cold State*

After deaerator filled up by feed water pump no.1 and pressurize feed water line from deaerator to boiler feeding unit. Start the operation of STUB. When water start coming from air release valve of STUP feeding unit, close air valves then put IDF & FDF in operation and start firing burners no.2 and 4 either by mazut or NG. The operation of STUP from the beginning is done by firing the furnace at

cold state (50°C) water temperature. and increasing the pressure to 3 kg / kg<sup>2</sup>, rate of temperature. rise in the drum not exceed 1°C / mint, temperature difference between bottom and upper not exceed 40 °C, increasing the pressure of drum from 3 kg/cm<sup>2</sup> to 15 kg/cm<sup>2</sup> will take about three hours. The graphs in figures no. 15 and 16 illustrate the heating procedure for drum.

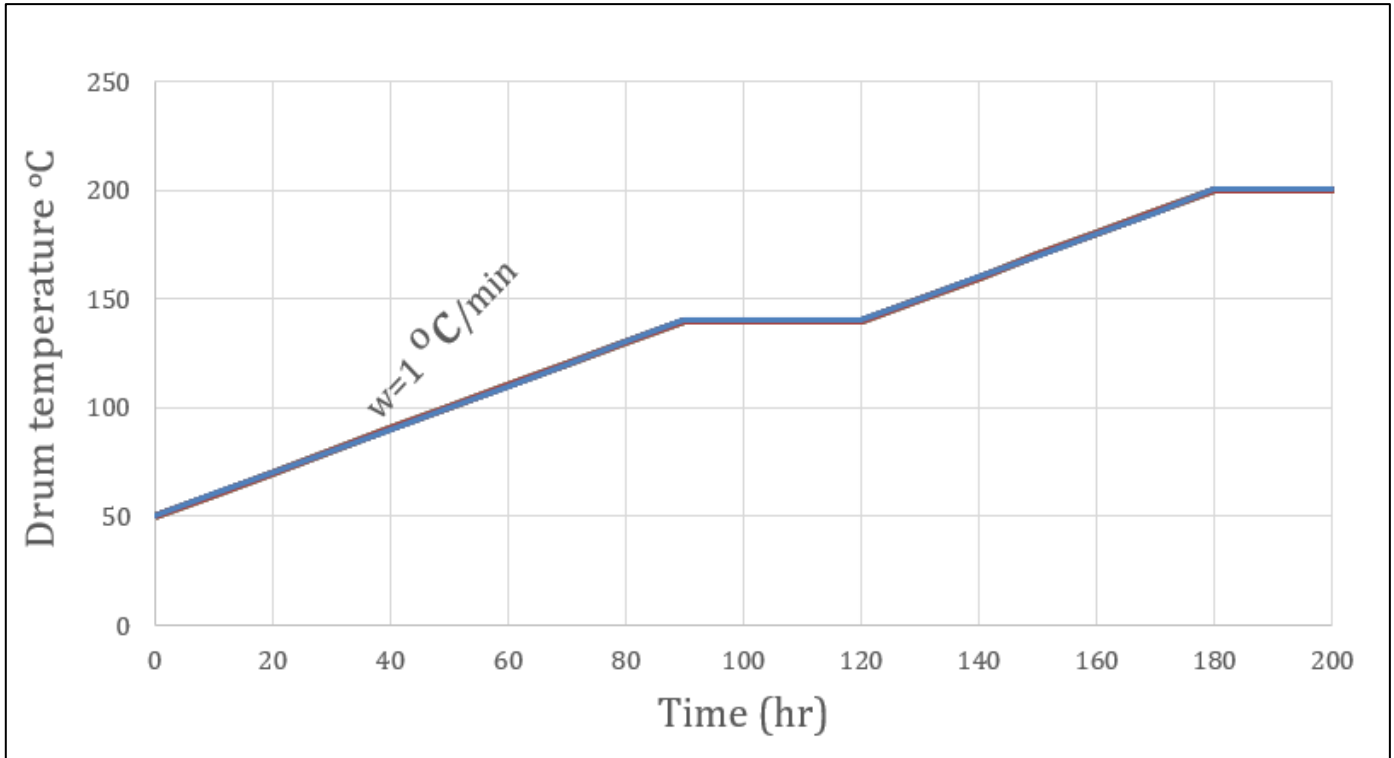


Fig 15 Drum Temperature Versus Time

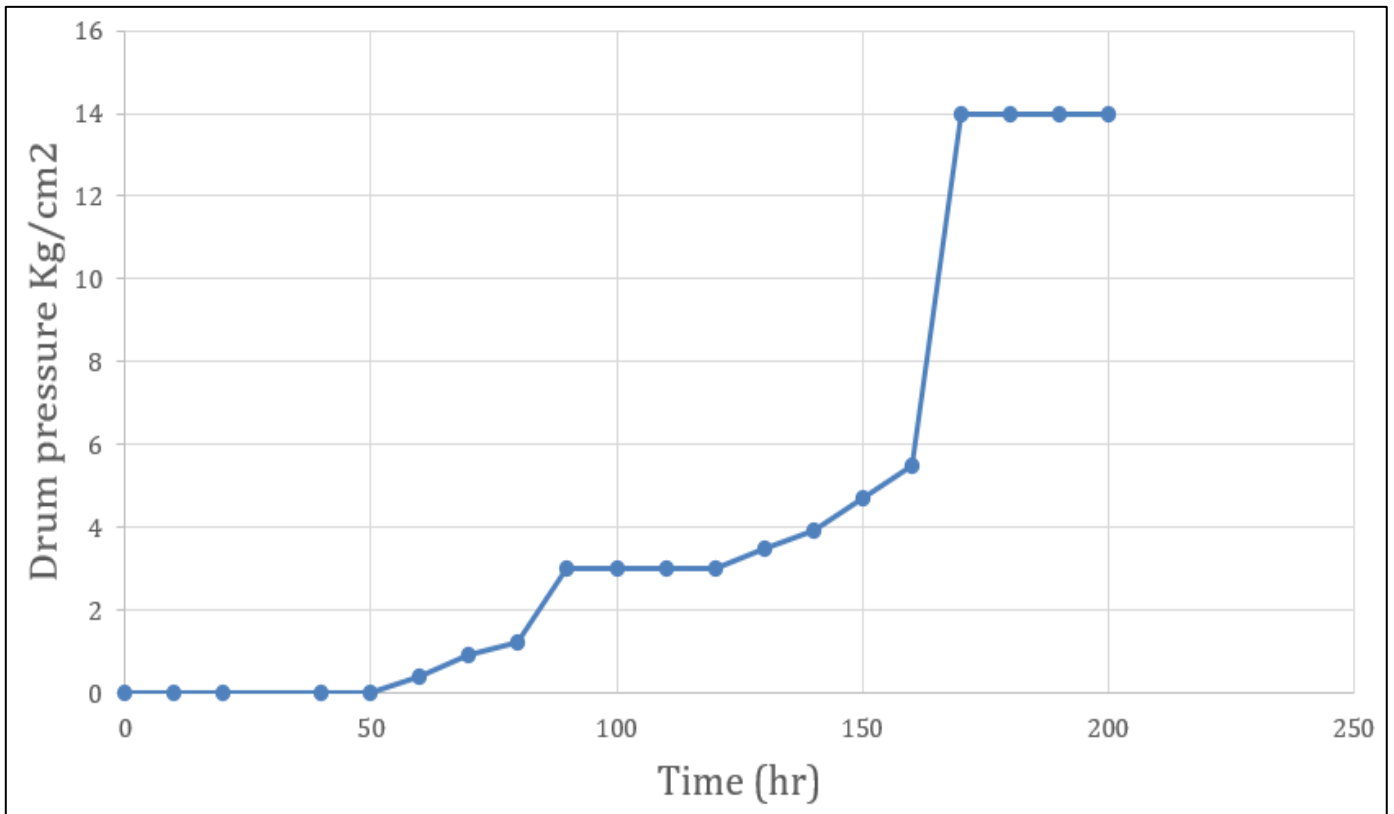


Fig 16 Drum Pressure Versus Time

➤ *Shot Blasting*

Tubes in superheater become fouled with different kinds of accumulations. Since any accumulation of foreign matter on the surfaces of tube decrease the efficiency, it is important that tubes be kept clean. This is done by pressed steal balls (shot) on the tube surface and collect them in the shot bunker then it is pushed upward to upper hopper

under vacuum by the use of compressed air with pressure about  $1.6 \text{ k / cm}^2$  the ejector is used to take air from upper hopper in order to be under vacuum for falling the shots rapidly on the surfaces. The ejector is worked on the steam from line  $13 \text{ kg / cm}^2$  directed to ejector nozzles. before that load bottom bunker with sufficient shot and check shot ejector for condition. This is illustrated in figure 17.

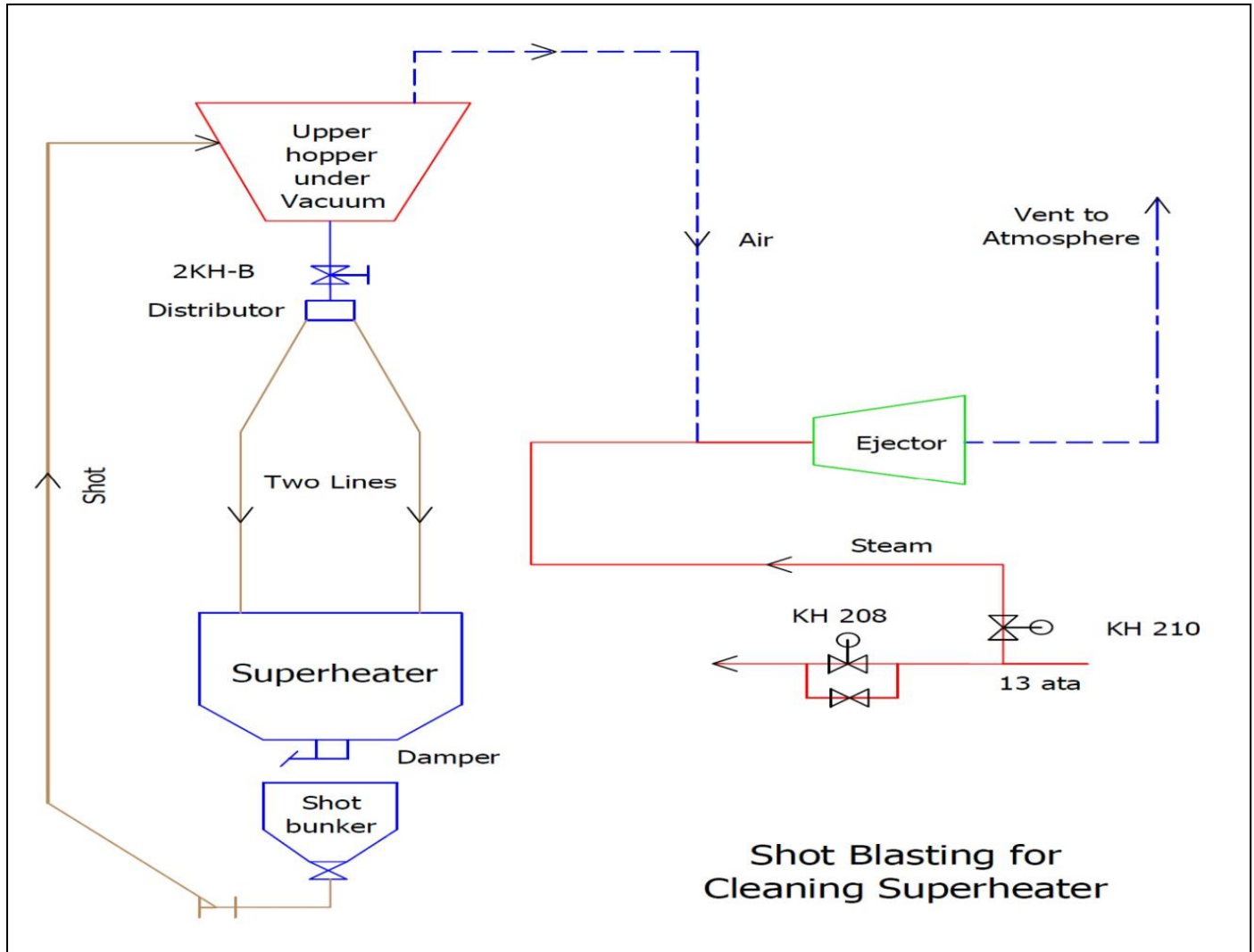


Fig 17 Shot Blasting

➤ *Operation of STUB Under Load*

The main work of operation staff during normal operation of boiler to provide load as following, sustain steam pressure at boiler outlet, supplying stable water for boiler level of drum  $\pm 50$  and temperature of steam in superheater =  $250 \text{ }^\circ\text{C}$ , sustain of excess air according to mode, sustain steam quality normal (analysis), all automatic control switch on, continuous control during operation of water gauge column, blowing of water gauge glasses must be made every 5 - 6 days, and the readings of water level indicator must be periodically (not less once a shift time) compared to one another and to the readings of water gauge glasses. Put IDF and FDF in operation, check the burners and combustion chamber, at all output of boiler the flame cone in the furnace must not contact the walls of the burners housing or the surrounding tubes or hit the opposite water screen inside the furnace. A normally operating burners must produce a flame cone should fill in

all the combustion chamber, the flame must be of high light brightness. the tail of flame cone should be transparent and free of fumes (smoke). increasing air quantity by FDF then increase fuel consumption for increasing the steam pressure and temperature, then prepare header  $13 \text{ kg / cm}^2$  for giving steam to the steam boilers for starting units.

➤ *STUB Shut Down*

After the operation of thermal units and connect them to the grid, the STUB must switch off, this is done as follow: Before STUB shut down, change the draft air from automatic to distance control, then start to decrease pressure of gas by closing control valve KH415 (Main valve for supplying gas to STUB). After that STUB output has dropped down about 70% of rated output to do that: 1-close gas control valve KH415 on gas supply line 2-close valve KH242, KH243, KH244, KH245 on gas supply line to

burners 3-close valve KH240 on gas supply line to burners.4-open gas control valve KH415 and blow out the gas supply line with compressed air then closed KH415, KH247. If flame cone have died out do as 1- cut phosphate feeding to STUB.2- cut continuous blowing system and water- steam sampling cock.3- close valve KH401 and KH204 on STUB feed water line. if necessary feed water to drum from bypass KH409. After feeding is stopped, open recirculation line from drum to economizer. before cut STUB from line, open superheater blow valve KH209 and after that close steam valves on STUB steam line (valves KH208 and PZ1). Ventilate furnace during 10 minutes, then stop IDF and FDF. If positive pressure in drum remains, check water level in the drum, if it go down, feed STUB with water and cut out recirculation from drum to economizer. in case of shut down STUB, saturation temp drop in drum must not exceed  $0.1^{\circ}\text{C} / \text{mint}$ . also temperature between top and bottom in drum not exceed  $40^{\circ}\text{C}$ . After 6 hours from the time of shut down, blowing of low header of screen is a must. Finally when STUB is completely stopped, chemical preservation of STUB must be done.

#### ➤ Protection of STUB

The following are the protection of STUB:

- Level rise in boiler drum (+150mm) up to second limit.
- Level drop in boiler drum (- 100mm).
- Mazut pressure drop after control valve =  $8 \text{ kg} / \text{cm}^2$ .
- Mazut flame extinction in furnace (9 seconds).
- Air pressure drops after airheater =  $50 \text{ kg} / \text{cm}^2$  in 9 seconds.
- level rise in boiler drum up to first limit + 100mm m emergency discharge valve KM -211 is opened.
- level drop in boiler drum to first limit (emergency discharge valve KM-221 is closed).
- Gas pressure drop after control valve to  $100 \text{ kg} / \text{m}^2$ .
- Switch off IDF or FDF.
- Steam pressure rise after superheater ( $14 \text{ kg} / \text{cm}^2$ )

#### IV. CONCLUSION

STUB is considered to be one of important devices in some thermal power plant as a helper to the main steam generating units in case of war and crises, especially when all the units are stopped or out of operation due to any reason and it is difficult to restart them again after stoppage or for quite some time because of the shortage of steam in the steam units. By operating and firing the start-up boiler to provide steam at a pressure of  $13 \text{ kg} / \text{cm}^2$  for fuel oil and gas system, also for vacuum ejector to create a vacuum in the steam turbine and to sealing for starting the steam turbine and rotate it in the beginning of operation. Usually there are two start boilers one of which in operation and the other is in reserve. When the steam generation units are operated and connected to the grid, the STUB is extinguished and preserved chemically.

#### ABBREVIATION

DR: Drainage

FDF: Forced draft fan

FW: Feed water

IDF: Induced draft fan

NG: Natural gas

QAV: Quick acting valve

RS: reducing station

SAH: Steam air heater

STUB: Start up boiler

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