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CFD Investigation on Optimized Basket Profile Elements in Ljungstrom Air Preheater

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***Abstract*- Rotary regenerative ljungstrom air preheater is a type of heat exchanger. This heat exchanger is utilized to heat the cold air at coal based thermal power stations. The heat is exchanged between the hot flue gases and cold air which is flowing in opposite direction i.e, in different sectors. As APH rotates at 2-4 rpm, the hot flue gases flow in one section that hot section moves in to the cold section. Such that, the cold air extracts heat from this heating element profiles. In this CFD analysis study, experiment details were collected from the 210MW of RTPS shaktinagar. To study about CFD analysis different element profiles were developed in solid works and imported to ANSYS 18.1. After precise CFD simulations the outlet temperature of element profiles were obtained. This analysis gives relatively good results.**

***Keywords:* Solid Works, Ansys 18.1 CFD software, element profiles etc.**

1. INTRODUCTION

In a coal based thermal power plant, air preheater is a device which is used to exchange the heat between the hot flue gases and cold air which is flowing in opposite direction i.e, in different sectors. As APH rotates at 2-4 rpm, when the hot flue gases passes through the heated section, due to the rotation of APH, this hot section is further moved in to the cold section. Such that, the cold air extracts the heat from this element profiles and this hot air is utilized in the combustion chamber of a boiler, such that it increases the thermal efficiency of a thermal power plant. As a result, the lower temperature flue gases were left to the atmosphere. Usually, air preheaters are of two types. In recuperative air preheater in this, heat exchange takes place between the two fluids simultaneously flowing adjacent through the separating wall. In regenerative air preheater heat is exchanged between the hot flue gases and cold air which is flowing in opposite direction i.e, in different sectors.

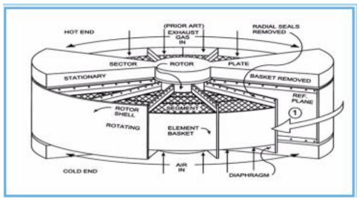

Fig.-1 Ljungstrom air preheater

Ljungstrom air preheater [Fig.-1] is one of the important heat recovery systems in coal based thermal power plant which was invented by Ljungstrom in 1920[1]. A Warren study on Ljungstrom air preheater and his experimental results confirms that there is a reduction of 10% fuel consumption in coal based thermal power plant [2]. Sandira ELJSAN shows that, the optimized regenerative air preheater operating parameter increases the efficiency and overall efficiency of a coal fired boiler. Thus there is a reduction of fuel consumption by 35% [3]. A Sreedhar volloju study shows that the heat exchange mainly depends on element profiles. The performance was compared these profile with different Reynolds number by using residual time test and cold flow study [4]. Hong yue wang study mainly focused on temperature distribution in the matrix and also shows, the semi analytical methods were examined on three dimensional heat transfer of tri-sectional RAH (Rotary air preheater) [5]. Sandira alagi used commercial CCM (computational continuum mechanics) solver for the analysis of distribution of temperature between the air preheater solid elements of combustion products and the fluid flow of cold air.

2. HEAT TRANSFER ELEMENTS.

The element profile of air preheater is the main part for better heat transfer. The different types of heat transfer elements are as follows,

1) Notched Corrugated (NC): This element profile is in use even though it has relatively low in thermal efficiency. This profile is mainly used in coal fired units [Fig.-2].

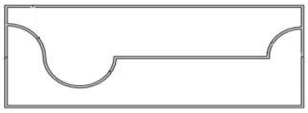

Fig.-2: Model of NC

2) Double Undulated (DU): Double undulated heating element is applied when there is a deposition of ash on the plates is expected to be more, especially this element is used in low load thermal power plants. Because of the wide and inclined surfaces or the volume availability the cleansing of the deposited ash is easy by using soot blowers [Fig.-3].

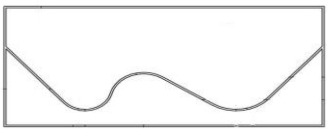

Fig.-3: Model of DU

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3) Advanced Clear Element (ACE): This has the highest rate of heat transfer and better thermal performance when compared to that of the other heating elemental profile. There is a decrease in the flue outlet and increase in the cold outlet temperature [Fig.-4].

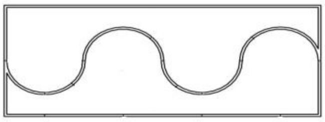

Fig.-4: Model of ACE

4) Notched Flat (NF): This profile has lower thermal efficiency but it is used in many coal fired units because of its wide open design which is suitable for better cleansing or maintenance of air preheater [Fig.-5].

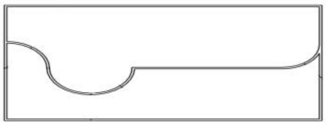

Fig.-5: Model of NF

5) Corrugated Undulated (CU): This corrugated undulated profiles is used in natural gas fired units in which these heating profiles is suitable for producing low density flue gasses from natural gas fired units [Fig.-6]

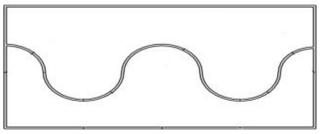

Fig.-6: Model of CU

3. EXPERIMENT MEASUREMENTS

The five types of profiles have been tested. These profiles are namely as follows,

(1) Notched Corrugated (NC) profile
(2) Double undulated (DU) profile
(3) Advanced Clear Element (ACE) profile
(4) Notched Flat (NF) profile
(5) Corrugated Undulated (CU) profile

Generally these elements are made-up of corten steel. Corten steel has more erosion resistance, more corrosion resistance and high thermal conductivity.

Experimental data were collected from RTPS (Raichur thermal power station) of KPCL.

Specifications of a unit and Ljungstrom air preheater are as under;

Plant specification:

- Capacity - 180 MW Unit
- Turbine - 3000 rpm
- Frequency – 49.5-50 Hz
- Power factor - 0.7-0.8
- Ambient temperature - 35 ^{0}C

Specification of Rotary air preheater:

- Type - Ljungstrom air preheater
- Rotor rotation - 2 rpm
- Rotor diameter – 5.86 m
- Heating plate height- 1200 mm
- Heating plate thickness – 0.6 mm
- Plate material - Corten steel

Table -1: Average Values of Readings

Medium	**Inlet temp.**	**Inlet Pressure**	**Outlet temp.**	**Outlet pressure**
Air	315.56K	2.0548 KPa	561.75K	1.736 KPa
Flue gas	584.75 K	-0.5435 KPa	486.68 K	-1.5447 KPa

Table -2: Properties of Flue Gas

Sr. No.	**Property**	**Value**
1.	Density	0.624 Kg/ m3
2.	Specific heat (constant pressure)	1.1797 Kj / Kg.K
3.	Thermal conductivity	0.04066 W / m.K
4.	Viscosity	0.025 Pa.s
5.	Enthalpy	280.35 Kj / Kg
6.	Molar mass	27.2323 g / mol

During experiment, sufficient number of readings was taken both at inlet and outlet of the APH. The average values of all the measurements were obtained and presented in Table-1. The thermal power plant is using Lignite coal as a fuel and the property of the flue gas is present in Table-2.

3. CFD ANALYSIS

The geometry design and modeling of element profile were done in solid works software and imported to ANSYS 18.1 for CFD analysis. On the basis of literature review optimized model of elements had been taken for analysis and application of k-ε turbulence method on the elements. The main aim of the analysis is to find out the outlet temperature of both the air and flue gases on the optimized elements with respect to that of the corresponding boundary conditions [Table-3].

Table-3: BOUNDARY CONDITIONS

Medium	**Inlet temp.**	**Inlet Pressure**	**Outlet temp.**	**Outlet pressure**
Air	315.56K	2.0548 KPa	-	1.736 KPa
Flue gas	584.75 K	-0.5435 KPa	-	-1.5447 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. As far as result concerned the flue outlet model 1 and model 3 are slightly less but when compared to these two

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profiles the air outlet temperature of model 3 is more than the model 1. Thus model 3 shows more heat transfer and it shows a good agreement.

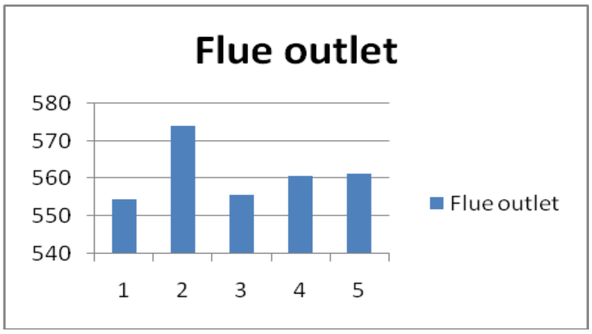

Chart.-1: Flue outlet

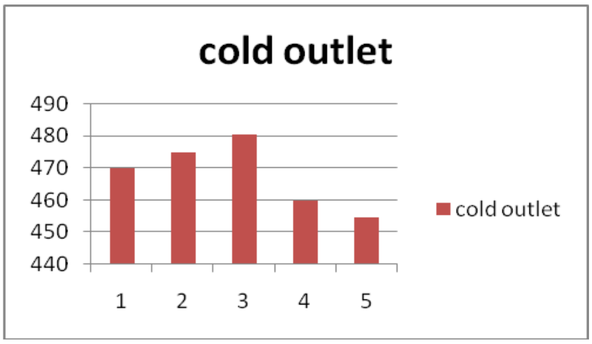

Chart.-2: Cold outlet

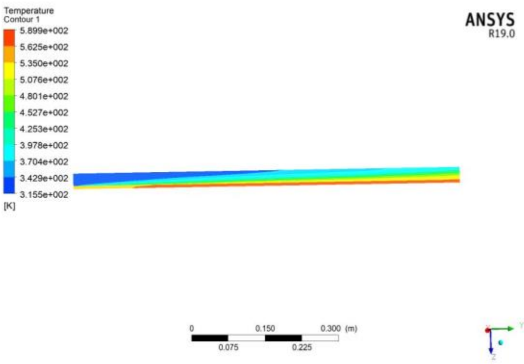

Fig-7: Temp. Contour for NC

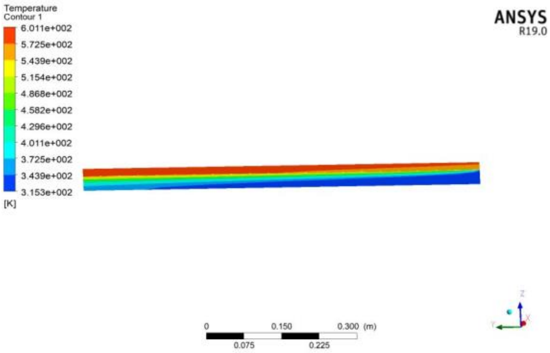

Fig-8: Temp. Contour for DU

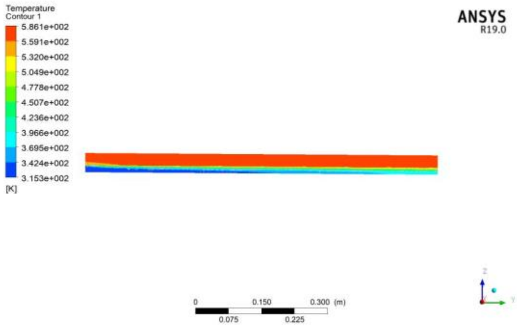

Fig-9: Temp. Contour for ACE

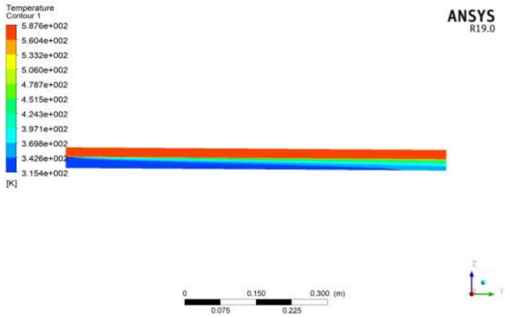

Fig-10: Temp. Contour for NF

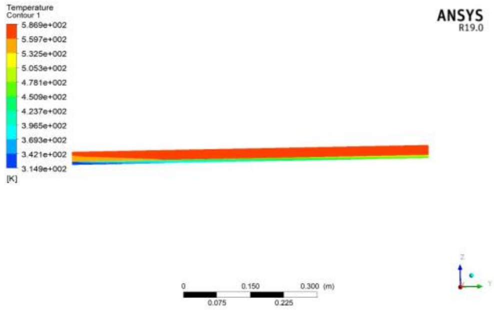

Fig-11: Temp. Contour for CU

5. CONCLUSION

In this research work, CFD investigation and experimental study were carried to optimize the heating elemental profile of air preheater.

1) Heat transfer mainly depends on the element profile

2) Advanced Clear Element (ACE) shows the highest heat transfer compared to the other heating profiles such that here is an increase in the cold air outlet temperature which is used in the boiler for combustion and also there is a decrease in the flue outlet temperature.

In future, this study can also be done by using different materials and for problems involving heat transfer of elemental profiles.

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