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CFD Analysis and Optimization of Heat Transfer Basket Element Profiles of Ljungstrom Air Preheater (APH)

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Abstract - *The Ljungstrom air preheater is one of the main components in the coal fired power plant for the extraction of the waste heat from the hot flue gases in order to increase the plant efficiency. In this air preheater, element profiles are the main component for heat exchange. At steady state, these profiles are optimized and carried out CFD analysis on these element profiles to check or to investigate the temperature distribution between the hot flue gases and cold air at the low* effectiveness *region of Ljungstrom Air preheater. The main aim of this study is to find out the heat exchanging behavior of element profiles and to find the outlet temperature of both the air and flue gases in the low* effectiveness *region.*

Key Words: CFD analysis, element profiles, solid works

1. INTRODUCTION

In most of the power plants, the Ljungstrom air preheater (Fig.-1) is used to extract the waste heat from the hot flue gases to preheat the cold air which is blown by the PA fans and FD fans. The preheated air is utilized in the boiler furnace for better combustion in order to increase the combustion rate and increases the efficiency of the boiler and thus it reduces the fuel consumption of the power plant. This Ljungstrom air preheater is divided in to cold section and hot section in which the hot flue gases will flow in the hotter section and cold air will be flowing in cold section and this air preheater consists of element profiles, rotor, double seals, single seals, motorized motor to drive the APH, speed controller, actuators etc,.

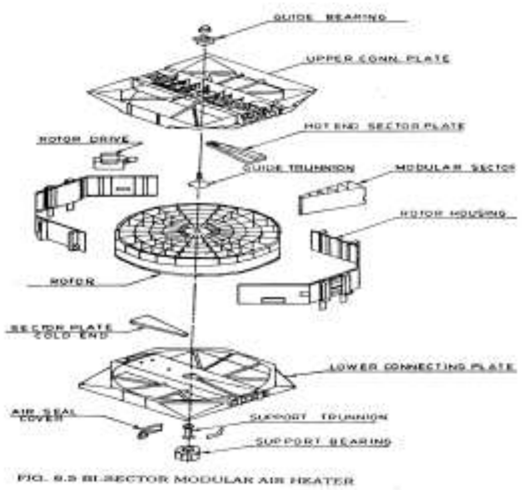

Fig.-1 Ljungstrom air preheater

The most important part of air preheater for the heat exchange between both the fluids hot flue gases and cold air is element profiles. When the air preheater is made to rotate about 2-5 rpm by a rotor, the hot flue gases will flow over the surface of these element profiles and is stored by these profiles after some time the heated part will come in contact with the cold air flow, thus the heat from the element profiles is extracted by the cold air and this preheated air is passed to the boiler furnace for complete combustion of the powdered coal and thus it increases the thermal efficiency and overall efficiency. These element profile materials are made up of steel and steel alloys. In this study we used corten steel as a material in which it is anti corrosive and anti erosive and can withstand higher temperatures. Hence, these material properties are suitable for experiment. Assuming these profiles to be at steady state and at low effectiveness region of Ljungstrom Air preheater (Fig.-2).

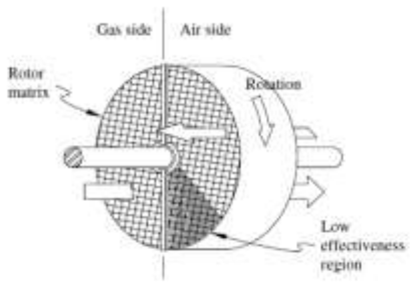

Fig.-2 Low effectiveness region of Ljungstrom Air preheater

The CFD analysis is carried out by using the material properties and air preheater data collected from the RTPS 210 MW power plant as boundary conditions and applied on these element profiles and analyzed the results using Ansys 18.1 version.

2. HEAT TRANSFER ELEMENT PROFILES

The different heat transfer element profiles is the main parts of the ljungstrom air preheater and are as follows.

2.1 Notched Corrugated

This profile has lower thermal efficiency even though it is used in all the coal fired based thermal power plants (Fig.-3).

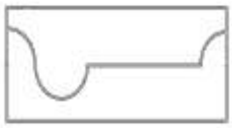

Fig.-3 Notched corrugated

2.4 Double undulated

This profile is inclined and notched geometry and used mainly at intermediate and hot side portion of air preheater basket matrix (Fig.-4).

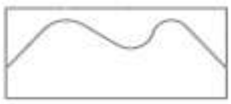

Fig.-4 Double Undulated

2.5 Advanced Clear Element

This profile element profile helps in easy cleaning of plugged as by using soot blowers and this gives better performance than the other profiles at low effectiveness region of air preheater (Fig.-5).

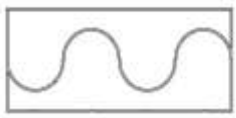

Fig.-5 Advanced Clear Element

2.2 Notched Flat

This profile has lower pressure drop and has more thermal efficiency. This type of profiles is used in lower plugging applications such as oil and gas power plants. Since, it is difficult to clean the plugged ash from the profile (Fig.-6).

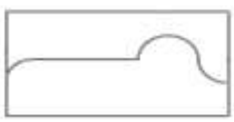

Fig.-6 Notched Flat

2.1 Corrugated Undulated

This profile is used in the natural gas fired power plants and these profiles is used for flue gases produced when fired with natural gas (Fig.-7)

Fig-7 Corrugated undulated

3. EXPERIMENT MEASUREMENTS

The different heat transfer element profiles were examined by using the specification of power plant, specification of Ljungstrom air preheater, average readings of air preheater (Table 1) and properties of flue gases (Table 2). The specifications were listed below in the following.

Plant specifications are as follows:

- Capacity - 180 MW Unit
- Turbine - 3000 rpm
- Frequency – 49.59-50 Hz
- Power factor - 0.7-0.8
- Ambient temperature - 35 ^{0}C

Specifications of air preheater are as follows:

- Type - Ljungstrom air preheater
- Rotor rotation - 3 rpm
- Rotor diameter – 5-10 m
- Heating plate height- 800 mm
- Heating plate thickness – 0.60 mm
- Plate material - Corten steel

Table1: Average readings of Air preheater

Medium	Inlet temp.	Inlet Pressure	Outlet temp.	Outlet pressure
Air	310K	2.054 kPa	560 K	1.735 kPa
Flue gas	574 K	-0.5432 kPa	490 K	-1.544 kPa

Table 2: Properties of Flue gases

Sr. No.	Property	Value
1.	Density	0.623 kg/ m^3
2.	Specific heat (constant pressure)	1.1796 kj/kgK
3.	Thermal conductivity	0.04064 W/mK
4.	Viscosity	0.023 Pas
5.	Enthalpy	280.35 kj/kg

4. CFD ANALYSIS

The geometry of different element profiles was drawn and modeling is done in solid works and these models were imported in Ansys 18.1 fluent software and automatic meshing is used, setup, steady state, energy equation, k- ε turbulence model, boundary conditions as mentioned below CFD analysis is carried out by using the collected data from 210MW RTPS power plant as boundary conditions is listed below in following (Table 3).

Table 3: Boundary conditions

Medium	Inlet temp.	Inlet Pressure	Outlet temp.	Outlet pressure
Air	310K	2.0545 kPa	-	1.734 kPa
Flue gas	574 K	-0.5431 kPa	-	-1.5444 kPa

4. RESULTS AND DISCUSSIONS

A both experimental and analytical result shows that there is a decrease in the flue gas outlet temperature [Chart.-1] and increase in the air temperature [Chart.-2] which is shown as below.

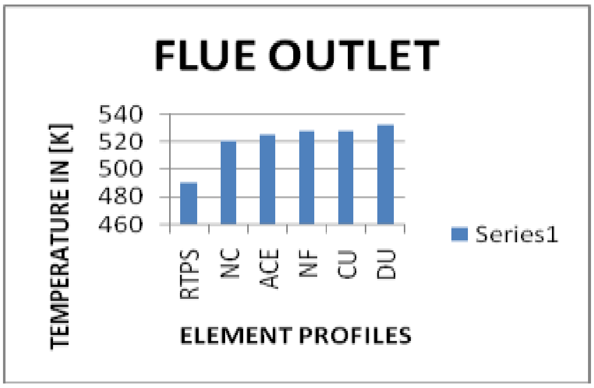

Chart.-1: Flue outlet

In this above, Chart.-1. It clearly shows that the temperatures of different profiles at the low efficient region of Ljungstrom Air-preheater. In these profiles from the CFD analysis and optimized profile Notched Corrugated (NC) gives lower flue outlet temperature than the other profiles. But, we found that the Notched Corrugated (NC) outlet temperature is slightly higher than the RTPS air preheater.

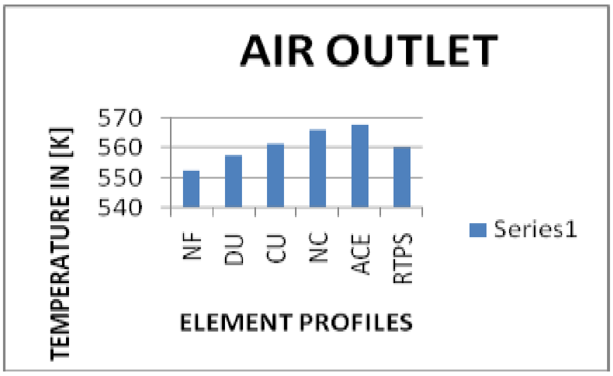

Chart.-2: Air outlet temperature vs Element profiles

In this above, Chart.-2. It clearly shows that the temperatures of different profiles at the low efficient region of Ljungstrom Air-preheater. In these profiles from the CFD analysis and optimized profile Notched Corrugated (NC) gives slightly lesser than Advanced Clear Element (ACE) profile. But, on comparison with the Flue outlet temperature NC is lesser than Advanced Clear Element (ACE) profile. Hence, this Notched Corrugated (NC) profile is higher than RTPS air preheater and this profile can be used in the low efficient region for better efficiency or to improve the efficiency of the air preheater and it also helps in easy cleansing of the deposited ash.

Note: For easy comparison observe the first three bar columns in chart.-1 and last three bar columns in chart.-2.

4.1 TEMPERATURE CONTOURS OF DIFFERENT PROFILE

The temperature contours of different profiles are shown below from Fig.-8-12. These temperature contours shows how the temperature variation takes place in the optimized profiles of air preheater. The blue color shows the cold inlet and red color shows the Flue inlet temperatures. The color variation indicates the temperature distribution from hot flue gases to the cold air.

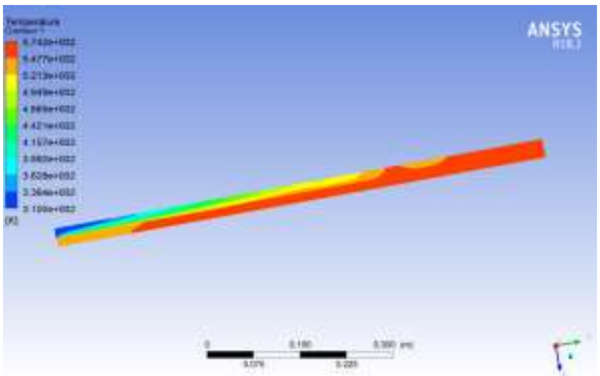

Fig-8: Temp. Contour for NC

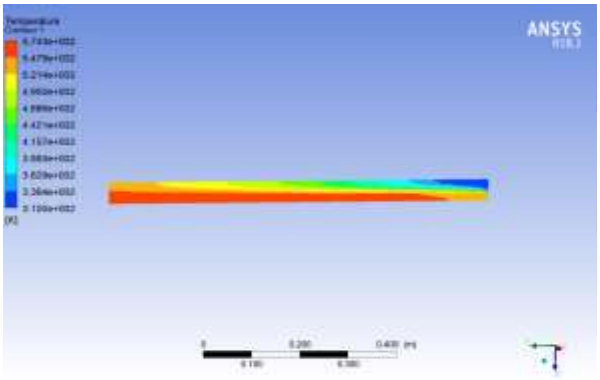

Fig-9 Temp. Contour for DU

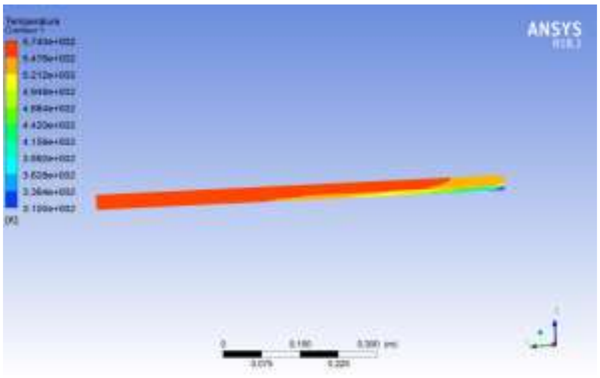

Fig-10 Temp. Contour for ACE

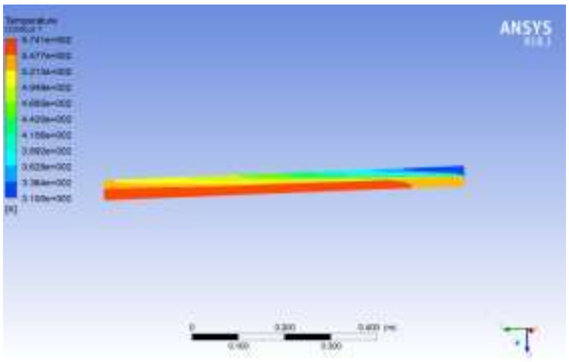

Fig-11: Temp. Contour for NF

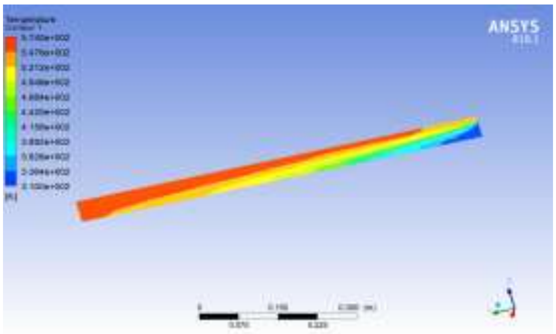

Fig-12: Temp. Contour for CU

5. CONCLUSIONS

In this research work, "CFD analysis of Basket Element profiles at Low Effectiveness Region of Ljungstrom Air Preheater".

1. Heat exchange and temperature distribution of Ljungstrom air preheater mainly depends on the element profile.

2. From the CFD analysis and optimized profile Notched Corrugated (NC) gives lower flue outlet temperature than the other profiles. But, we found that the Notched Corrugated (NC) outlet temperature is slightly higher than the average flue outlet temperature of RTPS air preheater.

3. From the CFD analysis and optimized profiles, air outlet temperature of Notched Corrugated (NC) gives slightly lesser temperature than Advanced Clear Element (ACE) profile. But, on comparison with the Flue outlet temperature Notched Corrugated (NC) is lesser than Advanced Clear Element (ACE) profile. Hence, this Notched Corrugated (NC) profile is higher than RTPS air preheater.

In future, this study can be applied for different materials and at different region of air preheater in order to increase the efficiency of the air preheater.

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BIOGRAPHIES

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