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Analysis of Boiler Super Heater Tubes from High Flue Gas Temperature

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Abstract— Most of the fossil fuel & Cement Plant waste heat based thermal power plants are facing the problem of Boiler Super Heater tube leakage due to high flue gas Temperature. This will affect the working of power plant and income in general. The research is to study boiler super heater tube leakage problem and find the causes of tube leakages with the help of Computational Fluid Dynamics simulation. An Auto CADD 2-D modeling of super heater is performed and Import to Computational Fluid Analysis software where the temperature of flue gases over the Super Heater Tubes using the actual boundary conditions has been studied. The Computational Fluid Dynamics results will be useful for to avoid the same in future projects and can be avoid the leakage in already running the Thermal Power plants with providing the Shield arrangement over the critical zone of super heater tubes to reduce the erosion and restricting Super Heater Tubes.

Key Words – Computational Fluid Dynamics (CFD), Super Heater Tube Leakage, Super heater Tubes, Super Heater Coils.

I. INTRODUCTION

The electricity sector in India had an installed capacity of 254.049 GW as of end September 2014. India became the world's third largest producer of electricity in the year 2013 with 4.8% global share in electricity generation surpassing Japan and Russia. Captive power plants have an additional 39.375 GW capacity. Non Renewable Power Plants constitute 87.55% of the installed capacity, and Renewable Power Plants constitute the remaining 12.45% of total installed Capacity. India generated around 967 TWh (967,150.32 GWh) of electricity (excluding electricity generated from renewable and captive power plants) during the 2013–14 fiscal. The total annual generation of electricity from all types of sources was 1102.9 Terawatt-hours (TWh) in 2013.

As of March 2013, the per capita total electricity consumption in India was 917.2 kWh. The per capita average annual domestic electricity consumption in India in 2009 was 96 kWh in rural areas and 288 kWh in urban areas for those with access to electricity in contrast to the worldwide per capita annual average of 2,600 kWh and 6,200 kWh in the European Union. Electric energy consumption in agriculture is highest [citation needed] (18%) in India. The per capita electricity consumption is lower compared to many countries despite cheaper electricity tariff in India.

With the ever-increasing demand for electricity it is very necessary for the power plants to generate electricity without forced outages. Boiler Super Heater tube failure is the prime reason of forced outages at coal fired thermal power plants & Waste Heat Thermal Power Plants.

Coal reserves in India is one of the largest in the world. As on April 1, 2012, India had 293.5 billion metric tons (323.5 billion short tons) of the resource. The production of coal was 532.69 million metric tons (587.19 million short tons) in 2010-11. The production of lignite was 37.73 million metric tons (41.59 million short tons) in 2010-11. As on 2011, India ranked 3rd in world coal production.

After combustion, the flue gases passes over the super heater Tubes, abrasive in nature of coal may damage Super Heater Tubes. It has hampered working of power station and overall efficiency of power station. So study of boiler tube leakage and finding the solution for the problem is need of thermal power station.

II. LITERATURE REVIEW

Ajay N. Ingale & Vivek C. Pathede (2012) [1] analyzed the tube leakage through CFD Modeling considering two temperature plots, one for steam flowing inside the SH tube and other for temperature of flue gases flowing over the SH Tube. Based on the temperature plots they found that the SH tube bend to be exposed to the high temperature region. This may lead to fatigue and cracks near the weld joints of the tube resulting in change in shape and cracks near the corners.

Prashant Kumkale (2014) [2] conducted investigation on super heater tubes through CFD analysis with various temperature plots, and found that velocity is high at SH tube bend and pressure drop more at the tube bend.

Aditya Kumar Pandey (2012) [3] conducted flue gas flow distribution on low temperature super heater (LTSH) tubes through CFD analysis and found that flue gas flow changes direction as it flows from extended pass to LTSH tube bundles. Extended pass is tapered. Due to this no uniform velocity distribution can occur at the top of LTSH.

Shaji Kumar (2012) [4] conducted 3-D CFD analysis of tube temperature distribution in the boiler tubes. The analysis of temperature distribution for every location inside the domain is conducted by setting constant heat fluxes and varying parameters such as mass flow rate of steam, steam temperature, flue gas temperature in the boiler tube is influenced by the above parameters. All parameters affect the temperature distribution in the boiler tubes and the existence of scale is very significant which decreases the temperature of the flue gas. Therefore existence of scale must be eliminated.

Saripally et al. (2005) [5] conducted a simulation of thermal flow in an industrial boiler using a CFD package. Computer simulation has been employed to understand the thermal flow in the boiler to resolve the operational problem and search for optimal solution. The combustion and thermal flow behavior inside the boiler is studied to make the boiler more efficient, less emissive and less prone to tube rupture. The study performs a detailed simulation of combustion and thermal flow behavior inside the industrial boiler. Due to excessive heating the rupture of super heater tubes may lead to boiler shutdown, increasing the expenses incurred. The CFD analysis provided fluid velocity, pressure, temperature, and species concentration throughout the solution domain. During the analysis, the geometry of the system and boundary conditions such as inlet velocity and flow rate was changed to view their effect on thermal flow patterns or species concentration distribution.

Masoud et al. (2006) [6] reported the reasons for tube damage in the super heater platen section of the 320MW Bisotoun power plant. A three dimensional modeling was performed using a computational fluid dynamics code in order to explore the reasons for the damage of super heater tubes that occurred in a series of elbows belonging to long tubes. The code had ability of simultaneous solving the continuity, the Reynolds-Averaged Navier–Stokes equations by employing the turbulence, combustion and radiation models. The main aim of the modeling was to find the reason for the tube rupture inside the boiler. The study largely focused on heat transfer to the boiler tubes and the temperature field inside the boiler by incorporating combustion models besides other transport phenomena calculations.

McKenty et al. (1999) [7] successfully simulated several different types of industrial boilers and incinerators fired with different types of fuels. Comparisons were made with measurements taken at various outlets show good agreement with the predicted values. Wardle (2000) used ultrasonic Nondestructive Oxide Thickness Inspection System (NOTIS) to nondestructively assess a large number of tubes in a relatively short time. Prior to the development of this system, the only method was through the destructive removal of tube samples.

Srikanth et al. (2003) [9] concluded the failures of boiler tubes due to fireside corrosion in a waste heat recovery boiler utilizing the exhaust gas. Reported that the high corrosion propensity and consequent failures in the low temperature sections of the boiler were found to be directly related to the formation of hydrated ferric sulfate in these regions.

Chaudhuri (2006) [14] analyzed Tube failure and concluded that the failure takes place due to short-term overheating in the final super-heater tubes. It is also reported that the un-failed re-heater tubes exhibit higher tensile properties than that of platen super-heater tubes.

Ranjbar (2007) [13] analyzed the tube failure through chemical analysis on boiler cold and hot re-heater tubes. It was concluded that the improper maintenance and feed water Quality / chemistry are the main causes of the failure, these lead to the various types of corrosion mechanisms.

Rahman and Sukahar (2008) [8] presented the Tube Temperature distribution in a water tube boiler through application of finite element method (FEM). The Two-dimensional FEM models were developed and axi-symmetric triangular elements for the tube cross section area were employed. The results showed that the temperature distribution at the tube wall decreases with increased mass flow rate of steam and increased scale thickness.

Korytnyi et al. (2008) [12] developed the tool of engineering that the “combustion behavior of coals” in coal fired utility boilers can be predicted. The computational fluid dynamic (CFD) codes can successfully predict the performance of full-scale pulverized-coal utility boilers of various types, provided that the model parameters required for the simulation are properly chosen and validated.

Purbolaksono et al. (2009) [11] investigated the Re-Heater Tube Failure through FEM Modeling to find out that main cause of tube failure due to scale formation on internal tube surfaces which will reduce the heat transfer area (HTA) across the Tubes.

III. CONCLUSION:

The Purpose of this CFD analysis is to find out the Super Heater Tube Portion which to be affected by High Flue Gas Temperature. The Identified Super Heater Tube Portion to be shielded with SS Plates. The Shield Plate will safe guard the Super Heater Tube where the weak portion has been find out. Providing SS plate Transfer the Heat safe manner to Super Heater Tube.

Due to this will be avoided the Super Heater Tube Leakage, there is maintenance of Super Heater Tubes, Improve the Power Production without any plant shutdown, subsequently will Improve the Power Plant Income.

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