Implementation of Supercritical Technology in Power Plant (An Analysis)

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Abstract

The Main motive of this paper is to show that how is the supercritical boilers are differ from other boilers and adoption of this Super-critical technology is beneficial .Steps for improving efficiencies in these boilers are mentioned. Challenges that comes or some factors play their role. How it is beneficial in future i.e., is given. Many issues are highlighted which comes in front of us during the implementation of supercritical technology like implementation issues, operational and maintenance issue and the environmental issue. Along with that how we can overcome with these issues and risks is given in this paper. I have shown the result and future scope in this project. We have to manage in proper way to obtain maximum output or made the operation successful. Electricity formation is produce on coal fired plants. These plants contribute for about 50% overall power generation worldwide. This dependency for electricity production on coal is likely to be continued in near future also as the coal is cheap, easily available and evenly distributed if we analyse the overall coal related scenario.

Keywords: Coal Fired Plants, Supercritical Technology, Reheater Tubes, Supercritical Boilers, Emission Reduction.

I. Introduction

Electricity formation is produce on coal fired plants. These plants contribute for about 50% overall power generation worldwide. This dependency for electricity production on coal is likely to be continued in near future also as the coal is cheap, easily available and evenly distributed if we analyse the overall coal related scenario.

Conventional coal plants operate on subcritical technology with low thermal efficiency, which results in huge environmental pollution and sudden reduction in limited reservation of coal. Due to these reasons, super-critical and ultra-supercritical generating plants have attracted the attention of power utilities. Plants have high generating capacity on either thermal efficiency.

Presently, many of the supercritical plants are in business concern found in different countries. The United States is the earliest country to develop technology of supercritical power generation. In 1992, the 107 thermal power units in service of 800 MW and above in the United States were all supercritical units. Among them the largest single machine capacity is 1300 MW. In 1999, the US department of energy put forward the vision 21 plan [1] to develop advanced power generation technology.

II. Literature Survey

Sanjay Kumar Patel et al. [2] (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 operates in a higher pressure and temperature zone as compared to subcritical boilers leading to increased thermal efficiencies.

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. CYCLE ANALYSIS

3.1 What is supercritical?

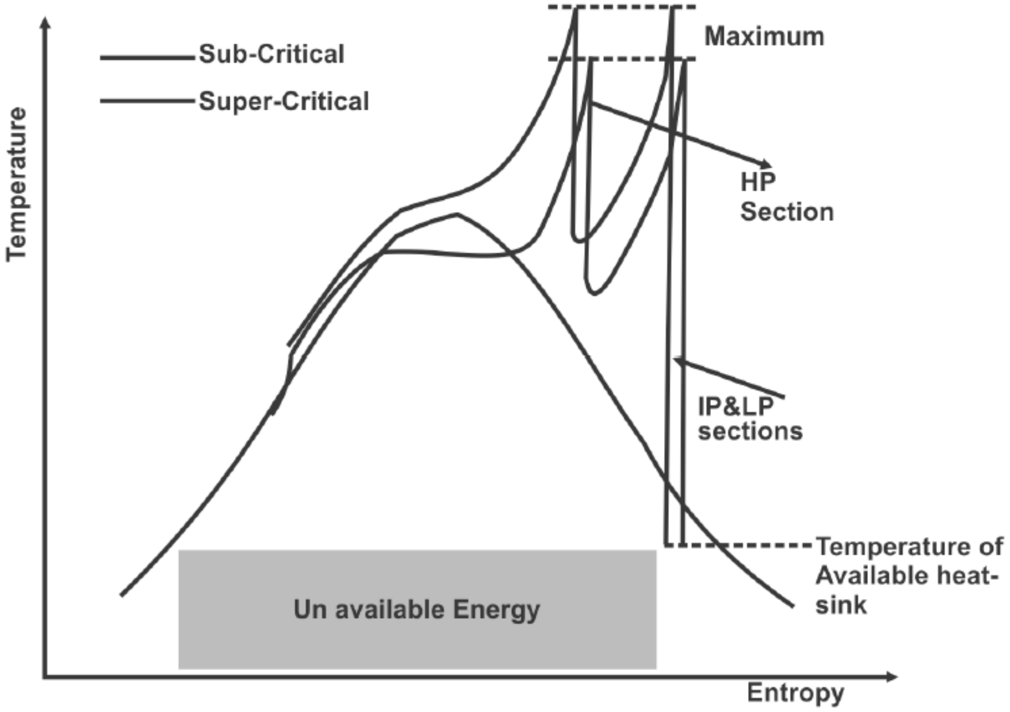

Figure 1. Represent Supercritical Technology on T_S Diagram

Supercritical is a thermodynamic assertion explaining the element character where clear distinction is not possible that whether it is in liquid or in gaseous form .Water reaches this position at pressure more than 22.1MPa.

At approximately 19MPa, the process made cycle is sub-critical in the boiler evaporator [6] as it has non-uniform hybrid of H20 & steam. Drum type boiler is utilized to deviate the steam from water afore superheated and way to turbine. Directing pressure above 22.1MPa, the loop chain is known as supercritical .The circuit medium is the individual state fluent with homogeneous unvarying properties and both (steam & water) should be kept together.

3.2 Why Supercritical?

SCPP power plants allows the increment of efficiency from 45% stand on chilling circumstances but in can be greater than 50% in ultra-supercritical power plants depend upon the steam situation , on the enriched methods and element feature. Development prospects with coal regaining its dominant positions for power generation and with increasing environment consciousness, emphasis worldwide is shifting in supercritical and ultra-supercritical power plants.

Furthermore six hundred SC&USC power plants [7] (status 2004) with total capacity above 300 GW were operating or under construction mainly in USA, Japan, China, Europe, Russia, Korea and other countries.

3.3 Parameters for different Technology :

The linking of steam process having parameters and unit sizes used for performing the thermodynamic modeling for coal fired plant options in Indian conditions is shown in table.

Plant Type	Unit Size	Main Steam Pressure	Main Steam Temperature	Reheat Steam Temperature
Subcritical	500 MW	166 bar	538 °C	538 °C
Low supercritical	660 MW	247 bar	538 °C	565 °C
High supercritical	800 MW	270 bar	565 °C	593 °C

IV. Implementation Issues

4.1 Technology Issues

Supercritical boiler technology has matured to a point such that the technical hazard correlate for supercritical boilers are now alike of subcritical boilers. However as supercritical boilers are designed for higher steam temperatures and pressures than subcritical boilers and also operate using a once-through evaporator, designers and owners are beware for certain issues to decrease the technical risks. These include:

- Water wall cracking
- NFC
- Slagging

1. *Water wall cracking*

TFC of water wall tubes is the result of tube failures in supercritical boilers. It is not clear why supercritical boilers found with cracking than subcritical boilers however possible reasons include higher metal temperature and applied lower alloy steel. Fireside corrosion is also helps to provide thermal fatigue cracking. The oxygenated water treatment may reduce chances for water wall cracking.

2. *NFC*

Most modern supercritical boilers operate using sliding pressure. When the boiler is operating at piece burden the pressure is subcritical and the furnace acts as a once through evaporator. This design requires a HMF by the tubes to avoid DNB & subsequent overheating of the tube metal and its designing has an undesirable feature. This feature causes tubes that experience higher than average fluid flow.

Some supercritical boiler suppliers are now offering lower body of matter flux designs with internally rifled tubing to overcome this problem.

3. *Slagging*

Supercritical boilers devised accompanying a spiral tube configuration to produce a high fluid mass flux in the tubes. The spiral configuration requires the tubes to be installed at an inclined angle typically between 10 to 15 degrees from the horizontal. The inclination of the tubes is thought to enhance propensity of slag and clinker to form on the walls compared to vertical tubing, which is typically used in subcritical boilers. The higher fireside temperatures of SC boilers may also contribute to increased slagging.

The risk issues stated above are observed in some supercritical plants. There are over 600 such plants operating over the earth. Arrangement of diminishing these risks required to considered in the designing and operating of the plant:

- Use of oxygenated water chemistry
- Use of non-slagging coal in the boiler
- Selection of coal to avoid fire-side corrosion
- Consider rifled furnace tubes and possibly vertical tube furnaces with rifled tubing.

4.2 Welding of Materials

The development of special steels and alloys to ensure technically sound and safe operation while dealt with in detail further. Special welding equipment will need to be obtained by EPC/NonEPC contractor responsible for implementation.

V. Operational and Maintenance Issues

5.1 SC Technology in IAC and Indian Coal

IAC are different from those of other countries and the heat rate can be achieved under Indian conditions. The Indian coal contains the superior moisture, having low CV and high ash content. The ash contains silica giving it a higher abrasive character. The ambient conditions are ideal for sub critical or supercritical plants and therefore the differential progression at heat rate between the two technologies would be same. The techno-economic liveliness of SC & [8] USC technology is not altered under different ambient conditions.

VI. Results and Discussion

6.1 Analysis of Reheat Cycle

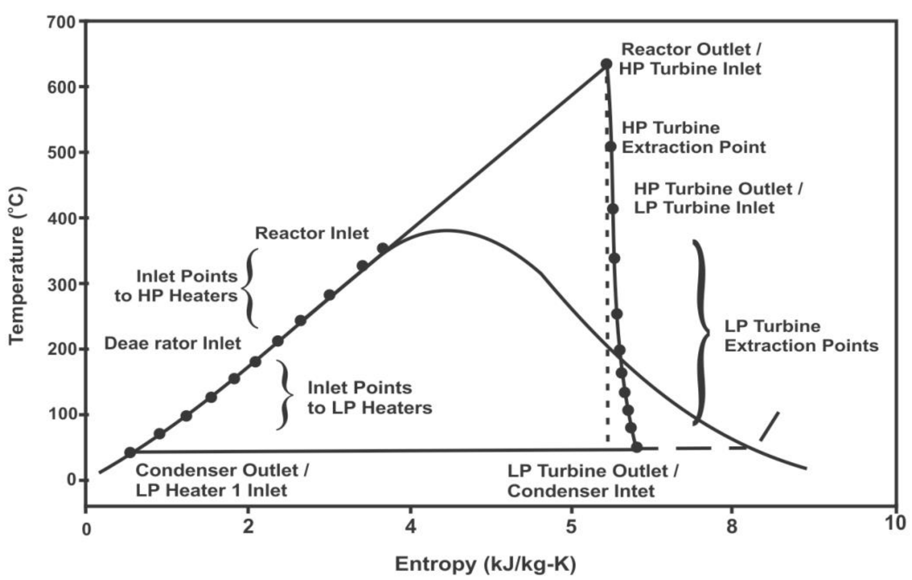

Figure 2. T-S diagram of cycle (no-reheat) conditions

6.2 Choice of Intermediate Pressure for Reheating of Steam

For conventional sub-critical units an intermediate pressure in the range of 25-45 bars has universally been adopted for reheating of steam. Mostly super-critical units, which are in operation or under development for 60-80 bars has been adopted for reheating of steam [9] (AD 700 project).

VII. Conclusion

Analysis shows that higher output is gettable with proposed design of units operating with high temperature steam on sub-critical pressures comparing with output of supercritical units operating with same steam flow rates. TE of these proposed units is comparable with supercritical units, which may be improved up to performance of supercritical units with proper choose the designing conditions. However, exergy analysis reveals that these proposed units are relatively lessefficient to utilize the available energy of coal comparing with supercritical units. The units will be most economical & cost effective comparing with super critical units and the reason is LP designing of plant components.

Efficiency improvement is productable and lowest cost technique to deplete all emission including CO2.

- Power generation efficiency increases with growth and deploymentation of newly CAG technologies.
- Technologies to give out progressively tight environmental controls.
- Reduction in emission as efficiency would increase.
- Deploy plants with higher performer corresponding with value price & availability.
- Cost comparison of new coal electricity producing method & shows that withstanding the marginally higher first cost of higher efficiency plants, the COE and the output based emissions are reduced as the efficiency increases in plants both without and with CO2 capture.
- Through the study of energy analysis, we understand the effectiveness of CFPP and identify improvement and its methods are valuable in evaluating & shall use along different pertinent information to guide efficiency improvement efforts for steam PP .Of course ,efficiency of some plant components is improved by increasing their size .The end favor of the present to put in perspective total and specific emission of CO2 from TPP in India and analyze the plants relative performance from the point so view of net generation, emission of CO2 , unit vintage and plant capacity.

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