RENOVATION AND EFFICIENCY ENHANCEMENT OF PULVERIZED COAL FIRED BOILERS (3 x 35 TPH - RUSSIAN MAKE) *- A Case Study*

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BHEL, Haridwar is having a 12 MW Captive Power Plant with three Russian make water tube Pulverized Coal Fired Boilers. It was commissioned in 1968. Due to ageing, frequent steam leakages were observed in Economizer coils and Super Heater coils specially from clamping area and from the bends. Similarly frequent water leakages were observed from bends and from clamping area of Water Wall pipes. Also, wearing of Rotors at bearing area and at Air Sealing plates in Hammer Mill was frequent. Due to these failures in Boilers, Hammer Mills and irregular oil supply, the availability of Boiler has become less, resulting in poor power generation.

To over come these problems, it was considered to renovate Economizer coils, Super Heater coils and Water Wall tubes. Accordingly all the Boiler's pressure parts were renovated & two halves sleeve system were introduced where clamps were provided in Economizer coils & Super Heater coils of the Boilers. In order to increase the availability of the Hammer Mills, sleeves in two halves system were provided on Rotor & at Air Sealing location where worn out due to coal erosion were observed. Since Producer Gas Plant was adjacent to Thermal Power Station, so this gas and its by product Coal-Tar was introduced in Boilers as a supplementary fuel in addition to existing Furnace Oil.

With above renovation of the Boiler pressure parts, modification in Hammer Mills and introduction of multi-fuel system, the efficiency of the Boiler has increased considerably.

1. Introduction :

BHEL, Haridwar is having a 12 MW Captive Power Plant with three Russian make water tube Pulverized Coal Fired Boilers. Each boiler is of 35 t / hr capacity, working pressure 40 kg/cm^2 and working temperature 440 ^{0}C. Main fuel is pulverized coal having average calorific value of 3320 kcal/kg supported with residual fuel oil. Each boiler is equipped with 2 hammer mills each of 6 t/hr capacity. There is one Czechoslovakia make 12 MW Turbine – Generator set. Producer Gas Plant is also adjacent to Thermal Power Station. It provides Producer Gas to manufacturing blocks for industrial applications. Producer Gas & its by – product (coal tar) is also used as Fuel in the boilers.

The boilers were commissioned in 1968. Due to ageing frequent breakdown were occurring in pressure parts which was ultimately affecting the power generation due to non availability of boilers. Hence, techno-economic feasibility study was conducted to assess renovation potential of boilers and in other associated facilities which are prone to breakdowns such as Coal-Pulverizer (hammer mills)& ID fans.

Since installation of new power project, goes through long Environmental Impact Assessment (EIA) studies, Government / Ministry approval processes, development of infrastructure for the projects, following the financial approval which also takes considerable time and require high capital investments. Hence it is economical to revamp Old Thermal Power Plants instead of going for new ones.

In view of this, all the three Russian Boilers were renovated with necessary modifications successfully during 1987 to 1989.

2. Need for Renovation & Modification :

In view of Power shortage, Government has directed to add several thousand Megawatts of thermal capacity by renovation & modernization prior to 2012 & has also estimated an investment of Rs.75000 crores for renovation & modernization.

Due to acute power shortages along with scarcity of funds, many countries have led to resort to renovation / revamping of old power plants instead of building new thermal power stations.

For enhancing capacity, many countries are carrying out Renovation of their old Thermal Power Plants based on old Pulverized coal firing Technology through making major modification including replacement of oil burner with new design efficient oil Burners.

India has world’s fourth-largest coal reserves. The Geological Survey of India estimates that there are 111.88 billion tons of coal in India, we use 56 million tons of coal every year and this figure will rise to 195 million tons by the turn of the century.

Our plant needs uninterrupted Power and steam supply for manufacturing processes. We use to get the supply from UPSEB where there is power cut / grid failures, the production gets affected, hence it had been essential to keep our Thermal Power Station in continuous running condition. Therefore, the need of renovation of our plant was essential.

3. Present and Future Power Requirement :

The demand of electricity is increasing rapidly both in the domestic and industrial fronts. Electrification of Rural areas, Household consumptions is expected to grow at a rate of 14%.

At present India has an installed capacity of 1,46,902.8 MW as on 30.11.2008. The country will need a capacity addition of 4,15,000 MW in next 10 years and between 800,000 MW to 950,000 MW by 2030 to achieve the targeted growth of over eight percent annually. This would imply substantial increase in annual oil imports which could be around 300 to 400 million tons and coal imports that could touch 800 million tons annually.

India currently imports over 70 percent of its crude oil requirement, which is around 114 million tons. In the case of coal, though India has large reserves, the quality is not so good due to high ash content. Over next 25 years an estimated Rs 60,000 billions is required to provide electricity to consumers at affordable cost. Government has targeted for providing electricity in all villages by 2012 by decentralized distributed generation options.

In different countries per capita electricity consumption in KWH is shown below :

COUNTRY	**PER CAPITA CONSUMPTION IN KWH**
USA	13456
AUSTRALIA	11299
UK	6614
BRAZIL	2183
CHINA	1484
EGYPT	1287
INDIA	569
WORLD AVERAGE	**2465**

It may be seen from the data above, that there is still gap between demand and supply of electricity in the country. This gap may be bridged either by adding new power plants or renovating the existing power plants. Therefore, at BHEL, we have considered to renovate our existing power plant to improve the availability of power.

4. Specification of Boiler & Auxiliaries at T.P.S, BHEL Haridwar :

Our 12 MW Captive Power Plant is having 3 nos. Russian Make Water Tube Boilers. Each Boiler is equipped with 2 nos. Hammer Mills, 2nos. Raw coal Feeders, 1 no. each I D & F. D Fan, & 1 no.Turbine of 12 MW capacity. The details of some equipments & accessories are given below :

A. Number of pulverized coal fired Russian Boilers	**: 3 Nos.**
a. Capacity of each Boiler	: 35 t / hr
b. Working pressure	: 40 kg/cm^2
c. Working temperature	: 440 ^0C
d. Furnace volume	: 179 m^3
e. Radiating heating surface and each Boiler	: 176 m^2
f. Total heat input for generating rated parameters	: 26 to 28 million kcal/hr
B. Number of hammer mills per boiler	**: 2 Nos.**
• Capacity of hammer mill	: 6 t / hr
C. Raw Coal Feeder	: 2 Nos. in each boiler
• Capacity	: 2.3 to 15.2 t / hr.
D. I D Fan	
a. Capacity	: 78000 m^3 / hr
b. Head	: 270 mm WC
c. RPM	: 730
E. F D Fan	
a. Capacity	: 41500 m^3 / hr
b. Head	: 430 mm WC
c. RPM	: 730

F. Feed Pump

a. Number of Feed pumps	: 3 Nos.
b. Capacity	: 65 m^3 / hr
c. Pressure	: 60 kg / cm^2
d. RPM	: 3000

G. Return water supply water pump

a. Number of Pumps for condenser cooling	: 2 Nos.
b. Discharge	: 5000 m^3 / hr
c. Pressure	: 3.1 kg / cm^2

H. Dredge pump / Slime pump

a. Number of pumps for discharging Ash & slag to ash pond	: 4 Nos.
b. Discharge	: 150 m^3 / hr
c. Head	:35 m WC

I. Chimney Height **:** 80 m.

5. Identification of Problematic Areas in Boilers & their Auxiliaries :

Major problematic area observed were pressure parts of boilers (economizer coils, super heater tubes, water walls) , hammer mills and I D Fan blades. The details are given below :

Boiler :

In boiler, bends of economizer coils, super heater Coils, water walls and feed water pipelines are the most critical areas where leakage starts frequently due to Erosion / corrosion. In this present study :

a. ***Super heater area***: There are 62 coils (tube size 32 mm x 3 mm) coming from boiler drum and going to various headers inside the furnace. Total length is about 3600 m. It is fitted horizontally by various stainless steel clamps at various locations Due to vibration of the coils; it is likely to erode and is prone to steam leakage from weld area on tubes and also at bends on either side due to additional friction caused by flue gas, erosion takes place.

b. ***Economizer area***: There are 74 coils (tube size 28 mm x 3 mm) having 13 loops on either side of the coils, bends embedded in headers. Total length is about 3900 m. Each coil is clamped at two locations width wise. Due to vibration of the coil, it is likely to erode and is prone to leakages from weld area also at bends on either side due to additional friction caused by flue gas, erosion takes place ultimately water leakage starts from coils.

c. ***Water walls area***: There are 48 pipes (tube size 60 mm x 3 mm), total length of water wall pipes is 4500 m, fitted inside the furnace by clamps at various locations. The clamping areas and bends are prone to leakage and they need more strengthening for having cushioning effect on these areas.

d. ***Feed water pipe lines***: The size of feed water pipe is 89 mm x 3 mm. Water coming from feed pump and it goes to boiler drum through these pipes at pressure 60 kg/cm^2. The clamping areas and bends are prone to leakage and they need more strengthening for having cushioning effect on these areas.

e. ***Air pre heater blocks*****:** There are 4 blocks in upper zone and 4 blocks in lower zone in the flue gas path to heat the air of F D Fan required in furnace. The tube size is 40 mm x 1 mm. In Upper block there are 2000 tubes each of length 2.2 m and there are 2200 tubes of length 3.2 m in bottom zone. These tubes get chocked due to unburnt coal dust and clinkers. Due to chocking in tubes, it requires time to time Blocks cleaning, which is very time consuming process.

f. ***Coal Burners & Oil Burners:*** Each Boiler is equipped with 4 Coal Burners, 2each on either side & Oil Burners are fitted concentric to Coal Burners. Frequent cleaning of oil burner nozzle attracts for modification in Oil Burner.

g. ***Single support Fuel & Insulation of Oil pipe line:*** Boiler has provision of only one supporting fuel. If there is problem in supply from distance Supplier, it affects boiler operation. Oil pump house is situated at long distance. There is problem of oil flow from Pump House to Boiler inlet in Winter Season & in rainy season.

6. Problematic Area in Coal Pulverizer (Hammer Mills) :

Each boiler is equipped with 2 hammer mills. There are no standby mills in the boiler, hence it is essential to run both the hammer mills simultaneously for generation of full capacity of required steam. The following locations / areas were identified due to which Hammer mills come under breakdown frequently resulting in generation obstruction.

a. ***Hammer Mill Rotor***: The length of rotor is 3.4 m and its maximum diameter is 250 mm. There are 11 disc of diameter 360 mm each of 90 mm thickness, 18 mm thick disc and 45 mm thick disc (one number each) on either side of the rotor. 72 hammers of manganese steel each of 9.9 kgs of equal weight to avoid vibrations, are fitted with the help of holders on these discs for pulverizing the coal. Coal pulverization takes place in enclosed chamber. The pulverized coal is sent to boiler furnace for burning through coal distributor pipe with the help of air pressure received from F D Fan. Leakage of powdered coal from Hammer Mill is protected by woolen felt fitted on air sealing plates on either side. Two numbers heavy duty Spherical .Roller Bearings SKF No 22334CK are provided on either side of the rotor for smooth running of the rotor.

b. ***Hammer Mills*:** Erosion occurs at 4 locations in the bearing ends and 4 locations at air sealing plates at either side of Rotor. After coal leakages, surrounding area becomes heavy polluted. Two guide discs are provided (45 mm thick and 18 mm thick disc) on either side of the rotor to prevent axial dispersion of powdered coal from hammer mill enclosed chamber. These discs get eroded due to passage of time and need replacement once in 2 months. Its replacement is time consuming process since it requires shifting of Motor for removal of rotor coupling, bearings along with pedestal and air sealing plates.

c. ***Problem of Temperature rise in Hammer Mill Bearing* :**

- Due to worn out of woolen felt, fitted on either side of Bearing, Coal powder entered in bearing & gets mixed up with grease, thus bearing temperature rises & ultimately mill has to stop for cooling of Bearing. Woolen felts are replaced & bearing grease is replaced.
- Bearings are water cooled. In summer season bearing temperature increases & it requires special care & additional source is required to cool bearing.

d. ***Coal Distributor Pipe lines:*** There are four pulverized coal pipe lines for each coal burners having Bends. These Bends gets eroded due to erosion & leakages start in due course, resulting stoppages of mill for repair. Coal pollution starts & it requires immediate site cleaning. Its classifier requires time to time setting for proper size pulverized coal flow for better combustion in Boiler Furnace. Ceralin Bends were fitted in place of steel bends for longer life.

e. ***Design of Coal Bunker:*** Each Boiler has two coal Bunkers one each for each Hammer mill having 26 Hrs coal storage capacity. During rainy season, coal sticks on Walls, which requires time to time Bunker cleaning. Its slope was to be modified for smooth of the coal & other alternative to be thought of for smooth flow of coal.

f. ***Battery Cyclone:*** Each Russian Boiler was provided with 2nos. battery cyclones in flue gas path before chimney. Its efficiency was low & its maintenance was very tough.

g. ***I.D. Fan:*** Each Boiler is equipped with one I.D. Fan to draw Flue gases from Boiler & send the same to Chimney. Its blades get eroded & require reblading. It is time consuming process. Some improvement is needed to increase its life.

7. Procedure for Replacing Pressure Parts of Boiler :

a. Proper selection of material and welding procedure.
b. Purchasing of material of I.B.R quality & to get original T.C from manufacturer duly approved by Director of Boilers of that state.
c. Entering of material in the stock duly verified by Asstt. Director of Boiler.
d. Prepare drawing of pressure part to be replaced in the Boiler.
e. Getting approved these drawing from Director of Boiler after submitting necessary fees by Treasury challan.
f. The welding should be done by approved have High Pressure Welder / or Hire H.P Welder from market.
g. Getting of permission from Director of Boiler to carry out said work by said Welder at the Premises.
h. After completion of work, to invite Assistant Director of Boiler for Hydraulic test after submitting necessary Inspection fees.

i. Recording the quantity of material consumed in manufacturing the pressure parts in Stock register.

j. Offering Boiler for hydraulic inspection.

k. After successful Hydraulic test, displaying of X- Ray film of all welding joints to Director of Boilers, ultimately he will clear & will permit to run Boiler after repair / renovation.

8. Remedial Action taken to increase availability of the boilers for maximum generation / output by various modifications / renovation of the boiler and its Auxiliaries :

Boiler Area

a. Proper selection of material.

b. Thickness measurement of all pressure parts.

c. Developed technology to reduce leakage from bends and clamping areas in super heater coils, economizer coils, water walls and feed water pipe lines.

d. Design, installation, commissioning of Vertical Super Heater in place of Horizontal Super Heater Design.

e. Timely cleaning of air pre heater blocks.

f. Introduction of D M water cooling for cooling bearings of Boiler Feed Water pumps (3 nos.) to avoid mixing of raw water in boiler feed water.

Hammer Mill & Coal Distributor pipes Area

a. Developed technology to reduce breakdown time in hammer mills. Introduced Sleeve System in two halves at Air sealing plates area on Mill rotor where Rotor has worn out up to 5 mm deep & on bearing fitted area on either side of rotor.

b. Application of Ceralin bends for pulverized coal pipe bends to avoid coal erosion.

c. Interconnection of pulverized coal fuel lines to reduce breakdown time of mills.

d. Timely cleaning of coal bunkers.

Oil Burner, Oil pipe lines Area:

a. Introduction of heat traces for oil pipe lines for smooth flow of oil during rainy and winter season.
b. Introduction of latest design oil burners.
c. Introduction of oil flow meters for better fuel economy.

Introduction of supporting multi fuel system in boilers.

a. Installation and commissioning of producer gas firing system in place of costly furnace oil. ANNEXURE - I
b. Design, installation and commissioning of coal tar (a by product of producer gas plant as fuel). ANNEXURE – II.

I D Fan:

- Hard facing of I D Fan blades to increase life of the blades.

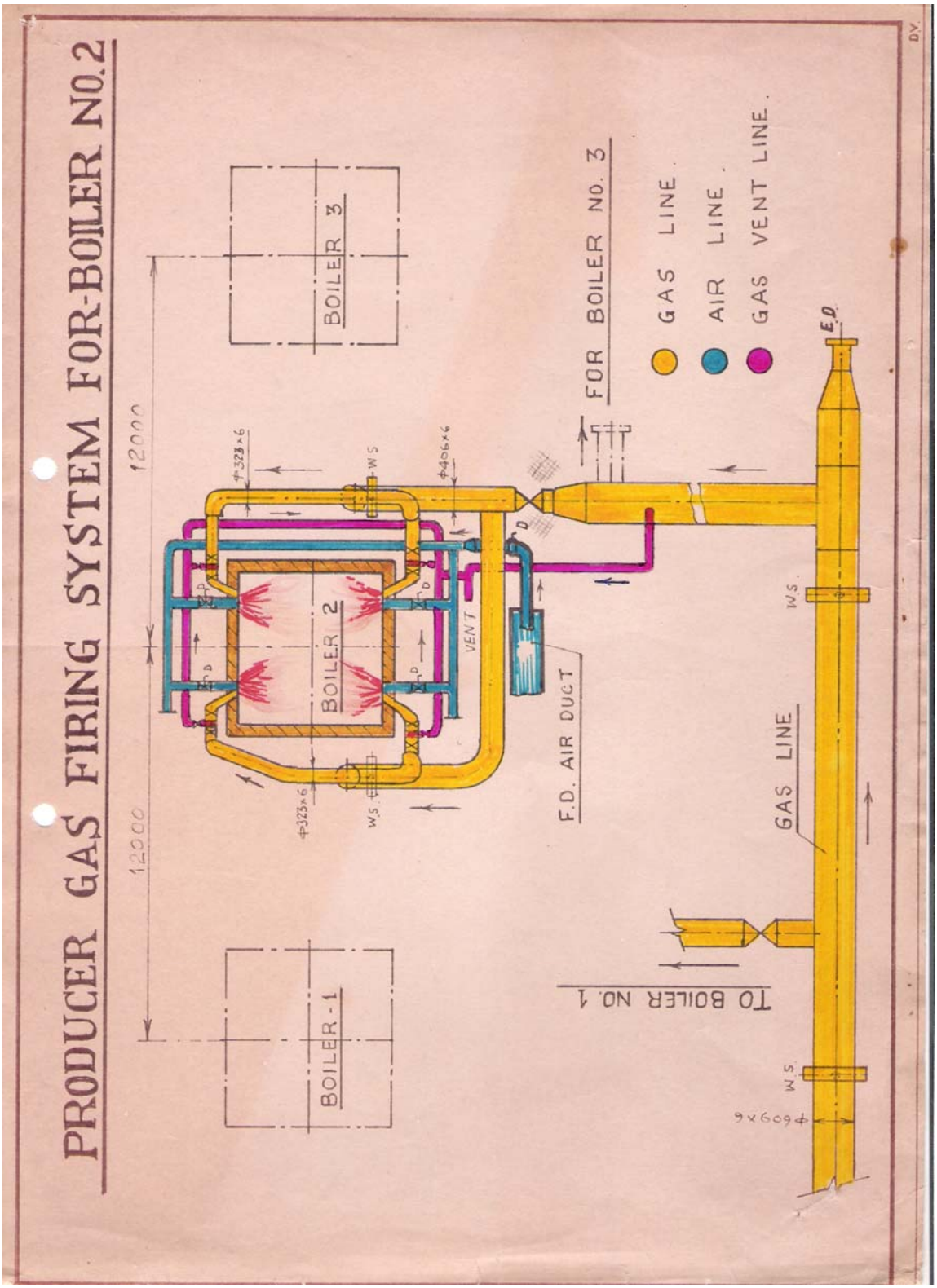
Introduction of Electro Static Precipitator:

- Introduced ESPs (Electrostatic Precipitators) in each boiler.

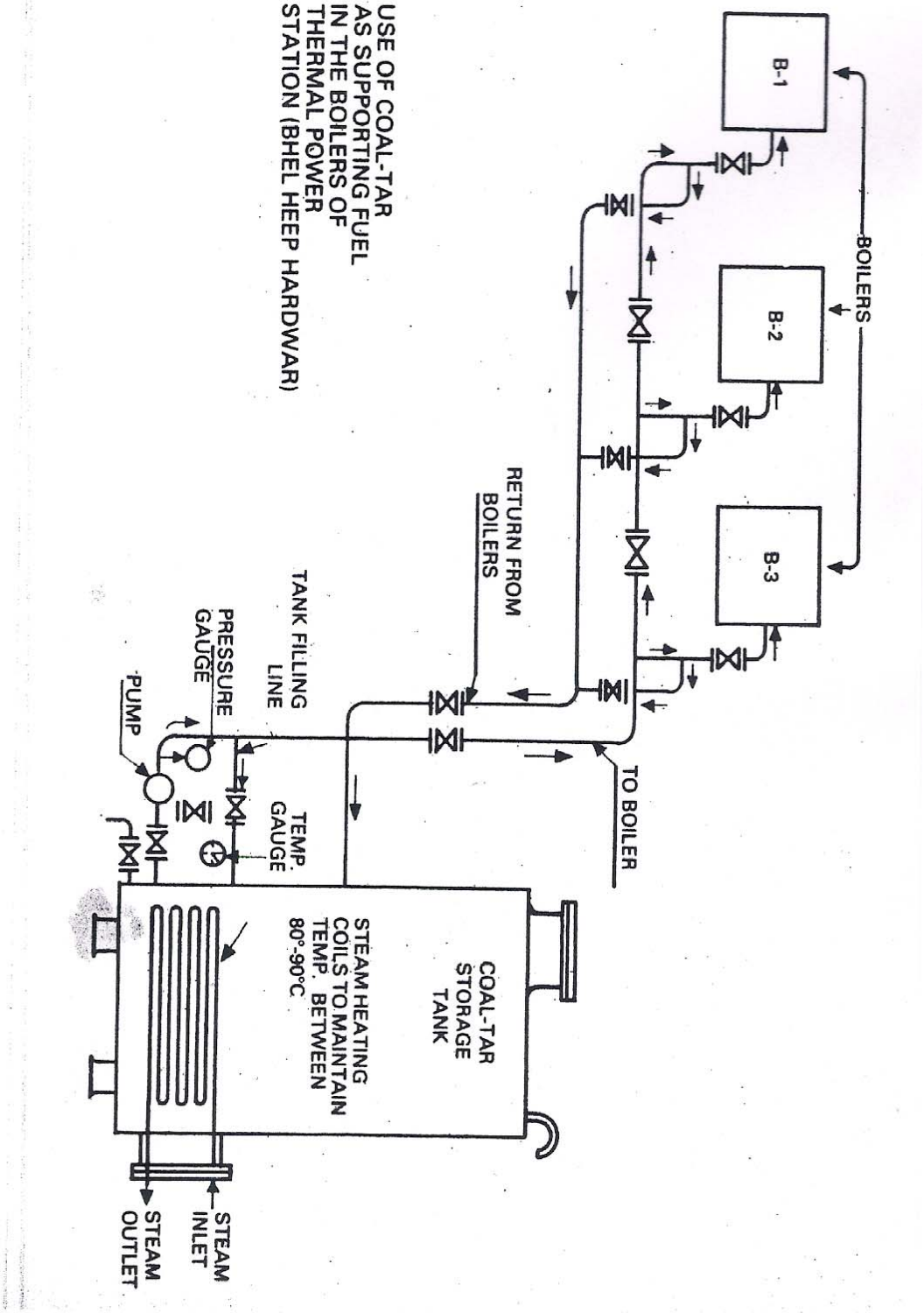
9. Conclusions / Results:

a. After renovation of boilers and various modifications done in clamping systems in the boiler's pressure parts and their auxiliaries, the availability of the boiler increased considerably and breakdown reduced to minimum.
b. Specific oil and coal consumption reduced.
c. Power generation increased.
d. Cost of power generation reduced.
e. Fugitive emissions in Hammer Mill area has been reduced.
f. With the installation of ESPs in each Boiler, suspended particulate matters in flue gas discharge from the chimney were further reduced.

ANNEXURE - I


PRODUCER GAS FIRING SYSTEM FOR-BOILER NO.2
BOILER 3
BOILER 2
BOILER-1
12000
12000
GAS LINE.
AIR LINE.
GAS VENT LINE.
FOR BOILER NO. 3
TO BOILER NO. 1
F.D. AIR DUCT
GAS LINE
VENT
W.S.
E.D.

ANNEXURE - II


USE OF COAL-TAR
AS SUPPORTING FUEL
IN THE BOILERS OF
THERMAL POWER
STATION (BHEL HEEP HARDWAR)
B-1
B-2
B-3
BOILERS
RETURN FROM
BOILERS
TO BOILER
TANK FILLING
LINE
PRESSURE
GAUGE
PUMP
TEMP.
GAUGE
COAL-TAR
STORAGE
TANK
STEAM HEATING
COILS TO MAINTAIN
TEMP. BETWEEN
80°-90°C
STEAM
INLET
STEAM
OUTLET