CFD Simulation for Analyzing Velocity and Pressure Drop In Primary Duct of Air Preheater

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Abstract: ***Air preheater performance in power plants plays a crucial role in increasing the thermal efficiency and thereby provides a better utilization of waste heat from flue gases. But presence of higher velocity gradient and poor pressure distribution among the flow passages results in boundary layer separation in the airpreheater duct which increases turbulence of air hence lowers the thermal efficiency. This paper aims at studying different velocity and pressure differences present in the primary duct and measure to counter them with the help of computational fluid dynamics (CFD) analysis tool fluent 14.0.***

I. INTRODUCTION

Air preheater is a device used to pre heat air before its utilization power plants and I.C engines. It increases the thermal efficiency of any system by reusing heat of exhaust gases.Air preheater in a steam boiler comes under heat recovery system in which it pre heats combustion air from heat recovered from flue gases to enhance thermal efficiency of Boiler as shown in figure 1. There are two types of air preheater(APH) tubular and regenerative type. Tubular type APH has many tubes through which ambient air flow and comes in contact with flue gases which are flowing outside the tubes. Regenerative type of APH works as a recuperator which consist of heat absorbing material in the rotating wheels which absorbs heat and is released to ambient air when it passes the wheels.

II. LITERATURE REVIEW

Pre heating of combustible gas in a boiler increases its efficiency by 1 degree for every 22 degree centigrade rise [1]. The commonly used method is to recover the heat of flue gases by effective methods [2]. For increasing efficiency and saving fuel forced the strategist to recover heat from flue gases which was earlier lost to atmosphere.[3-5]. Air preheater (APH) were employed for this purpose. There are many types of air heater which are used in many small and large industries like tubular, plate and cast iron heaters etc [6-8]. APH can be of two types recuperative and regenerative type. Recuperative type transfer heat continuously among cold and hot fluid which are flowing separately one in closed tubes and other fluid over it. Regenerative type exchange heat alternatively. Frictional resistance creates pressure drop in the air ducts which causes shock losses at inlet, outlet and bends between flow passages. This drop is proportional to square of mass flow rate [10]. Normally at the start of recuperative cycle the leakage is zero but with time leakage increases which can be kept below 3 percent with proper maintenance. Dew point erosion is general problem in APH as the flue gases are dust laden containing sulphates or chlorides, on condensing these acids corrodes the tubes [11].

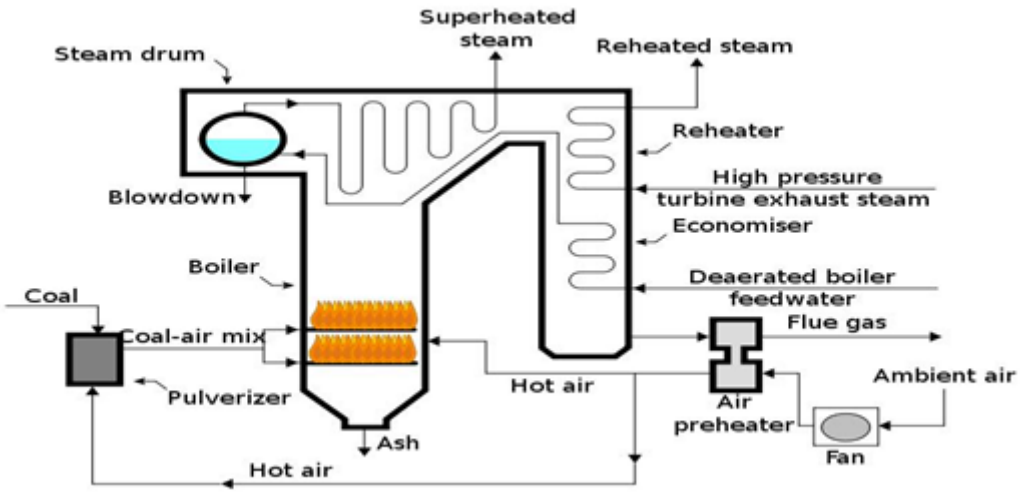

Fig.1. Diagram of coal fired steam generator with air preheater

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Objective and Methodology: The main objective of this work is to perform CFD analysis of APH duct to stabilize flow pattern at outlet and find Pressure and velocity distribution in straight and curved section of air pre heater using ANSYS fluent.

Mathematical Calculation: Thermal performance of APH is evaluated on the basis of following calculations:

$$q = m_g C_p (T_1 - T_2) \quad (1)$$

Where q= heat transfer rate (Kcal/hr); Cp is specific heat; mg is mass flow rate(kg/hr) of flue gas; T1 and T2 are incoming and outlet flue gas temperature of APH.

For air

$$T_2' = T_1' + q/(m_a C_p) \quad (2)$$

Where T2' and T1' are outgoing and incoming air temperature; maCp is thermal capacity.

Logmean temperature difference for cross flow arrangement is given by

$$LMTD = \frac{[(T_1 - T_2') - (T_2 - T_1')] \times F}{[\ln(T_1 - T_2')/\ln(T_2 - T_1')]} \quad (3)$$

In APH, gas and air film coefficient (Tf&Tf') are almost equal and given by

$$T_f = \frac{(T_1 + T_2)}{2} + \frac{LMTD}{4} \quad (4)$$

$$T_f' = \frac{(T_1' + T_2')}{2} + \frac{LMTD}{4} \quad (5)$$

Geometric modeling of air preheater

Pressure outlet =0 Inlet mass flow rate 23.63 and 27.81 kg/s

Fluid –Air and Density 0.85 and 0.79 Kg/m^3

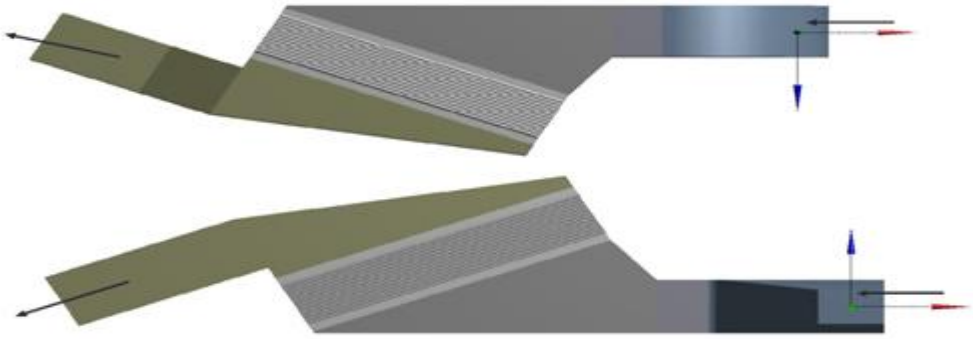

Figure 2. Diagram of APH primary duct

Flow Boundary Conditions are := Mass flow at inlet 23.63 and 27.81kg/s and outlet pressure is zero.Fluid has no slip condition with walls with initial velocity and pressure is taken 0

III. RESULTS AND DISCUSSION:

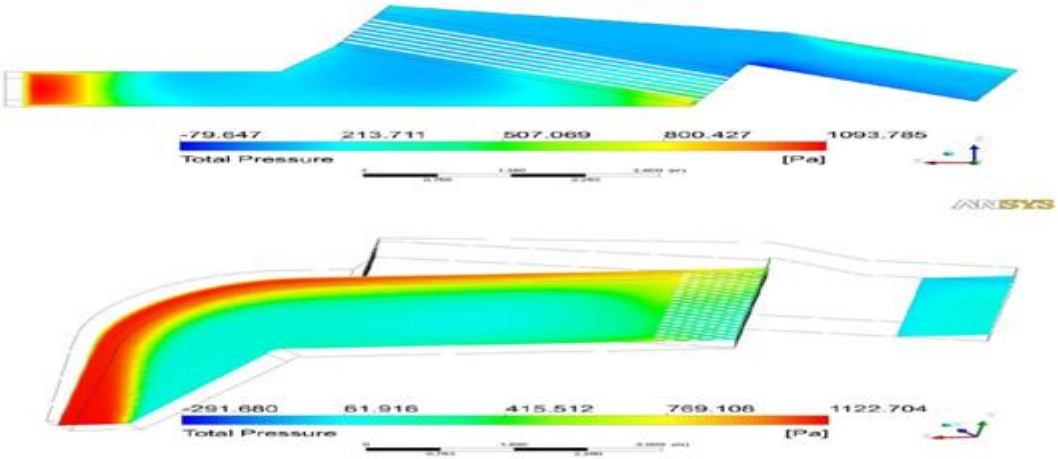

Figure 3. Total Pressure contours of Air Preheater duct

Fig. 3 and fig. 4 shows the Pressure and velocity contours at baseline duct. When the fluid flow enters from divergent section to elbow section, the non uniform pressure adjust itself and is maximum at outer wall of elbow section to counter for centrifugal force.

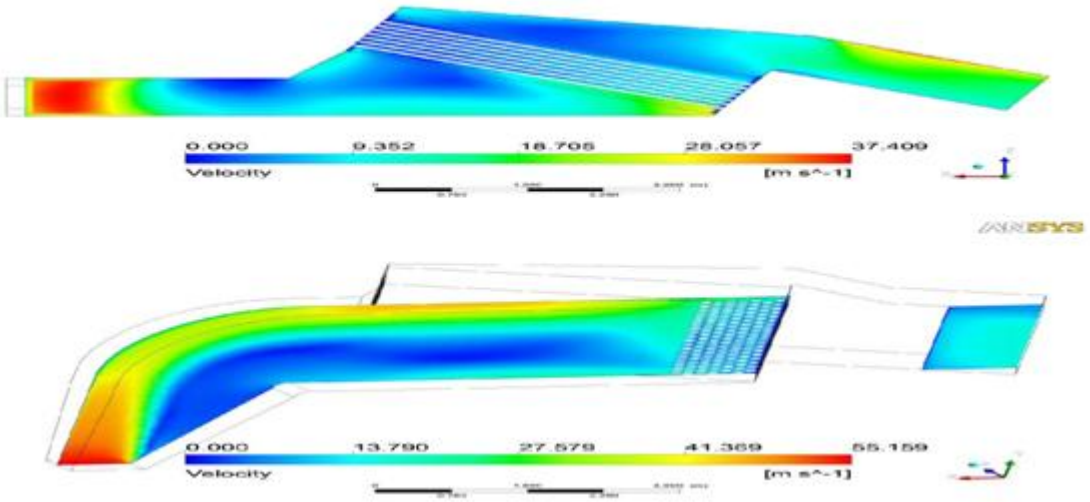

Figure 4. Velocity contours of Air Preheater duct

This change of flow from straight to curve part of elbow results in adverse stream layer pressure gradient effect.

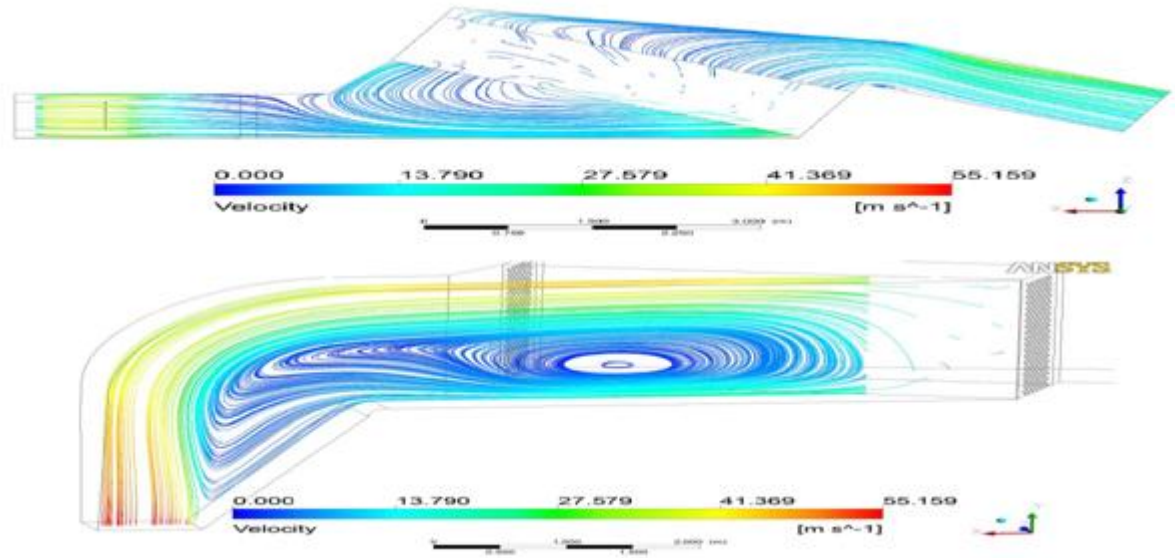

Fig.5 Velocity streamline contours of Air Preheater duct

IV. CONCLUSION

the inlet of elbow, the boundary layer experiences the effect of adverse pressure gradient and produce boundary layer separation. Due to this reverse flow occurs at outlet and creates higher turbulence in the duct. This can be countered with an opposite sign of local pressure gradient as shown in fig. 5 at the outlet of duct which nullify the effects and restore a uniform pressure conditions.

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