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CFD Analysis of Superheater in View of Boiler Tube Leakage

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Abstract*— All the thermal power plants are facing the problem of boiler tube leakage. Bhusawal Thermal Power Station (BTPS) is also facing the same problem of Boiler Tube Leakage frequently. The consequences of which affects the working of power plant and national income in general. The aim of this paper is to study boiler tube leakage problem in the super heater and try to find the causes of tube leakages with the help of simulation. A 2-D modeling of super heater is performed using CFD and temperature of the flue gases over the coils using the actual boundary conditions has been studied. The CFD results can be useful for the maintenance engineer to make suitable prediction of the tube life and make suitable arrangement for the high temperature zone to reduce the erosion of tube coil and restricting the tube leakage problem.

***Index Terms* – CFD, Boiler Tube Leakage, Superheater.**

I. INTRODUCTION

Thermal power plants contribute about 71% to all India installed capacity of electric power generating stations. Coal continues to be the dominant fuel source for fossil fuel steam generation in the Indian electric utility industry accounting almost 55% of the power generated. With the ever-increasing demand for electricity it is very necessary for the power plants to generate electricity without forced outages. Boiler tube failure is the prime reason of forced outages at coal fired thermal power plants. Whole world is facing problem due to crisis in energy sector. The production rate of energy is insufficient in proportion with the demand. Thermal hydel, nuclear and non-conventional power stations are running at their full capacity. Due to over-load the power stations are also facing many technical difficulties. One such major difficulty arises due to boiler tube leakage in the thermal power stations.

Coal available from various parts of Maharashtra which is used in thermal power plants has ash content about 30-40 %. Due to low quality coal, flue gases liberated from combustion of coal carries fly ash with it. After combustion flue gases passes over the superheater, airpreheater etc. Abrasive nature of coal may damage heat exchangers. 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. CFD ANALYSIS

A. Introduction

CFD analysis of superheater can be useful to gain insight to the gas flow distribution. Efforts are made to measure the velocity and pressure distribution of flue gases which will be useful to find the effect of the operating parameter on the tube erosion rate and velocity and pressure distribution inside the superheater of 210 MW boiler. CFD has evolved as important tool for modeling of coal fired boiler and it can useful to quantify the gas flow field and temperature distribution with the boiler superheater.Hence CFD model of superheater was developed to study the velocity, pressure and temperature distribution of the steam inside the superheater. Thus this study is focused on simulating isothermal turbulent flow within the boiler superheater.

The use of CFD codes for modeling of combustion, heat and fluid flow is a useful tool to predict the performance of boilers among the scientific and industrial communities. The CFD help engineers to optimize the operating conditions and also to improve the design of new boilers. Numerous sub-models for simulating in the furnace processes such as combustion, the conduction, convection and radiation modes of heat transfer and chemical reaction have been developed by researchers. The development of the models depends on the availability of accurate and approximate experimental data in order to compare with the predicted results.

B. Role of Computational Flow Analysis in Boiler Tube Leakage

Power generation units have to be controlled properly to ensure continuous energy production. CFD modeling has been used to study boiler tube leakage problem by considering the superheater section. It explains the fundamental physical processes that determine the interactions among the input and output variables. This model can simulate various operating procedures similar to those actually used in power plant operation. Hence, simulation of the SH helps to understand its behavior.

Computer simulation of the superheater provides the detail of the flow pattern over the tube, the colored plots of temperature of the flue gases which will be helpful to the maintenance engineer to know the process and knowing the critical areas and reasons of tube failure. Taking this view in consideration some objectives was set for the work on BTL.

Stepwise Approach for CFD Analysis is divided into 4 steps which are as follows.

- Create Geometry in HYPER-MESHING.
- Mesh Geometry in HYPER-MESHING.
- Pre-Processing (Defining boundary
- Condition).
- Post Processor.

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III. CFD RESULTS

A. *Temperature Plots*

There are two temperature plots one for the steam flowing inside the final SH tube and other for the temperature of flue gases flowing over the final superheater tube. Figure 1 shows the variation of temperature of steam flowing inside the final superheater tube and figure 4 shows the variation of temperature of flue gases flowing over the final superheater tube. As the superheater is nothing but the heat exchanger it increases the temperature of the steam flowing inside the tube and hence the temperature of the flue gases is decreasing from inlet i.e. from left side to the right side. At certain region sudden temperature variation leads to the thermal embrittlement. Tube bend is found to be exposed to the high temperature region. This may leads to fatigue and cracks near the weld joints of the tube resulting into change in shape and cracks near the corners.

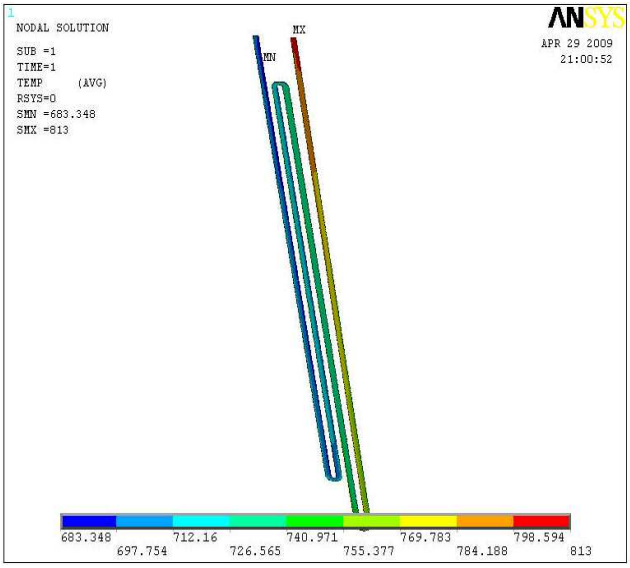

Fig. 1. Temperature plot of steam flowing inside superheater

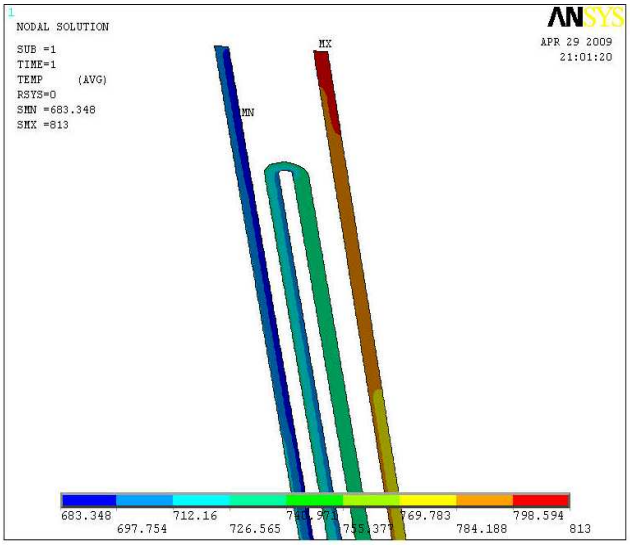

Fig. 2. Variation of temperature of steam for the top section of superheater

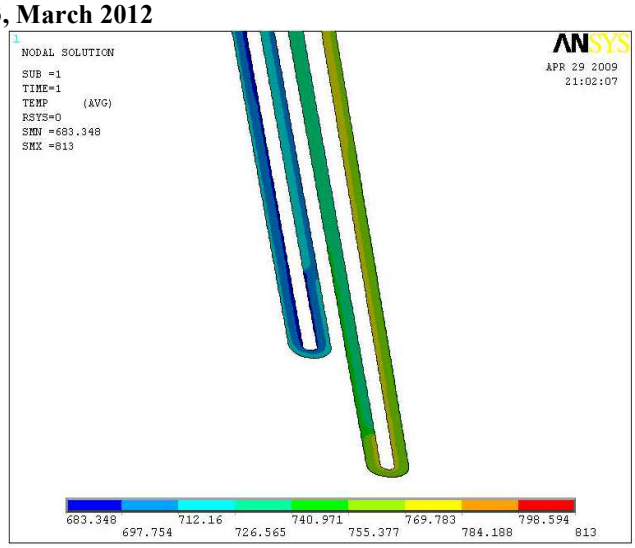

Fig. 3. Temperature plot of bottom section of superheater

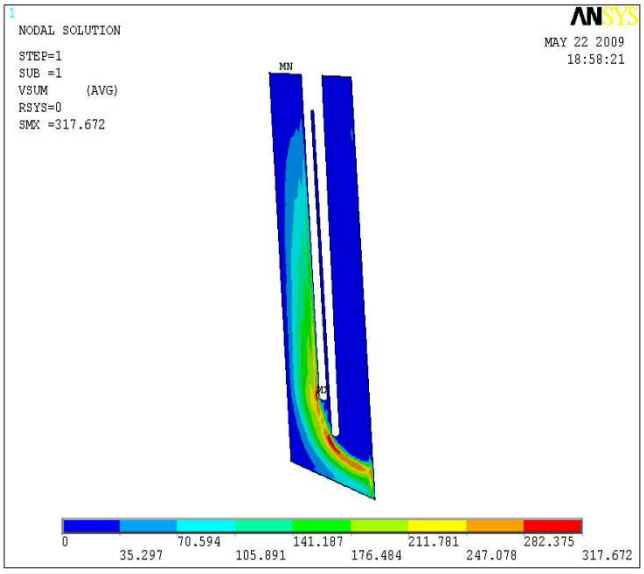

Fig. 4. Overall temperature plot of flue gas flowing over superheater

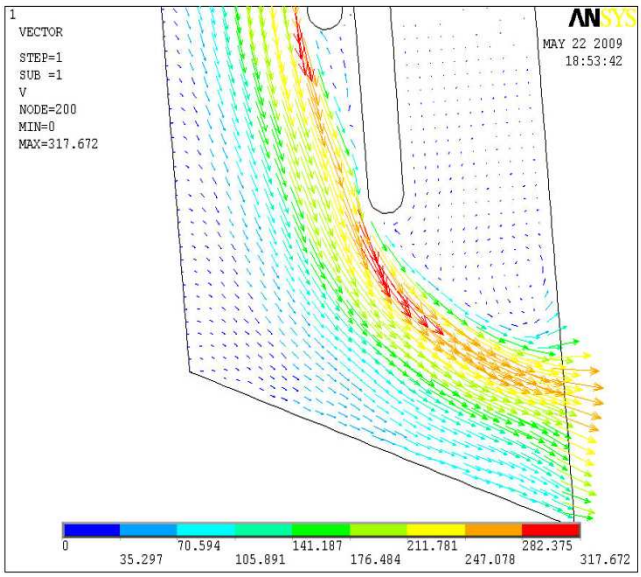

Fig. 5. Variation of temperature of flue gas flowing over superheater for bottom section

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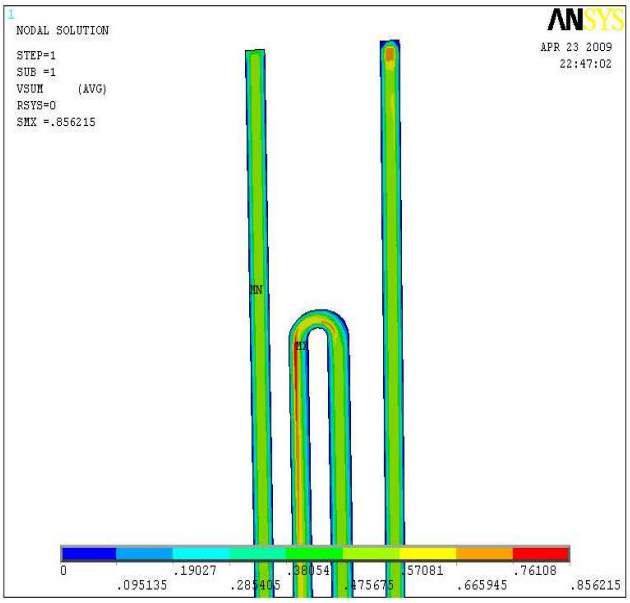

Fig. 6. Variation of velocity of steam for the top section

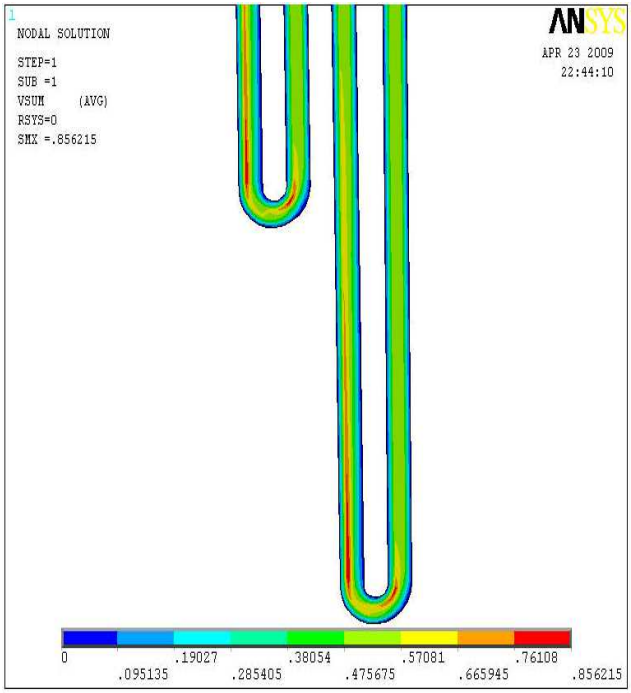

Fig. 7. Variation of velocity of steam for the bottom section of superheater

IV. CONCLUSION

The result obtained with CFD model shows more realistic picture of final superheater. The temperature plots show that the high temperature affecting zones are the U-tube bends of the superheater. The CFD analysis of the final superheater tube was done with the critical study of boiler tube leakage. Due to limitation of software it was very difficult to mesh the geometry with higher number of cell. Hence, in future this progress report will be of great importance to the researchers working on the boiler. The scope for future work is to go for 3-D model, which shows the open door to work in this area of CFD.

Following are important conclusions drawn from the work carried out on study of boiler tube leakages and CFD analysis of final superheater.

1. The erosion due to flue gas containing fly ash and overheating are playing major role in boiler tube leakages. So, it is very necessary to reduce the erosion and indirectly reduction in breakdown time.
2. The CFD result shows the temperature near the U-tube bend found more than the permissible. In one U-tube pass the temperature of steam in the tube increases by 57^0C. This fluctuation of temperature causes the boiler tube leakage. And hence more attention should be given to maintain the designed values of velocity and temperature.

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