International Journal of Advance Research In Science And Engineering http://www.ijarse.com
IJARSE, Vol. No.4, Special Issue (01), April 2015 ISSN-2319-8354(E)

STUDY ABOUT EFFICIENCY IMPROVEMENT OF THERMAL POWER PLANT & ADVANCE TECHNOLOGIES IN DIFFERENT TYPES OF PLANTS

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ABSTRACT

The purpose of the study outlined in this is to identify major energy loss areas in India's thermal power stations and develop a plan to reduce them using energy and exergy analysis as the tools. The energy supply to demand is narrowing down day by day around the world due to the growing demand and sometimes due to ageing of machinery. Most of the power plants are designed by the energetic performance criteria based not only on the first law of thermodynamics , but the real useful energy loss cannot be justified by the fist law of thermodynamics, because it does not differentiate between the quality and quantity of energy. The present study deals with the comparison of energy and exergy analysis of thermal power plants stimulated by coal. Our national electricity requirement is about 2100MW against 1615MW supply; this is evident of about 21% deficit in terms of power requirements. Considering the high capital cost involved in new generation "clean technologies" developing countries like India having an abundance of cheap fossil fuel reserves have to give a major thrust to improvement in fossil-fired power technologies. Steam turbine based generating plants form the backbone of power generation in many countries in our country too, Base load is presently largely generated by fossil fuel based power plants. Most of these plants employ sub-critical coal fired boilers driving steam turbines to generate power. The adoption of "Supercritical cycles" for thermal plants on a wide scale has the ability to improve overall system efficiency, as well as provide benefits of lower emissions both on land & in air. Steam cycles for supercritical application operate at very high pressure & temperatures; these are thus characterized by features that take full advantage of the advanced parameters like higher expansion in turbines, more stages of feed heating & higher input levels to boilers, contributing to higher system efficiency.

KEY WORDS: Energy, Exergy, Effective, Efficiency, Improvement, Thermal Power Station, Different types of power plants.

I. INTRODUCTION

The expansion on the demand side resulted in over stretching of the current electricity generation capacity coupled with aging thermal plants which are still utilising old technology. The paper will focus on the energy efficiency improvement in thermal stations. Thermal Power Stations generate electricity through a thermal power plant; its installed capacity is designed with a common range of boilers feeding into common steam receivers from where any of the turbines tape the steam. Currently only few boilers are in operation with an output of approximately 1615MW. The power plants use coal as the primary input for generating electricity.

The plant use 20-30% of energy value of primary fuels and the remaining 70-80% is lost during generation, transmission and distribution of which major loss is in the form of heat. The heat rate of a plant is the amount of fuel energy input needed (Btu, higher heating value basis) to produce 1 kWh of net electrical energy output. This study was done to identify various methods to reduce the heat rate of existing coal-fired power plant in India by identifying areas that cause the most heat losses and introducing the new technologies that cater for the losses. Energy and exergy analysis is used for the identification of these loses. Energy analysis evaluates the energy generally on its quantity only, whereas exergy analysis assesses the energy on quantity as well as the quality. The aim of the exergy analysis is to identify the magnitudes and the locations of real energy losses, in order to improve the existing systems, processes or components, This study identifies specific plant systems and equipment where efficiency improvements can be realized either through new installations or modifications, and provides estimates of the resulting net plant heat rate reductions and the order-of-magnitude costs for implementation.

Power generation technologies have also kept pace. Through old technologies like steam, hydro and Nuclear Turbine have progressed to dizzying levels, newer “clean technologies’’ like wind & solar have also gained a major share of the grid in many countries, like India. There is now an ongoing debate both in favor of and against these clean technologies like. These are characterized by higher capital investment & longer pay back periods. Also these are site specific &always cannot be set up near consumption centers. The paper dwells on these advanced Technologies so alternatives to the conventional one. Considering the high capital cost involved in new generation “clean Technologies”[1] developing countries like India having an abundance of cheap fossil fuel reserves have to give a major thrust to improvement in fossil-fired power technologies. [1]

1.1 Aim

The main aim of the study is to identify areas where energy losses are occurring and develop them for efficient and effective improvement in a thermal power station.

1.2 Objectives

The object to satisfy this are

- To conduct energy analysis of the overall plant and determine the efficiencies and energy losses of all the major components on the power plant.
- Select and develop the areas where energy losses are being experienced.
- Determine the costs and payback periods for the new technologies suggested for efficiency improvement.

1.3 Scope

The study scope encompasses three major tasks, energy and exergy analysis and the identification of methods to reduce the energy losses of power plant and the determination of their associated costs involved with the installation of the possible measure to cater for the problem. Energy analysis is to be done on components from the combustor to the electrical generator.

II. CURRENT SUPPLY DEMAND SITUATION

Table (1) shows the current demand supply in India[1]

Table (1) Demand situation

Maximum Demand	1615 MW
Available Maximum Capacity	1615MW
Maximum Demand	2100MW

Our national electricity requirements are about 2100MW against 1615MW supply; this is evident of about 21% deficit in terms of power requirements as shown in table 2, the future supply- demand forecast in India will require an additional of 1750MW by 2015 to further increase the power shortage.[1]

III. FUTURE SUPPLY DEMAND SITUATION

India will require an additional 1750MW by 2015. In view of this situation, the project seeks to increase output from Thermal Power Station (TPS) in the process closing down on the power shortages now and in the future. Energy efficiency improvement measures provide a win-win situation by promoting cost-savings, lowering environmental impacts while at the same time promoting economic growth and social development. In addition to generating very large annual energy savings, present outlays on energy efficiency would avoid investment in energy infrastructure that would otherwise be needed to keep pace with accelerating demand. Efficiency improvement in all power plants can result in a sustainable gain in terms of electricity supply but this will need to be aided by other supply options such as imports and commissioning of new plants around the country.[2]

IV. METHEDOLOGY

The project is going to cover the following areas:

- A description of the facilities and their principal operation on the plant.
- A discussion of all major energy consuming systems.
- A description of all recommended Energy Conservation Measures (ECMs) with their specific energy impact.
- Energy and exergy analysis of the whole plant.
- A review on the implementation costs, benefits and payback period.
- Specific conclusions and recommendations.

V. DESCRIPTION OF THE PLANT

A schematic diagram of a plant with its various significant components is shown in Figure (1). The continuous supply of de-mineralized water is ensured to the condenser hot well for the normal running of the plant at a constant load. The condensate extraction pump (EXP) feeds the feed water to the ejector from the hot well. After the ejector exit, the feed water passes through the gland steam cooler, and the low pressure heater (LP). From the outlet of the low pressure heater (LP) the condensate enters into the boiler feed pump (BFP) where the condensate is pumped from the high pressure heater one (HP1) to high pressure heater three (HP3). Then the condensate passes through the economizer, and then enters into the boiler drum. There is a continuous circulation of water between the drum and the water walls and a part of the feed water is converted into steam. The steam is separated in the boiler drum and supplied to the super heater section and the boiler condenser section. The super heated steam produced in the super heater then enters into the turbine through the turbine stop valve and then rotates the electrical generator. After expansion in the turbine the exhaust steam is condensed in the condenser and is used for the closed cycle as shown in Figure (1).[3]

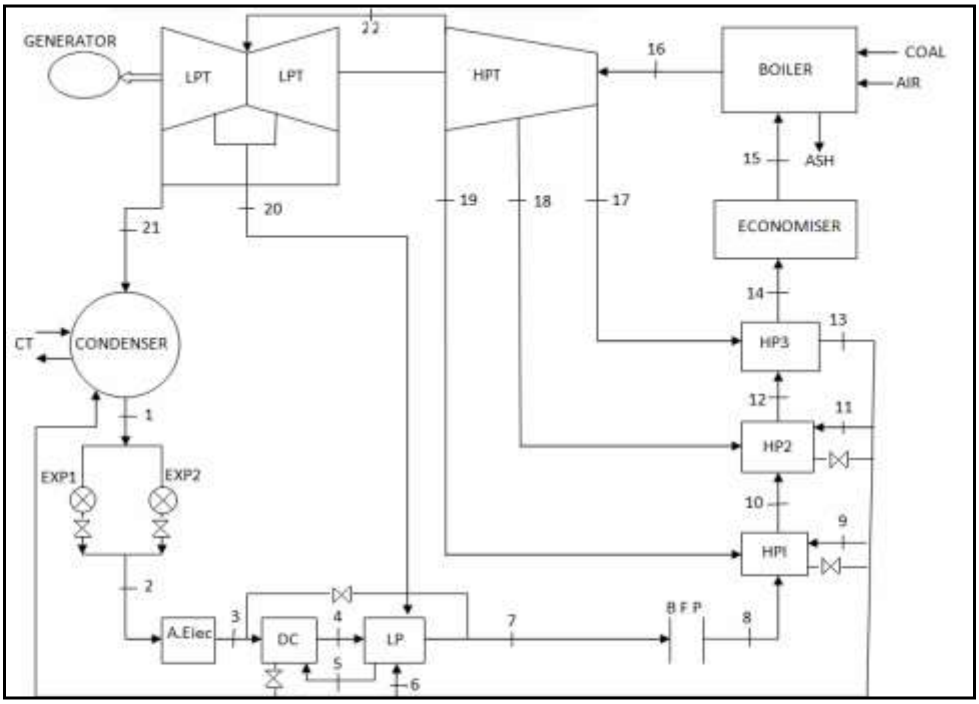

Fig (1) Schematic Diagram of Thermal Plant

VI. RANKINE CYCLE

Rankine cycle is the idealized cycle for steam power plants; it is a heat engine with a vapour power cycle (Wiser, 2000). The common working fluid is water, and the cycle consists of four processes as shown in Figure (2)

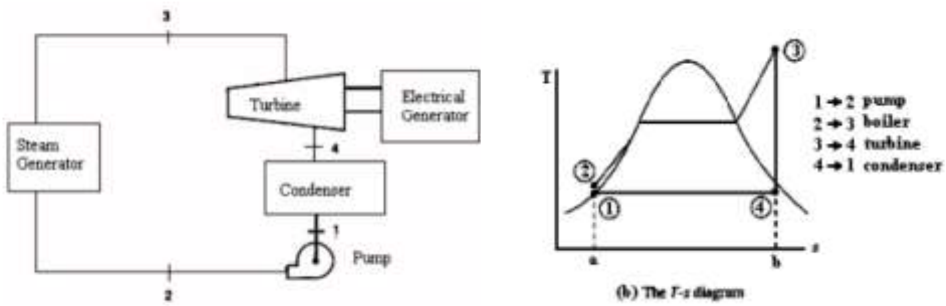

Fig (2) Rankine Cycle Representation of Power Plant

6.1 Power Plant Circuit

- **Process 1-2**: Isentropic compression (Pump; during the isentropic compression process, external work is done on the working fluid by the pumping. Pumping takes place from low to high pressure.
- **Process 2-3**: Isobaric heat supply (Steam Generator or Boiler; heat from the high temperature source is added to the working fluid to convert it into superheated steam. Pressurised liquid enters a boiler where it is heated at constant pressure to dry saturated vapour.
- **Process 3-4**: Isentropic expansion (Steam turbine); an isentropic process, the entropy of working fluid remains constant. The dry saturated vapour expands through a turbine, generating power. The temperature decreases and pressure drops, and condensation can take place may occur.

- **Process 4-1**: Isobaric heat rejection (Condenser; An isobaric process, in which the pressure of working fluid remains constant. The wet vapour then enters a condenser where it is condensed at a constant temperature to become a saturated liquid.

6.2 Energy Analysis

In an open flow system there are three types of energy transfer across the control surface namely working transfer, heat transfer (Qk), and energy associated with mass transfer and/or flow. The temperature (Tk) from the heat source and the network (W) developed by the system are used for the analysis of open flow systems and to analyze plant performance whilst kinetic and potential energy changes are ignored. The energy or first law efficiency of a system is defined as the ratio of energy output to the energy input to system.[4]

6.3 Exergy Analysis

Exergy is a generic term for a group of concepts that define the maximum possible work potential of a system, a stream of matter or heat interaction; the state of the environment being used as the datum state. In an open flow system there are three types of energy transfer across the control surface namely working transfer, heat transfer, and energy associated with mass transfer or flow. The work transfer is equivalent to the maximum work, which can be obtained from that form of energy . Energy analysis is based on the first law of thermodynamics, which is related to the conservation of energy. Second law analysis is a method that uses the conservation of mass and degradation of the quality of energy along with the entropy generation in the analysis, design and improvement of energy systems. Exergy analysis is a useful method; to complement but not to replace energy analysis.[4]

VII. DISCUSSION OF RESULTS

From the energy analysis, the overall plant energy loss is calculated as 81.72%. The comparison of energy losses between different components is given in Figure 4. It is observed that the maximum energy loss (47.79%) occurred in the condenser, this is due to the reason of heat energy expulsion from the condenser. Thus the energy analysis diverts our attention towards the condenser for the plant performance improvement. Approximately half of the total plant energy losses occur in the condenser only and these losses are practically useless for the generation of electric power. Thus the analysis of the plant based only on the First law principles may mislead to the point that the chances of improving the electric power output of the plant is greater in the condenser by means of reducing its huge energy losses, which is almost impracticable. [4]

Hence the First law analysis (energy analysis) cannot be used to pinpoint prospective areas for improving the efficiency of the electric power generation. However, the Second law analysis serves to identify the true power generation inefficiencies occurring throughout the power station.

VIII. DIFFERENT TECHNOLOGIES IN POWER PLANT

8.1 Hydro Electric Power Plant

Due to the abundant availability of coal, a large number of thermal sets were set up by the British for meeting power demand in India’s emerging cities. Due to the limited manufacturing capabilities of equipment in India all these plants were set up using imported equipment .The power equipment industry was established in India with the setting up of the first plant of BHEL at Bhopal in November 1956, under Heavy Electrical India limited (HEIL). Heavy Electricl plant in Bhopal is the mother plant of BHEL. The largest engineering &Manufacturing enterprise in India in the Energy-related and infrastructure sector, It was dedicated to the nation on 6th of

November 1960 by first prime minister of India Pt. Jawaharlal Nehru. BHEL spread of Operations with 180 products groups caters to the core sectors of Indian economy, power, industry, transportation, Transmission, oil & GAS, Renewable energy etc.In service of the nation BHEl sets generates 73% of the total power in the country while accounting for 65% of India's total installed generating capacity 1, 23,668 MW.From the above we see that India was a pioneer in the introduction of clean Technologies like Hydropower.

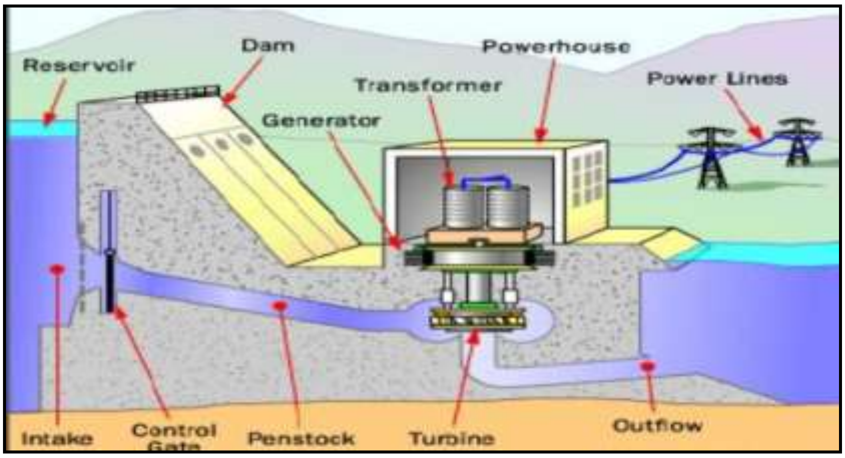

Fig (3) Hydro Electric Power Plant

There have been subsequent in power plant Technologies the world over, mainly in the Thermal &Nuclear Segments. Due to the abundant availability of coal in India, the Technology base for manufacture of large size steam turbines utilizing these coal. The first steam station was set up in Calcutta in 1899. We have a share of around 59% in India's total installed generating capacity contributing 69% (approx.) to the total power generated from utility sets (excluding non-conventional capacity) as of March 31, 2012.Through these technologies suited India's interests, they are one being categorized as technologies that harm the envoirnment. this coupled with the system of earning Carbon credits for reduction of green house Gas emissions has led to a resurgence for the use of clean Technologies. For the past few years the India has made great strides in these newer clean Technologies like Wind, Tidal & the latest being Solar.[8]

8.2 Wind Power Plant

Wind power generation was not taken up on a wide scale owing to lack of suitable large size generation plants, lack of suitable micro Grid to connect these plants & proper support from the government & power buyers. However this has now seen a vast change with the government mapping the wind potential areas of the country mainly in coastal regions & in hill areas of Karnataka, Maharashtra, etc. The indigenous availability of large size WEG's up to 2MW, Govt. support for buying the higher priced Wind power coupled with ability to en cash CER's of these plants have made Wind power an attractive investment source for many Govt. as well as private firms. In the process, the contribution of Wind power has grown to almost 15000MW as on date & is expected to rise further. Although a relative newcomer to the wind industry compared with Denmark or the US, a combination of domestic policy support for wind power and the rise of Suzlon (A leading global wind turbine manufacturer) have led India to become the country with the fifth largest installed wind power capacity in the world. Though Wind power seems attractive, it is best by a major problem of continued availability & dependability. In spite of great developments in technologies, it is still expensive compared to conventional technologies, thus limiting its reach beyond a point.[5]

Fig (4) Wind Power Plant

8.3 Solar Power Plant

Solar power is another one clean technologies emerging in a strong way across the world, notably in countries USA & Southern Europe like Spain, Italy &also Egypt. In the past use of solar energy was limited to direct use of solar heat for heating purposes or for power generation using photo-Voltaic method. In this method the efficiencies were quite low with high capital costs, thus limiting its use to far flung areas where no other technology could be built. However the newer technologies developed over the years have bluunte the drawback to a great extent. In most parts of India, clear sunny weather is experienced 250 t0 300 days a year. The annual global radiation varies from 1600 to 2200 kwh/m2 which is comparable with radiation received in the tropical and sub-tropical regions. The equivalent energy potential is about 6,000 million Gwh of energy per year.[7]

Some of the Technologies are (I) Parabolic trough technology and (ii) Linear Fresnel reflector. Parabolic trough system is a type of solar Thermal energy collector. At the receiver can reach 4000C and produce steam for generating electricity. Power tower systems the reflected rays of the sun are always aimed at the receiver where temperatures well above 10000C can be reached. Solar tower technology: All of the illustrated technologies use different proven methods to capture the solar heat in large collectors & transfer this heat to fluids or water to generate steam, which is then used to power a conventional steam power plant.[8]

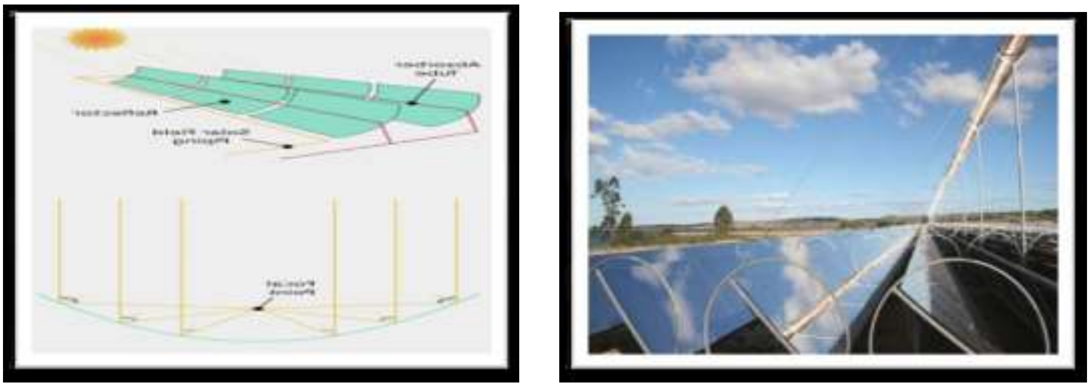

Fig (5) Solar Power Plant

8.4 Tidal Power Plant

Tidal potential in our country is huge, as we are blessed with a large coastlines of almost 5000km.The identified economic tidal power potential in India is of the order of 8000-9000MW. The other clean technology is the field of Nuclear Technology. The 320MW Tarapur Atomic power station (TAPS) was the first nuclear power plant in India. A 500MW plant went operational in 1969. BHEL has further upgraded its facilities to supply steam turbines for Nuclear Power stations up to 700 MW capacities being set up by Govt. of India. From the above we can conclude that there are many technologies in the world which can be collectively called ``Clean technologies’’. These are characterized by low to Zero Emissions & pollutions & therefore environment friendly. Because of their clean nature these newer technologies like Wind, Tidal, and Solar & Nuclear have also gained major share of the grid in many countries However, there is now a ongoing debate both in favor of & against these Clean technologies. These technologies are characterized by higher capital investment & longer pay back periods. Also, these are site specific & always cannot be set up near consumption centers. Hence their use till date has been limited to those countries which have a good financial position or those wherein the demand for clean technologies has surpassed the negative aspects of these technologies. One clear common factor that emerges from the above technologies is the Steam Turbine, which is an important part of most of the above. Therefore the world focus has again shifted to further development of Steam turbines based power plants as these are not very capital expensive, are relatively efficient & have a long & reliable service life[6]

Fig (5) Tidal Power Plant

IX. CONCLUSION

The paper set to show the weakness of depending on energy analysis only power plants as a performance measure that will help improve efficiency. Exergy analysis was undertaken at the thermal power plant which highlighted the areas that could be addressed to improve the efficiency. A recommendation of retrofitting and replacement was done for the system. On going work in development of intelligent power plant is expected to improve stability of steam headers, responsiveness to steam demand, increase power generation flexibility, minimize operations cost, improve overall plant efficiency, increase fuel cost savings and reduce CO2 Emission. Though older technologies like steam, hydro & nuclear turbines have progressed to dizzying levels, newer clean technologies like wind, tidal & solar have also gained major share of the grid in many countries. Though there exists an ongoing debate both in favour of & against these clean technologies as these are characterized by higher capital investment and longer pay back periods. Presently, base load in our country is generated by fossil fuel based power plants. Considering the high capital cost involved in new generation `` Clean Technologies``, developing countries like India having an abundance of cheap fossil fuel reserves have to give a major thrust to improvement in fossil-fired power technologies. We have also seen how the Steam Turbine based power station is prevalent in both the new as well as old technologies, in both the polluting as well as ``Clean Technologies”, thus emerging the leader of choice for power generation. Lastly the paper highlights how the power plant technologies including supercritical steam turbines to meet & exceed emerging requirements of society.

REFERENCES

[1]. Tekin T. and Bayramoglu M., (1998) Exergy Analysis of the Sugar Production Process from Sugar Beets, Int. J. of Energy Research, Vol 22 ,591-601,1998

[2]. Naterer GF, Regulagadda P, Dincer I., (2010), Exergy analysis of a thermal power plant with measured boiler and turbine losses, Applied Thermal Engineering 2010; 30:970–6.

[3]. Kapooria R.K, Kumar S, Kasana K.S,(2008), An analysis of a thermal power plant working on a Rankine cycle: a theoretical investigation, Journal of Energy in Southern Africa.Vol.No.1. February 2008

[4]. Bejan, (2002), Fundamentals of Exergy Analysis, Entropy Generation Minimization, and the Generation of Flow Architecture, International Journal of Energy Research, Vol. 26, No. 7, 2002, pp. 545-565

[5]. Wind and solar power systems, Bocaraton London Newyork Washington, D.C.CRC press.ISBNO-8493-1605-7.

[6]. N.kodama, T.matzuzaka, and N.Inomita, "power variation control of a wind turbine using Probabilistic Optimal control, including Feed-forward Control for Wind speed", Wind Eng, Vol. 24, No 1, pp13-23, jan2000

[7]. Enslin, J.H.R., "Maximum Power Tracking: A Cost Saving Necessity In Solar Energy System", 16th IEEE Annual Industrial Electronics Society Conference, Pacific Grove, USA, 1990, pp.1073-1077.

[8]. Bill Williams, 2002, Solar and Other Renewable Energy Technologies, Hydro power by Subramanian 21st july-2010.