Analysis & Optimization of Super Critical Boiler Efficiency

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Abstract- In this paper discussion is around the surveys and reviews of previous paper related to the regarding topic. Looking to the statically information, rate at which power require increase is incredibly very high compare to the rate at which production capability raise. Boiler is a mind of power plant, so its efficiency is directly affected to the all over efficiency of the plant. Observation of case studies quantify heat rate reduction resulting from the methods described here. Analysis of published literature to review heat rate reduction usually achieve in the industry. While the study and analysis presented in this idea was provoked by the need to calculate and re-establish data for the specific processes noted above, the objective of this study is to extend a generally valuable finding the methods of Boiler efficiency of Thermal Power Plant boilers when a few metered information is either absent or obviously incorrect. Argument of method to decrease the heat rate of accessible power plants.

Keywords – Steam Separator, Spiral Water wall, Supercritical boiler

I. Introduction

The primary reason of the study is to measure whether supercritical thermal plant technology is a proven and mature industrial technology and whether up to date supercritical power plants installed in India will have a robust availability and reliability.

The objective of the study is to provide a comprehensive report regarding supercritical technology specifically in the context of operation of supercritical thermal power plants in India. The study will address the following issues.

[1] Evaluation of the present state of supercritical technology with respect to typical range of steam pressure and temperature and efficiency of plant.

[2] Differentiate supercritical technology from sub-critical technology such as sliding pressure versus constant pressure, feed water quality, start-up time etc.

[3] Adaptability of technology to Indian conditions. Effect of use of Indian coal on performance.

Evolution of Technology

The requirement for energy is closely linked to economic growth and standard of living. Currently, demand for all global energy is boost at an average rate of around 2% per annum. The growth rate in India is higher and was about 4 percent for the period of the previous plan time, even with serious constraint of generation capacity. Electricity generate from coal currently accounts for about 40% of the electricity generated worldwide and about 53% in India. As coal is a comparatively more abundant fuel source in India, it is likely to remain a dominant fuel for electricity generation in future also. The incorporated Energy Plan developed by scheduling Commission also considers that coal is likely to be the main energy source for the power sector in the foreseeable future.

The main argument difficult against coal excited thermal power production is the large quantity of carbon-di-oxide (CO_2) emission formed by them which supply in a large determine to greenhouse effect and global warming. CO_2 emission can be lowered by civilizing the effectiveness of coal excited power plants. Increasing the temperature and pressure in a vapor turbine increase the efficiency of the ranking steam cycle used in power making, in other words it decrease the amount of fossil fuel consumed and the emission generated. A one percent increase in efficiency leads to decline of emission of CO_2 by 2.5%. For an 800 MW coal based unit, the 1% increase in efficiency would lead to a life time decline in CO_2 emission of around one million tones.

There has been a steady development in the raise in vapor parameter used in coal fired plants. Vapor parameter has been raise from 80 kg/cm^2 for 50 MW vegetation to 170 kg/cm^2 for 500 MW units. Supercritical units use advanced steam parameter of 240 kg/cm^2.

"Supercritical" is a thermodynamic expression describing the state of a substance where there is no clear difference between the fluid and the gaseous phase (i.e. it behave as a homogenous fluid). Water reaches this state at a pressure above 221 Kg/cm^2.

The water-vapor cycle is sub-decisive up to an in use pressure of around 190 Kg/cm^2 in the evaporator part of the boiler. This means, that there is a non-homogeneous mixture of water and steam in the evaporator part of the boiler. In this case a tap type boiler is used for the reason that the steam needs to be separated from water in the drum before it is extremely heated and led into the turbine. Exceeding an operating pressure of 221 Kg/cm^2, the cycle is supercritical. The cycle standard is a single phase liquid with homogeneous property and there is no need to separate steam from water in a drum.

Development of Supercritical Technology

The primary supercritical units, 375MW Drake low C and 125MW Philo plants to be put into profitable procedure in UK and USA in the year 1957. In 1959, the famous Eddy stone 1 place in the ground own and operate by the Philadelphia Electric Co. was especially made in U.S.A. It was planned for 650º/565º/565ºC/351.8 kg/cm^2 steam situation but due to serious mechanical and metallurgical problems, it was later down-rated to 605º/565º/565ºC/330.38 kg/cm^2. Most of the troubles were due to the use of austenitic steels for thick piece workings, operating at high temperature. These steels have low thermal conductivity and high thermal development resulting in high thermal stress and fatigue cracking.

These troubles compressed the ease of access of then operating supercritical plants leading to new funds in developed country elegant back to sub decisive plants by means of live steam conditions of about 550°C/183.54 kg/cm^2. 118 supercritical plants be built in U.S.A. for the period of 1967 to 1976 with maximum unit capacity of 1300 MW. Supplementary putting in of SC plants was slowed due to their low ease of use. Environment concern for green house emissions subject in 1970s causing oil and gas combine round unit to be substitute for coal fired unit. Nuclear control stations were also, traditional but later nuclear production went out of favors totally on account of some major accidents to nuclear plants such as that of Three Mile Island in 1979 and of Chernobyl in 1986. The energy crisis in the mid-1970s and consequent prickly go up in fuel price, however, rekindle attention in the development of more capable coal based power plants. Troubles of resources suitable for high temperatures and pressures also, were solved gradually and availability of supercritical plants converged to and then became higher than that of comparable sub-critical ones. With improvements in toxic waste control tools in 1990s, new supercritical plants have been constructed with capacities of 500 to 800 MW and more than 190 supercritical vegetation were in method in U.S.A. by 2004.

Development of Supercritical Technology in India

The average efficiency of coal based power plants in India is very low being in the range of 27–34%. Increases in unit quantity contain be prepared to increase efficiency and decrease green house gas discharge. Bharat Heavy Electricals Ltd, (BHEL), the Indian company of large power plants has custom-made about 135 plants of capacity 200–250 MW and about 25 units of 500 MW. The first supercritical plant of capability 3X660 MW is at Sipat with South Korean tools. Another SC plant (3X660) at Kg/cm^{2}h. A number of supercritical and ultra-supercritical plants in the public division, private division and joint division are in different phases of development.

Concerning accessibility and consistency, previous studies of the coal fired sub decisive and supercritical plants had discovered that predictable sub decisive boilers have had better consistency during their first 10 years of operation. After 10 years, the standard outage time cause by the pressure parts of SC units had level off at less than 500 hours/year (representing about 94 percent availability) which is equivalent to figures for sub decisive plants. Availability of older SC units, when used for base load duty, is as good as sub decisive units. The standard annual accessibility factor for all 300 MW units in the previous Soviet Union from 1990 to 1995 was 95 to 97 percent, which was somewhat higher than SC power plant accessibility in the United States and Germany, where the best units had accessibility factors of 94 to 97 percent. Present production supercritical plants, however, have accessibility comparable to that of sub-critical plants.

II. LITERATURE SURVEY

On the basis of various studies, research and statistical data it is concluded that the rate at which power demand increases is extremely very high compared to the rate at which generation capacity increases. Boiler is a heart of power plant, so its efficiency is directly affected to the all over efficiency of the power plant.
It is necessary to increase the thermal efficiency of the power plant by changing/applying different parameters. Power is one of the basic requirements for the industries and socio economic in the state and country.
Different researchers have worked on this and concluded the result of this experiment.

Sanjay Kumar Patel et.al.[1] (May -August 2012) presented a performance analysis of supercritical boiler and concluded that, if increment in the load of boiler and drop in the load of turbine higher efficiency is obtained. The research work describes to parameters, boiler maximum continuous rating (BMCR) and turbine maximum continuous rating (TMCR) are varied by increasing the value of steam flow of super heater and reheaters . by increasing or decreasing these values we can find out which condition best for power generation. A comparative study between subcritical and supercritical boilers and analysing the performance of boiler, factor affecting efficiency of boilers has carried out with identification and analysis for improved working of supercritical plants.Analysis shows that at the same flow rate of subcritical and supercritical units for higher output, the steam temperature should be high at supercritical pressure. However supercritical boiler operate in a higher pressure and temperature zone as compared to subcritical boilers leading to increased thermal efficiencies.
Anooj G. Sheth et.al.[2] (apr.2012) determined the performance of supercritical power plant with the help of "GateCycle™ " and concluded the performance of supercritical power plant for its main equipments like condenser, steam turbine, boiler, pumps etc. with the help of GateCycle™ software, which is predicted performance of system is very close to the original performance. According to the experiment the gross power of turbine was found 728425.4 KW.
Chetan T.Patel et.al.[3] (may 2013) worked on efficiency with different GCV of coal and efficiency improvement opportunity in boiler and found that the boiler is the most useful device for any developing industries,so it is necessary to optimize the boiler efficiency. By using semi bituminous coal, the efficiency is 80.20% because of higher heating values, less moisture and ash content . While Indian lignite coal gives 77.51% efficiency on the same boiler because it has more ash and moisture content as compared to the semi bituminous coal.
K.N. Subrahmanyam et.al [4] (July 2015) worked on study of subcritical, supercritical and ultra supercritical thermal power plant and observed that all the power producers are looking to improve the efficiency a power plant and less impact on environment without compromising there market competitive. Introduction of these technologies on thermal power plants can changed in Rankine cycle working on temperature and pressure and improve the performance of power plants in this analysis 500 MW subcritical, 700 MW supercritical and 850 MW ultra supercritical thermal power plants. Ultra supercritical technology is more efficient then supercritical technology and subcritical technology in terms of efficiency and coal consumption. In this work introduces the various methods of steam generation and emission reduction with the cost of installation, operational cost and experience of operation as well as good and environmental performance.
J.W. Smith [5] (may 1998) presented a Babcock and Wilcox company supercritical(Once Through) boiler technology. In the history of the boiler development beginning with the world first ultra supercritical steam system, which began operation at the American Electric Power (AEP) Philo Station in 1957 through the development of world largest boilers, the pulverized coal fired 1300 MW units began operation in 1990 at the Zimmer power station jointly owned by Cincinnati Gas & Electric, Dayton power & Light and American Electric Power. The B&W Supercritical boiler has demonstrated efficient operation and high reliability in serving the load cycling needs of the United States utility market. The Chinese electric utilities are very similar to those of the U.S. utilities.

III. METHOD

3.1 MAIN FEATURES OF SUPER CRITICAL BOILER

3.1.1 Spiral Water wall

For sliding pressure boilers, maintaining uniform fluid conditions during low load / low pressure operation becomes critical to reduce the potential of tube damage caused by high metal temperatures. The lower part of the super critical boiler furnace is arranged in a spiral configuration such that the fluid path wraps around the boiler as it travels up the furnace. A comparison of fluid temperature distribution between the conventional vertical wall and the spiral water wall is shown in Figure 3.1

As a result of the uniform water wall fluid temperature profile that is achieved across the full range of boiler loads, the spiral water wall system does not require any flow adjusting devices to be installed at the furnace inlet.

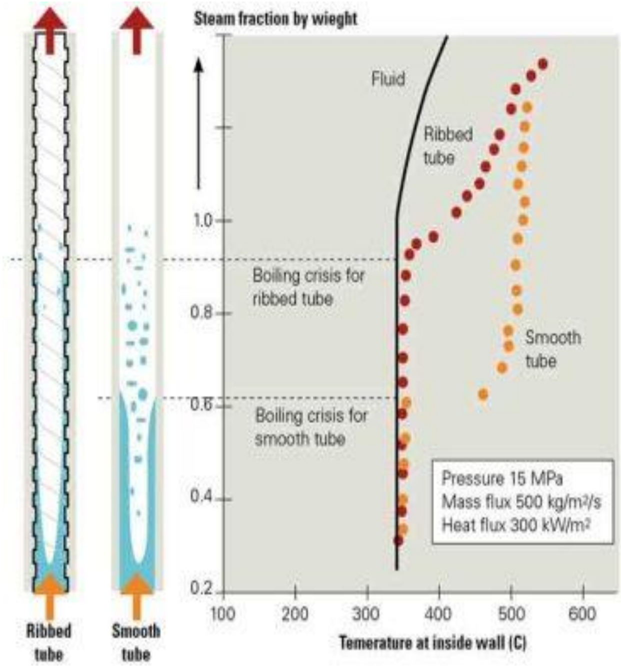

Fig.3.1 Fluid Temperature profile comparison for Water Wall Type

The principal concern with a sliding (variable)-pressure supercritical pressure design is the requirement for once-through operation. The mass flow in the furnace-wall tubes must be sufficiently high to avoid overheating or departure from nucleate boiling (DNB) while generating steam at subcritical pressures, and to avoid excessive metal temperatures and uneven steam outlet temperatures when operating at supercritical pressure at higher boiler loads.

To accomplish these objectives, the spiral-wall design has evolved. The principle of the spiral- or helical-wail furnace is to increase the mass flow per tube by reducing the number of tubes needed to envelop the furnace without increasing the spacing between the tubes. This is done by arranging the tubes at an angle and spiraling them around the furnace. For instance, the number of tubes required to cover the furnace wall can be reduced to one half by putting the tubes at a 30 degree angle. The centerline spacing or pitch (P) is made the same as on a vertical wall to prevent fin overheating. Additionally, by spiraling around the furnace, every tube is part of all the walls, which means that each tube acts as a heat integrator around the four walls of the combustion chamber.

The spiral-wall concept thus addresses two major challenges of the full-sliding (variable) pressure supercritical pressure boiler:

• Achieving the required mass flows to avoid overheating and excessive metal temperatures by reducing the number of tube circuits.

• Minimizing differences in tube-to-tube heat absorption by exposing each tube to all four furnace walls.

3.1.2 Steam Separator

As he Hitachi-Naka boiler is a Benson type unit, a steam separator and a separator drain tank were installed to separate the steam and the water at the furnace outlet during a low-load recirculation operation. This design is different from that of a conventional NC boiler, for which a steam drum is installed to separate the water from the steam under all operating loads. The steam drum is designed to have sufficient water storage capacity, and usually contains complicated internal parts, such as steam cyclones, scrubbers, internal feed pipes, and baffles. Because of the complex internals, steam drums require a large amount of maintenance work during outage periods. However, the steam separator design of a Benson boiler is simple in configuration and has no internal, therefore significantly less maintenance work is required.

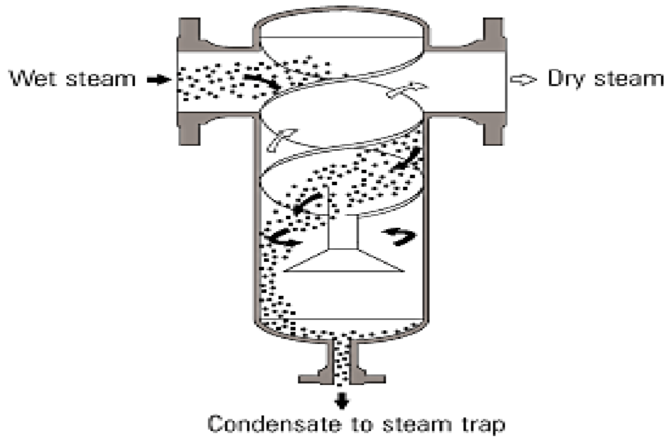

Fig 3.2 Steam Separator

3.1.3Introduction of software

Turbo C++ is a discontinued C++ compiler and integrated development environment and computer language originally from Borland. Most recently it was distributed by Embarcadero Technology, which acquired all of Borland's compiler tools with the purchase of its code gear division in 2008. The original Turbo C++ product line was put on hold after 1994 and was revived in2006 as an introductory-level IDE, essentially a stripped-down version of their flagship C++ Builder. Turbo C++ 2006 was released on September 5, 2006 and was available in 'Explorer' and 'Professional' editions. The Explorer edition was free to download and distribute while the professional edition was a commercial product. In October 2009 Embarcadero Technologies discontinued support of its 2006 C++ edition. As such, the Explorer edition is no longer available for download and the Professional edition is no longer available for purchase from Embarcadero Technologies. Turbo C++ is succeeded by C++ Builder.

IV.CONCLUSION

Conclusion derived from the data related to the boiler, if higher GCV coal is use in the boiler gives higher efficiency because its contain less amount of ash and moisture. In subcritical boiler higher GCV coal are used like semi-bituminous coal and Indian lignite coal gives 80% efficiency near about. If Indian bituminous coal is use in supercritical boiler having low GCV than above coal and found that higher efficiency than subcritical boiler. So if low GCV coal are use in supercritical boiler gives high efficiency than subcritical boiler because high temperature steam at supercritical pressure gives high thermal efficiency as well as emission is also reduced due to higher efficiency. However supercritical boiler operates in a higher pressure and temperature zone as compared to subcritical boilers leading to increased thermal efficiency. Simulation should be carried out by the adding different value of data. With the help of simulation, necessary changes should be carried out for the improving boiler and steam system efficiency. Parameters which can be improved the boiler efficiency is gives a best rest, if they are applies to the boiler system.

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