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"ESTIMATING OF COAL SAVING IN THERMAL POWER PLANT BY USING SOLAR ENERGY"

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ABSTRACT

Energy is a basic requirement for every sector of economic development in a country. As a result, energy demands have been steadily increasing along with the growth of human population and industrialization. Common sources of energy are coal, natural gas and petroleum from fossil fuels. This growing consumption of energy has rapidly depleted non-renewable sources of energy.Rising price of fossil-based fuels and potential shortage in the future have led to a major concern about the energy security in every country. In the present case study we have reduced the consumption of coal by 450 kg/24hr by rising the temperature of DM feed water (make up water) from 35 ^{0}C to 80 ^{0}C by use of solar energy in solar water heater (Evacuated tube type).Solar water heater can be implemented in any weather condition forthermal power plants for reducing the cost of sensible heat of makeupwater; as a result the fuel consumption will be reduced.It can be used as an accessory of thermal power plant. In India, 80% of mining is in coal and its accounts for 55% of India's energy need.Coal has been a major contributor in providing energy security of our country, but it is not a renewable resource; one day it will exhaust. Solar energy is a part of non-conventional source of energy. Also this energy is available in abundance limit. There are many disadvantages of using fossil-based fuels, such as atmospheric pollution and environmental issues. Fossil fuels emissions are major contributors of greenhouse gases which may lead to global warming. Combustion from fossil fuels is major source of air pollutants, which consist of CO, NOx, SOx, hydrocarbons, particulates and carcinogenic compounds. The Present Work is done on obtained parameters of 31MW Thermal power plant (HEG Bhopal).Solar water heater of evacuated tube type is a good alternative for increasing the efficiency of thermal power plant& to reduce the consumption of fossil fuel. e.

Keyword: *Solar, DM Feed water, MW, Fossil fuels*

I. INTRODUCTION

Material The steam is generated in the boiler of the thermal power plant using the heat of the fuel burnt in the combustion chamber. The steam generated is passed through steam turbine where part of its thermal energy is converted into mechanical energy which is further used for generating electric power. The steam coming out of the steam turbine is condensed in the condenser and the condensate is supplied back to the boiler with the help of feed pump and the cycle is repeated. Following are the important parts of thermal power plants:

- Boiler House
- Steam Turbine
- Condenser

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- Cooling Tower
- Feed Pump
- Electric Generator.

1.2 Working of Boiler in power plant

Generally Boilers are used to produce steam at high pressure than atmospheric pressure. The steam generator is also known as boiler. Steam is the most important working substance used for power generation in steam engines and in steam turbines. The generation of steam is done by evaporating the water in boilers at appropriate temperatures and pressures. A "Boiler" may be defined as a combination of equipments to generate steam from water by burning fuel. In industries the steam may be used for different purposes.A boiler is an enclosed vessel that provides a means for combustion heat to be transferred into water until it becomes heated water or steam. The hot water or steam under pressure is then usable for transferring the heat to a process. Water is a useful and cheap medium for transferring heat to a process. When water is boiled into steam its volume increases about 1,600 times, producing a force that is almost as explosive as gunpowder. This causes the boiler to be extremely dangerous equipment that must be treated with utmost care.

1.3 Classification of Boiler

1. According to Pressure of Steam Created in the Boiler

(a) Low pressure boilers – which can generate steam pressure less than 100 bar. Some boilers of this category are

- Cochran boiler
- Lancashire boiler
- Locomotive boiler
- Babcock Wilcox boiler

(b) High pressure boiler – which generate pressure above 100 bar . These are more efficient and reduced quantity of steam required for same power generation, compared to low pressure boilers. Some of this type are

- Lamont Boiler
- Benson Boiler
- Loffler Boiler
- Velox Boiler

2. According to the Relative position of Water and Hot gases

(a) Fire tube Boiler or smoke tube boilers.
(b) Water tube boilers.
In fire tube boilers, hot gases pass through tubes which are surrounded with water. There may be single or double tubes as in the case of Lancashire boiler or there may be a bank of tubes. The heat is condensed through the walls of the tube from the hot gases to the surrounding water.

3. According to the Position of Furnace

The steam boilers, according to the position of the of the furnace are classified as:
(a) Internally Fired Boilers- The furnace is located inside the boiler shell. Most of the fired tube steam boilers are internally fired.
(b) Externally Fired Boilers – The furnace is arranged underneath in a brick-work setting. Water tube steam boilers are always externally fired.

4. According to the Axis of the shell –

The steam boilers, according to the axis of the shell, may be classified as:
(a) Vertical boiler
(b) Horizontal boilers.
In vertical steam boilers, the axis of the shell is vertical. Simple vertical boilers and Cochran boilers are vertical boilers. In horizontals steam boilers, the axis of the shell is horizontal. Lancashire boiler, Locomotive boiler and Babcock and Wilcox boiler are horizontal boilers.

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5. According to the Number of Tubes – The steam boiler, according to the number of tubes, may be classified as:
(a) Single tube boilers and
(b) Multitubular boilers.
In single tube steam boilers, there is only one fire tube or water tube. Simple vertical boiler and Cornish boilers are single tube boilers. In multitubular boiler, there are two or more fire tubes or water tubes. Lancashire boiler, Locomotive boiler, Cochran boiler, Babcock and Wilcox boilers are some examples.

6. According to the Method of Circulation of Water and Steam: – The steam boilers, according to the methods of circulation of water and steam, may be classified as:
(a) Natural circulation boilers, and
(b) Forced circulation boilers.
In Natural circulation steam boilers, the circulation of water is by natural convection currents, which are set up during the heating of water. In forced circulation steam boilers, there is a forced circulation of water by a centrifugal pump driven by some external power.

7. According to the Use: - The steam boilers, according to their use, may be classified as:
(a) Stationary boilers
(b) Mobile boilers.
The stationary steam boilers are used power plants, and in industrial process work. There are called stationary because they do not move from one place to another. The mobile steam boilers are those which move from one place to another.

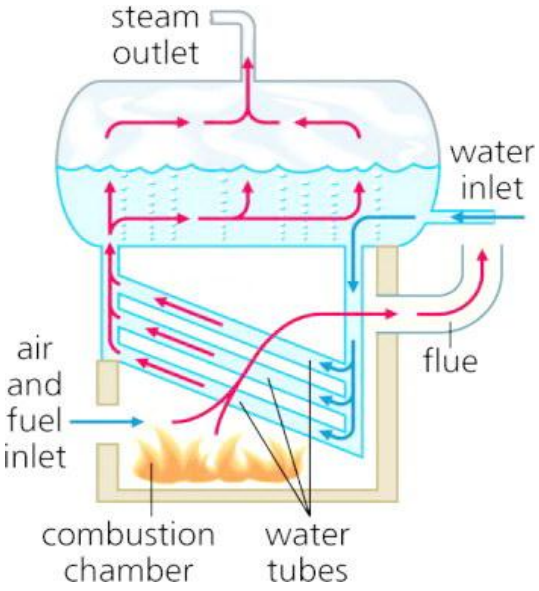

Fig 1.1 Steam Boiler (water tube type)

1.4 Boiler Efficiency:
It may be defined as the ratio of heat actually used in producing the steam to the heat liberated in the furnace. It is also known as thermal efficiency of the boiler. Mathematically,
Boiler efficiency or thermal efficiency:

$$\eta = \frac{\text{Heat actually used in producing steam}}{\text{Heat liberated in the furnace}}$$

1.5 Variables that affects the boiler efficiency
- Number of boiler passes
- Burner / boiler compatibility

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- Repeatable air/fuel control
- Preheated Boiler Feed Water (by Flue gas, Solar heater, Solar Pond.) [2]
- Pressure vessel design
- Proven stack temperature
- Accurate fuel specification
- Actual operating excess air levels

1.6 Electricity cost

The direct cost of electric energy produced by a thermal power station is the result of cost of fuel, capital cost for the plant, operator labour, maintenance, and such factors as ash handling and disposal. Indirect, social or environmental costs such as the economic value of environmental impacts, or environmental and health effects of the complete fuel cycle and plant decommissioning, are not usually assigned to generation costs for thermal stations in utility practice, but may form part of an environmental impact assessment.

1.7 Ways to reduce electricity cost

(1) To reduce the cost of fuel used in boiler
(2) Better use of fuel
(3) Try to use non conventional source of energy like Solar Energy, Wind Energy.

II. METHODOLOGY

2.1 Use of Solar Feed Water

Presently coal is used in Thermal power plant for Power generation. But todays Scenario of fossil fuel is not good from future point of view because coal will finish after some years and also the prices of coal are increasing day by day. So there is Essential requirement of saving of coal from every manner. In today time we can see that many researches have done on implementation of solar energy on existing thermal power plant. And the results are good from the coal saving point of view and also from environment.

Solar energy is Ecofriendly and silent in working it reduces the problem of noise. Many research are doing day by day for maximum generation of power from solar energy because these energy are naturally free and it will be millions of year in these earth The use of solar Energy in Power generation are increasing but it has some limitation from cost point of view because Fully solar based thermal power plant are more costly. And very high capital cost is required to make solar thermal power plant. Implementation of solar energy in medium power plant is easy and need very less amount of money to Implement it and easy to maintain.

For reduction of fuel cost in thermal power plant use of solar energy can save a lots of coal. There is a requirement to use of solar energy in small thermal power plant for saving of coal. Solar water heater is a good alternative to increase the temperature of Boiler feed water (makeup water). Increase in temperature of makeup water will reduce the cost of sensible heat in other words it reduces the cost of coal. [19] Solar thermal energy can be involved in different ways in existing power generation plants in order to replace heat produced by fossil fuels .solar field feed water preheating is a good way to reduce coal consumption. Many Research have shown that preheating of boiler feed water by different solar heating technique can reduce the consumption of fossil fuel. “Rankine regenerative steam cycled power plant has been modeled with thermo flow software the plant model incorporates also a field with solar Fresnel collectors that directly heats boiler’s feed water. [20] The proposed plant modification yields substantial fossil fuel input reduction”. The best results can be obtained when the group of solar water heaters is placed for heat boiler feed water exceeds its original design value. The work has done on coal based power plant of 31 MW by implement Evacuated tube solar collector for preheating of boiler feed water (25000 Liters make-up water) in every 24 hour.

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The work Include the following parameters

(1) The capacity of SWH required to maintain the temperature of 80- 90^0C in makeup water tank (feed water, 25000 liter)
(2) Type of solar water heater (Solar collector) required to maintain the temperature of 80^0C in Solar water tank.
(3) Cost required to implement setup (ETC) for preheat feed water of 25000 liters

Refer Appendix "A" for Sample calculation on evacuated tube.

2.2 Available parameters from 31MW Coal based Power plant

Boiler Specifications

General Features of Boiler used in HEG (Mandideep Bhopal)

Installed Capacity	31 MW Fuel(Coal)
Bituminous F Grade	
Boiler Type	Circulating
Fluidized bed Combustion	
Pressure	85Kg/mt^2
Temperature	485degreeC
Steam Generation rate	144TPH
Fuel Burning Rate	24.5TPH
DM water tank Capacity	3 tanks each of 100KL
Make up water required for every 24 hours	25KL
Normal Temperature of DM water	35degreeC

2.3 Selection of Solar Collector for heat 25000 Liters feed Water up to Temperature of 80-90^0C

There are many types of Solar Collectors are used for heat water according to requirement

1. Parabolic Trough Sola Collector
2. Solar Power Tower Collector
3. Parabolic Dish Collector
4. Flat Plate Collector
5. Evacuated tube Solar Collector

Parabolic Trough, Power Tower System & Parabolic Dish Collector are already used in Solar Thermal Power Plant for their high temperature generation capacity. Flat Plate Collector & Evacuated tube Collector is used for heat Small Quantity of Water up to 50000 Liters and maintains a temperature of 90-100^0C. [26] For 25000 liters feed water heating, evacuated tube solar collector will be perfect to maintain a temperature of 90^0C. than flat plate collectors in cold and cloudy climates. On the internal surface of the inner borosilicate glass tube there is a absorber plate which collects the radiation that passes through the glass layer. [26] This absorber plate is mostly of aluminum or copper as both of these metals have a high heat reflectivity and transitivity quotient. It is also painted black so as to allow it to absorb maximum amount of solar radiation.

2.4 Mechanism of Evacuated Tube Solar Water Heater

Evacuated solar water works on natural Process .it heats the water direct from sunlight obtain from sun.
The Evacuated tube collector are design in such a way that hot water with temperature range 60-80^0C will be available for maximum no of days throughout the year however the system can deliver the hot water at the temperature varying from 60-80^0C depending on the season and availability of sunshine. Right from top to bottom available hot water temperature remains almost same due to non-mixing design of system and plumbing Evacuated tube collector is suit for any type of water. Unique feature of (ETC). is its special lined hot water tank which prevents from the scale deposition on inner side of tank, as well, in case of etc. water heating takes place in glass hence there is no bonding of scales possible on smooth surface of glass tube.

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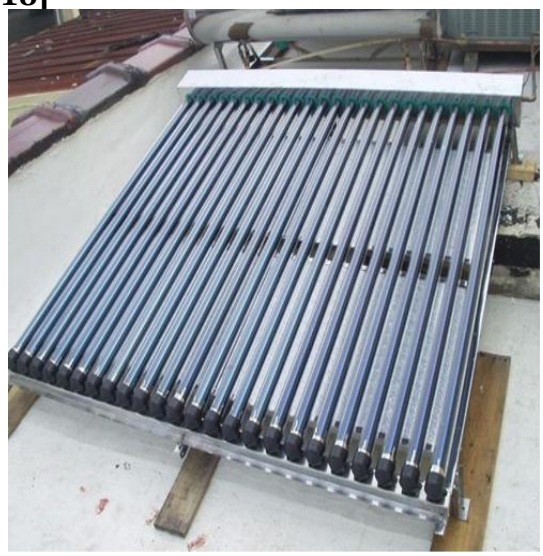

Fig: 2.1 Evacuated tube solar water heater

2.5 Working Principle of Evacuated tube Solar Collector System

ETC System works on a simple principle "Black body heat absorption Principle". The Principle Says, black color absorbs maximum heat, more than any other color. Solar water heating system using vacuum tubes of borosilicate glass with special coating of copper to absorb the collector energy are called as evacuated tube collector system (ETC). Vacuum tube as shown in fig shows the thermo siphon system which absorbs solar energy; the vacuum tube is an assembly of two concentric, borosilicate glass tubes.

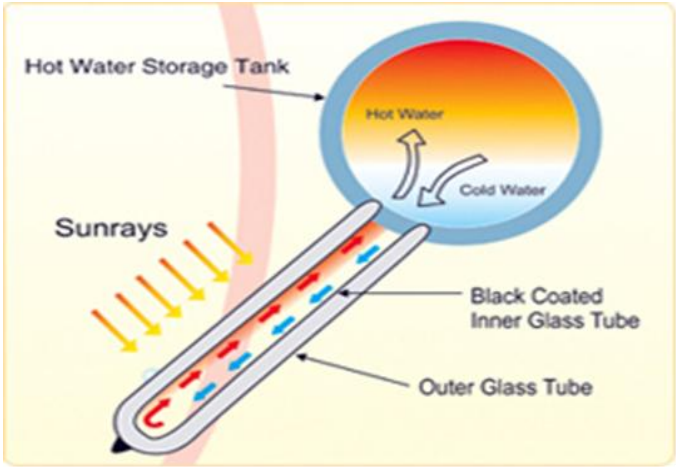

Fig: 2.2 working principal of evacuated

2.6 Advantages of Evacuated Tube solar collector water heating

Sunrays remain perpendicular to cylindrical absorber surface of vacuum tubes. It can absorb more energy resulting in more efficiency of the tubes. Even in smaller capacity range, many models are designed just by varying numbers of evacuated tubes. Hence wide ranges are available to select the exact system to match the individual requirement due to this feature, the system has become more economical and cost effective The flat plate collector uses costly metals like copper and aluminum. [23] On the other hand the Evacuated tube collector requires only glass tubes. This is made possible due to technological advancement, which has resulted in substantial cost saving.

1. Reduction in peak load.
2. Reduction in rate of global warming.

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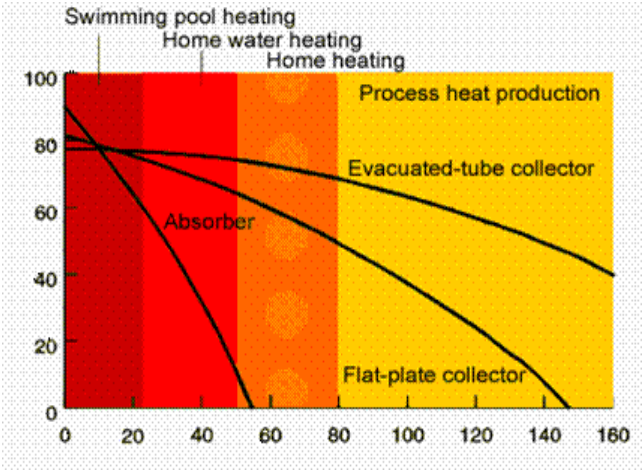
3. Negligible scaling of tubes.
4. Higher efficiency on high temperature.
5. Less space & more economical.
6. Long life more than 15 years.
7. Maintenance Free.
8. Heat loss in the tubes during the daytime is negligible (evacuated tubes)
9. Convection and Convecting losses are low.
10. Satisfactory performance even in extreme cold condition (-18 deg. C)

2.7 Efficiency Graph of different types of Solar Collectors

Efficiency graph showing performance of different types of Solar Collectors indicates evacuated tube collector has highest efficiency at higher temperature. [24]



2.8 Reasons for selecting evacuated tube solar collector

1. Due to high heat transfer rate of Evacuated tube solar heater, it will be efficient for Makeup water heating of boiler
2. Evacuated tube collector has more surface area than flat plate collector, for same Capacity. [30]
3. Evacuated tube collector is suitable for every weather condition.
4. In a cold season of winter evacuated tube maintain a minimum temperature of 60^0C
5. Evacuated tube collector is cheaper than flat plate for same capacity.
6. Evacuated tube collector need zero maintenance for any weather condition
7. For mass water heating evacuated tube collector are successful.

2.9 Maintenance and servicing of evacuated tube solar collector

Generally the water supplied through local municipal authorities is always of good quality. This is well treated, after demineralize the water in DM plant, the feed water become soft filtered and having hardness below 50 ppm. If such water is used through Evacuated tube, the maintenance and servicing required will be almost negligible. When the water hardness is higher or when the suspended dirt and impurities are present in the water, there is a possibility of stains dirt accumulation inside the vacuum tube. This can be easily removed by removing the evacuated tube and cleaning them properly. These services can be made available from trained solar plumbers through dealers. However for achieving consistent performance and better life of ETC. it is recommended to do servicing of whole system once in year, which includes cleaning of vacuum tubes and hot water tank. The rubber parts like seal, grommets etc. may require replacement while serving. This will be made available in the market.

2.10 Cost Required for Implement Setup

In thermal power plant of 31MW, in every 24hr 25,000 liters makeup water is required. Temperature of makeup water is normally at 35^0C at atmospheric condition for maintaining a temperature of 70-80^0C in 25000 liters makeup water. [25] Solar water heater (ETC) of capacity 25000 liters will be required. For capacity of 25000 liters solar water heater (ETC), money required is 20 lakh rupees.

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2.11 Area required to implementing the setup

Area required to implement solar collector of evacuated tube type for 25000 liters is 4000^{2}ft. Total 50 Solar Arrays(Evacuated tube type) will require of capacity 500litres each Solar array Dimension of Each array (Solar Collector) will be 12ft by 13ft. Tank of capacity 30000 liters will require to store 25000 liters hot water.

2.12 Size of Solar Array (ETC) for 500 liters of water

Dimension of Single array of capacity 500 liters that require solar panel of size 12 by13ft that contains total 60tubes,30tubes in left and 30tubes in right Every 50 solar array will install in column & row wise that will capture area of 40002ft. ETC solar panel of 500 liter

Fig: 2.3 Solar Arrays of capacity 500 Liters each

2.13 SYSTEM SPECIFICATION (Evacuated Tube type solar water Heater of Capacity 500 Liters)

Table: 2.1

1.	System Capacity	500 liters
2.	No. of Tubes	60
3.	Tube Specifications	Length-1800mm,58 mm OD
4.	Vacuum Tube Material	Borosilicate Glass
5.	Absorber coating	Coating of Aluminum Nitride by worlds latest innovative technology "Magnetron Sputtering Technique"
6.	Absorptivity	>92%
7.	Thermal Expansion	3.3×10^{-6}degc
8.	Stagnation Temperature	>200^{0}c
9.	Weight of single tube	2.2Kg
10.	Tube Resting Caps	UV Stabilized ABS Plastic
11.	Water circulation	Natural Thermo siphon

2.14 Tank Specification (Solar heated water storage tank)

Table 2.2

1.	Tank Capacity	25000
2.	Tank Material	SS-304L
3.	Tank Material type	Food Grade
4.	Insulation Material	PUF
5.	Insulation Thickness	50mm
6.	Type of Tank	Horizontal
7.	Tank cladding material	Pure polyester power coated cover
8.	Support Structure	GI- Powder coating

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2.15 Solar water storage tank of capacity 30,000 liters

These tank contain the Quality of high pressure insulation, Special nonstick lining to prevent scale deposition & corrosion also heavy duty dished end steel tank enhances tank life. Increases strength, pressure stability and avoids stress corrosion.Renowned Research institute From Germany & Australia first invented & successfully experimented the solar collector with evacuated tube technology .this technology was commercially implemented by some chines companies & numbers of systems have been installed all over the country which is working very successfully since last 15 years . now in china, millions of etc. are being installed, many of them even in used in hospital, swimming pool heating. Now the technology is widely accepted all over the world, many systems are working successfully throughout the world, even in developed countries like USA, Japan, Germany, Australia, Spain etc. Though the technology seems to be new for country, it is a well-proven & highly reliable product. That's why Government of India (MNES) Ministry of Non-conventional energy sources have approved the product etc. & decided to promote its use throughout our country.

2.16 Time required for rising temperature from 35 to 80^0C

Six hour direct sunlight is required to rise a temperature in any season (Data collected from sudarshan Saur limited)

Table: 2.3

Season	**Atmospheric Temperature**	**Temperature rise**	**ΔT**
Summer	35^0	80^0	45^0
Winter	20^0	65^0	40^0
Rainy	30^0	65^0	35^0

2.17 Performance Parameters on which Evacuated tube solar water heater work
(Data collected from sudarshan sour limited)

Direct sunlight of six hour is required to rise temperature. Rise of temperature is not depend on season, it only depends on availability of sunlight for six hour Solar water heater of evacuated tube type is most suitable for Indian climate. In summer season rise in temperature is rapid.

2.18 Existing layout of 31 MW Coal based power plant in HEG Mandideep

Layout of thermal power plant are shown below these layout contain the complete working of power generation by using coal as a prime fuel These Layout Contains

DM Water Plant
Coal handling

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2.19 Proposed layout of 31 MW Coal based power plant in HEG Mandideep

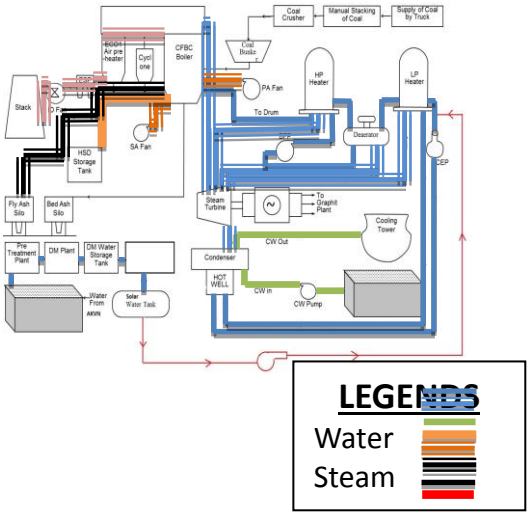

Fig 2.4 Proposed Layout of Thermal power plant

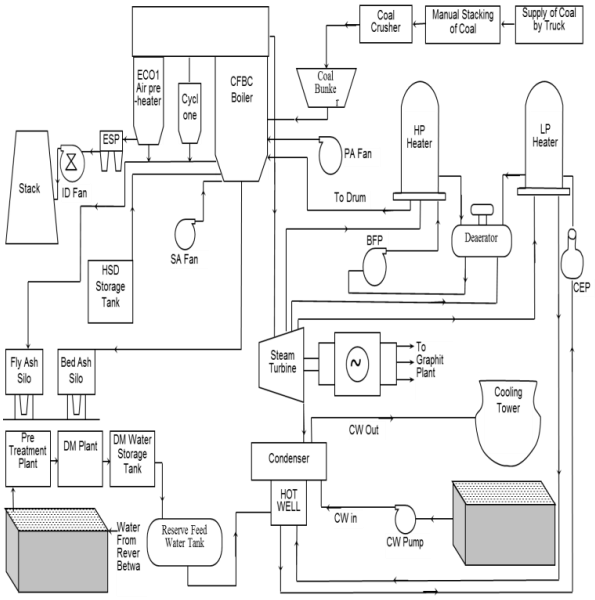

Fig: 2.5 layout of Existing power plant

Fig: 2.6 Water treatment plant of 31MW Thermal power Plant

In Proposed setup Solar heated feed water is directly send to boiler by feed pump Solar Panels will install near makeup water plant So water comes from DM Plant(Demineralized) will pass through Solar water heater of evacuated tube type than after rising temperature it will store in tank of capacity 30000liters(adiabatic chamber) It will maintain the temperature of hot water for 10-12 hours. Solar water heater cab be used as an accessory for preheat feed water in a thermal power plant.

2.20 Water Treatment plant for capacity 31 MW Thermal power plant

In a Water treatment plant of HEG, Water comes from AVKN, (Audyogik Vikas Kendra Nigam) Mandideep Bhopal. During water treatment, removes all the impurities contain in water and also demineralized the water by using chemical solution and acids and make water perfect for boiler feeding. Water treatment plants contain three tanks each of capacity 100KL.

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III. RESULT & DISCUSSION

3.1 Theory of coal saving

Calculation of coal saving is done on the basis of temperature rise of makeup water (25000 liter) in every 24 hours by solar energy. Temperature rise of makeup water by solar radiation is free by implementing solar water heater. Normally makeup water is send to boiler assembly at temperature of 35^0C, but by implementing solar water heater we can rise the temperature of makeup water up-to 90^0C without any running expense. By energy unit conversion we can calculate exact amount of coal save per day. By using the formula of temperature rise, $Q = mc_p\Delta t$ we can calculate the quantity of heat required to rise the temperature. We know that heat is a form of energy and also coal contains energy in the form of calorific value.

3.2 Performance Parameters

Thermal power plant of capacity	= 31MW
Amount of makeup water feed in every 24 hours	= 25000 liter at 35^0C
Required temperature of makeup water	= 90^0C
Calorific value of coal used	= 2500kilo-calorie per kg
Rise of temperature at constant pressure	= 1bar
Specific heat at constant pressure (C_p)	= 4184 J/kg/ºC
Price of coal in India	= 4000 to 7000 Rs per ton

3.3 Calculation of coal saving

Heat required Q to rise temperature of makeup water from 35 to 90^0C can be calculated by the formula given below

Table: 3.1

Sr.No. 1	Performance Parameters	Symbol	Formula	Unit
1.	Heat required	Q	Q= mcpΔT	joule

Where Q = Heat required
M = mass of water
C_p = Specific Heat at Constant Pressure = 4184 J/kg/ºC

3.4 Coal Prices in India according to Grade and Calorific value

(Data Collected from coal India limited)

Table 3.2

Unit/Grade of Coal	Calorific value(Kilocalorie/Kg)	Rs/Tonne
A	4000-3000	7100
B	2500-3000	4500
C	Below 2500	Below 4000

Calculation of coal saving in measured by equating the calorific value of coal and heat required to rise temperature of makeup water (energy balance).

Temperature rise of water is measure by using formula

$$Q = mcp\Delta T$$

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Where;
Q = heat required
Cp = Specific heat at constant pressure = 4184 J/kg/ºC
ΔT = Temperature rise
m = Mass of water
C = 2500 Kilocalorie/kg

For 31MW power plant

Calorific value of coal used in thermal power plant = 2500 kilocalorie/kg
Makeup water required per 24 hour = 25,000litres
Temperature of makeup water at atmospheric condition = 35^0C

Case: 1
Q = Heat required to convert 35^0C feed water to 80^0C
Q = mcpΔT
= (mass of water) (Specific heat at constant pressure) (rise in temperature)
= (25000kg) (4184 J/kg/ºC) (45 ºC) = 4707MJ

Calorific value of coal used 2500kcal/kg
4707000000joule =1125000 kilo calories
4707MJ heat is generated by burning of 450 kg of coal
450 kg of coal can save per day.

Case: 2
Q = Heat required to convert 35^0C feed water to 70^0C
Q = mcpΔT
= (mass of water) (Specific heat at constant pressure) (rise in temperature)
= (25000kg)(4184 J/kg/ºC)(35 ºC) = 3661MJ

Calorific value of coal used 2500kcal/kg
3661000000joule =875000 kilo calories
3661MJ heat is generated by burning of 350 kg of coal
350 kg of coal can save per day.

Case: 3
Q = Heat required to convert 350C feed water to 600C
Q = mcpΔT
= (mass of water) (Specific heat at constant pressure) (rise in temperature)
= (25000kg) (4184 J/kg/ºC)(25 ºC) = 2615MJ
Calorific value of coal used 2500kcal/kg
2615000000joule = 625000kilocalories
2615MJ heat is generated by burning of 250 kg of coal
250 kg of coal can save per day.

Case: 4
Q = Heat required to convert 35^0C feed water to 50^0C
Q = mcpΔT
= (mass of water) (Specific heat at constant pressure) (rise in temperature)
= (25000kg)(4184 J/kg/ºC)(15 ºC) = 1569MJ

Calorific value of coal used 2500kcal/kg
1569000000joule = 375000 kilocalories
1569 MJ heat is generated by burning of 150 kg of coal
150 kg of coal can save per day.

3.5 Saving of money in terms of coal consumption reduction per day

Table 3.4

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As we can see in above table of money saving us can save coal 450 kg per day of price 2025 Rupees by implementing evacuated tube solar collector setup for preheat make up water of capacity 25000 liter per day.

3.6 Saving of coal & money per year

As we can see in above table that after installing evacuated tube solar collector for preheating make up water of capacity 25000 liters per day as a result we can save coal 164250 kg per year of price 739125 lakhs rupees.

S no	Coal saving per year	Money saving per year	Calorific value of coal
1.	450 × 365 = 164250 kg	4.5 × 164250 = 7,39,125	2500 kilocalorie/kg
2.	350 × 365 = 127750 kg	4.5 × 127750 = 5,74,875	2500 kilocalorie/kg
3.	250 × 365 = 91250 kg	4.5 × 91250 = 4,10,625	2500 kilocalorie/kg
4.	150 × 365 = 54750 kg	4.5 × 54750 = 2,46,375	2500 kilocalorie/kg

All the above calculation of coal saving is done by using the coal of calorific value 2500kilocalorie/ kg if the thermal power plant use coal of higher calorific value then we can save more money per year. Also solar water heater is ecofriendly to environment it left zero emissions to the environment like Co_2 , So_2, No_2. (MNES) Ministry of Non-Conventional Energy Source also recommends the solar water heater for water heating so that the pollution spread by fossil fuel will reduce.

3.7 Payback time of proposed setup

The one time installation cost of solar water heater setup is 20lakhs Rupees that will be for forever there is no running cost required to maintain these setup as we can see in results we can save coal 164250kg per year of price 7,39,125 Rupees.so the payback time of proposed setup is only three years. Also this setup requires zero running & maintenance cost for at least 25 years.

3.8 Energy Conversion chart that used for energy balance of coal saving

Table: 3.5

1joule	=0.000239Kilocalories
1 Giga Joule	=1000000000joule
1 Calories	=4.1868 joule
1 kilojoules	=1000joules
1 mega joules	=1000000
1 watt hour	= 3.6 kilo joule
1 terajoule	= 1 000 000 000 000 joule
1 gigawatt hour	= 3 600 000 000 kilo joule
1 petawatthour	= 3 600 000 000 000 000 kilo joule
1 kilocalorie [I.T.]	= 4.186 8 kilo joule
1 calorie [I.T.]	= 4.186 8 joule
1 centijoule	= 0.01 joule
1 kilowatt hour	= 3 600 000 joule
1 megawatt hour	= 3 600 000 000 joule
1 kcal/kg	= 4.1868 kJ/kg
1 joule	=0.23885 calorie

IV. CONCLUSION

We know that coal is prime fuel for thermal power plant for generation of superheated steam for drive a turbine. due to Coal is limited source of energy and it is available for only next 40-50 years. With the rising demand of electricity, more fuel is required in Coal based thermal power plant. So saving of coal is very necessary in the thermal power plant.

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The solar thermal power plant is a good alternative for conventional (coal based) thermal power plant. Now a day's solar thermal power plant are works successfully in all over the world with different solar collecting techniques.

There are many types of solar collectors are used in solar thermal power plant like parabolic trough collector, parabolic dish collector, power tower system. And also many successful research have done for implementation of solar energy in existing thermal power plant for reduce the dependency of coal. In addition to environment and long-term financial advantages, solar thermal technologies will provide a number of further benefits, which are difficult to quantify. This includes a reduction of the dependency from imported fossil fuels as well as a growth in local employment.

In the present work we have done the implementation of solar energy in 31 MW thermal power plants for heat makeup water 25000 liter from 35 to 90^0C in every 24 hours by using evacuated tube solar collector. The evacuated tube solar collectors provide a substantial difference in the temperature of the working fluid. The amount of heat transferred to the working fluid depends on the incident flux of solar radiation and on the aperture area of the tubes. The heat transfer coefficient of the air gap in the tubes plays a major role in facilitating the heat transfer. Also evacuated tube solar collector is easy to service & maintain.

REFERENCES

1 Arora, Domkundwar (2002).Power Plant Engineering,5th Edition,Dhanpat Rai & Co, India pp.191-203
2 Rozer,w,. Generation of Steam in boiler. Coal energy 2003:28:239-48
3 Winter C.J., R.L. Sizmann and L.L. Vant-Hull, Solar Power Plants: Fundaments, Technology and System Economics, Springer-Verlag, New York, USA
4 Shirish Garug, Fellow and Ishan Purohit, Research Associate the Energy and Resources Institute (TERI),India
5 "Future of Solar Energy in India" Annual Report of India, Ministry of New and Renewable Energy Sources, 2005-2006
6 http//En.Wikipedia.org/Solar_Thermal_Energy
7 Muller-Steinhagen, h.and j.nitsch: The Contribution of renewable Energies to A Sustainable Energy Economy. Trans IchemE, part Process Safety and Environment Protection, Vol.83, pp.285-297(2005)
8 Weiss, w.,bergmann,i.andfaninger,g.:solar heat worldwide.aee intec (2007)
9 Muller-Stein Hagen, H; Trieb, F.: Concentrating Solar Power Plants. Royal Academy of Engineering, Ingenia Issue 18 & 20(2004).
10 Becker, M .and Meinecke, W (ED)(1992).Solar Thermal Technology, Comparative Study of Central Receiver, Parabolic trough, Parabolic dish and Solar chimney power plants (in Germany).Springer Publishing house, Berlin, 1992
11 Beerbaum B. and G. Weinrebe Solar thermal power generation in India: a techno Economic analysis, Renewable Energy, 21,2,1 2000,153-174.
12 Solar Energy (2011) Volume: 85, Issue: 2 Publisher: Elsevier Ltd, Pages 344-349 ISSN: 038092X DOI: 10.1016/J.Solener.2010.11.017
13 Proposed Partial Repowering of a coal-fired power plant Using low grade solar Thermal Energy Int. J. of Thermodynamics ISSN 1301-9724/e-ISSN 2146-1511 Vol.14 (No.1), pp.21-28, 2011
14 www.sciencedirect.com/science/article/pii/S0038092X10003579
15 www.tatabpsolar.com
16 www.sudarshansaur.com
17 www.shriramgreentech.com/Solar-Water-Heater.asp
18 http://www.shriramgreentech.com/Solar-Water-Heater.asp
19 Data Collected from Sudarshansaur Pvt Ltd
20 Rai GD (2009). Nin Conventional Energy Sources,Khanna Publisher, 4th edition, New Delhi, pp.47-122