

# Optimization and CFD Analysis on Profile Elements of Regenerative Rotary Air-Preheater

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**Abstract** - A Regenerative rotary air preheater is one of the important equipment in most of the thermal power plant. Rotary air preheater is also named as Ljungstrom air preheater this air preheater extracts the heat from the waste hot flue gases which is left out the atmosphere through chimney. The extracted heat is utilized to preheat the cold air and this hot air is further supplied to the boiler furnace for the better combustion of powdered coal. By this process the thermal efficiency of the boiler increases and facilitates reduced consumption of fuel. In this study one of the main heat transfer component of Ljungstrom air preheater is the different element profile. The optimized geometry of profiles were designed in solidworks and imported to CFD software for the analysis and CFD simulation on these profiles. The main aim of this study is to find out the outlet temperatures of different profiles. This study gives almost related results.

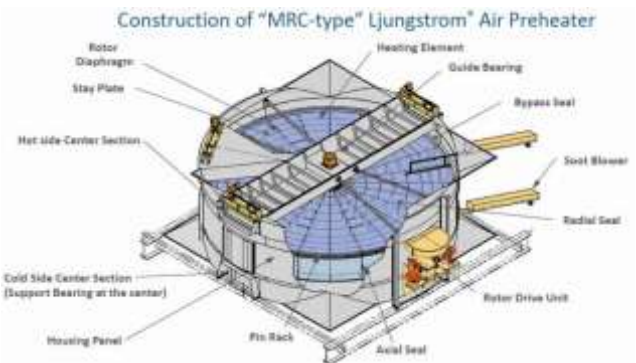


Fig.1 Rotary Ljungstrom Air-Preheater

**Key Words:** Solid works, CFD software, element profiles,.

## 1. Introduction

In a power plant, ljungstrom air preheater is one of the main heat exchanger component or equipment which is used to extract heat from the waste hot flue gases. Based on design ljungstrom air preheater has 2-3 sectors and it consists of element profiles, rotor, unit casing, motor drives etc, The main heat transfer or heat exchanging part of this is air preheater is element profiles which are placed in the baskets in matrix form and assembled in to one unit. The basket profile elements are of different types namely notched corrugated (NC), double undulated (DU), corrugated undulated (CU), notched flat (NF) and advanced clear element (ACE). When the air preheater rotates about 2-4 rpm around the vertical axis, the flue gases flow through the specified sector as shown in the below [Fig.-1]. The heat from the hot flue gases is extracted by the element profiles and due to the rotation of APH (air preheater) the heated part moves in to the cold air which is blown by the both the primary air fan and forced draft fan. Such that, the heat transfer takes place between the heated elements and cold air and then converted in to hot air which is passed to the furnace of the boiler for the complete combustion of fuel and results in increase of the thermal efficiency of the boiler and overall efficiency.

The rotary ljungstrom air preheater is one of the most important equipment in many thermal power plants is invented by Ljungstrom in the year 1920[1]. Warren publication on air preheater shows that his experimental analysis results that, due to the use of air preheater there is a reduction of 10% reduction of total fuel consumption in a coal based thermal power plant [2]. Sandira ELJSAN study on the operating parameters and optimization of regenerative air preheater his results shows that there is a 35% reduction of total fuel consumption in a coal based thermal power plant and also increased thermal efficiency and overall efficiency [3]. Sreedhar volloju study on air preheater depends mainly on element profiles and the results on performance of element profile were good at different Reynolds number on each element [4]. Hong yue wang mainly focused on how the temperature distribution takes place in air preheater matrix and he used semi analytical method and analysed the three dimensional heat transfer on tri-sectored ljungstrom air preheater [5]. Sandira alagi utilized commercial computational mechanics solver to get the results of temperature distribution between the solid elements and with both the cold air and hot flue gases.

## 2. Heat Transfer Elements

Heat transfer elements are the central or innermost important part of Ljungstrom air preheater. The different types of ljungstrom air preheater element profiles in use are as follows.

- 1) Corrugated undulated: These profile is usually used in fossil gas fired power plant units. This profile is closely and neatly packed together and this is appropriately

used for stacked gases produced when fired with fossil gas (Fig-2).



Fig-2 Corrugated undulated

2) Notched flat: To some extent it has comparatively lower pressure drop and has higher thermal efficiency such that it is used in lower ash depositing applications like oil and gas. Since it is very difficult to cleanse the highest degree of ash deposition (Fig-3).

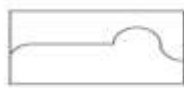


Fig-3 Notched flat

3) Notched corrugated: To some extent this profiles have low thermal efficiency, these are used mainly in all coal fired power plant units. (Fig-4).



Fig-4 Notched corrugated

4) Double undulated: These elements contain both alternate undulated inclined and notches. These were used mainly for intermediate and hot layered baskets of air preheater (Fig-5).



Fig-5 Double undulated

5) Advanced clear element: The design of ace gives the most appropriate solution for most of the air preheater issues in day today's power plants. This profile helps in easy cleaning of deposited ash by using steam soot blowers (Fig-6).

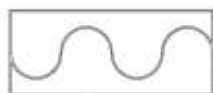


Fig-6 Advanced clear element

(2) Notched flat

(3) Notched corrugated

(4) Double undulated

(5) Advanced clear element

Usually these elements are made-up of corten steel. Corten steel is highly erosion resistance and corrosion resistance and ha higher thermal conductivity.

Experiment details is collected from RTPS (Raichur thermal power station) of KPCL.

Specifications of a plant unit and Ljungstrom air preheater is as follows;

Plant specification:

- Capacity - 210 MW Unit
- Turbine - 3000 rpm
- Frequency – 49.59-50 Hz
- Power factor - 0.7-0.8
- Ambient temperature - 38<sup>0</sup>C

Specifications of air preheater is as follows:

- Type - Ljungstrom air preheater
- Rotor rotation - 3 rpm
- Rotor diameter – 5.83 m
- Heating plate height- 800 mm
- Heating plate thickness – 0.60 mm
- Plate material - Corten steel

**Table -1:** Readings of Air Preheater

Medium	Inlet temp.	Inlet Pressure	Outlet temp.	Outlet pressure
Air	311.56K	2.0546 KPa	561.73K	1.735 KPa
Flue gas	584.73 K	-0.5432 KPa	486.68 K	-1.5445 KPa

**Table -2:** Properties of Flue Gas

Sr. No.	Property	Value
1.	Density	0.622 Kg/ m3
2.	Specific heat (constant	1.1798 Kj / Kg.K

### 3. Experiment Measurements

The different types of ljungstrom air preheater element profiles are tested and examined are as follows.

(1) Corrugated Undulated

	pressure)	
3.	Thermal conductivity	0.04065 W / m.K
4.	Viscosity	0.024 Pa.s
5.	Enthalpy	280.36 Kj / Kg
6.	Molar mass	27.2322 g / mol

The readings were taken both at inlet and outlet of the APH and the readings presented in Table-1. The coal based thermal power plant uses Lignite coal as one of the fuel and the properties of the flue gases is presented in Table-2.

### 3. CFD Analysis

The modeling of each element profile was done in solid works and imported for CFD analysis. As mentioned above in introduction part about the literature review, the optimization of each model had been taken for CFD analysis and applied k-ε turbulence method. The corresponding boundary conditions are given below in [Table-3]. The Aim of this study is, finding out the outlet temperature of both air and flue gases.

Table-3: BOUNDARY CONDITIONS

Medium	Inlet temp.	Inlet Pressure	Outlet temp.	Outlet pressure
Air	311.56K	2.0546 KPa	-	1.735 KPa
Flue gas	584.73 K	-0.5432 KPa	-	-1.5445 KPa

### 4. Results And Discussions

As per design of air preheater there should be a reduction of flue gas outlet temperature and increase in outlet air temperature. In this study the experimental and analytical results shows that model-5 gives good results when compared to the other profiles. Outlet temperature of both the hot flue gases and air is as shown in the below Chart.1-2. The temperature contour of each profile is as shown in the below Fig. 8-12.

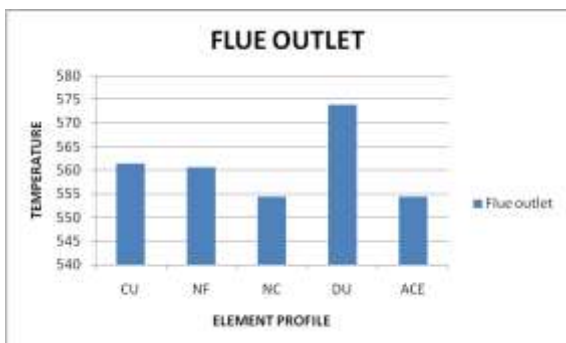


Chart-1: Flue outlet

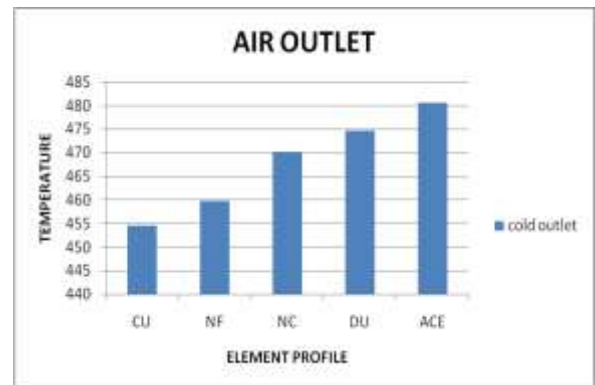


Chart-2: Air outlet

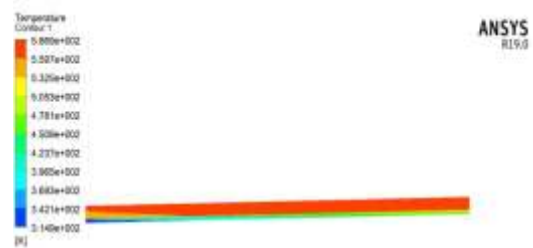


Fig.8- Temperature contour of CU



Fig.9- Temperature contour of NF

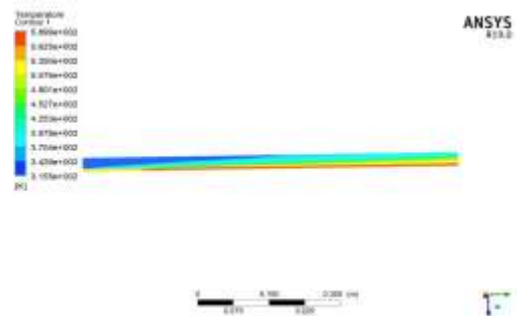


Fig.10- Temperature contour of NC

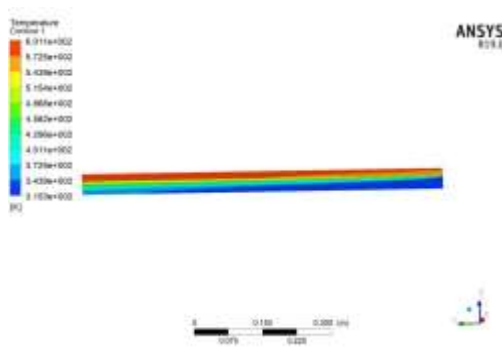


Fig.11- Temperature contour of DU

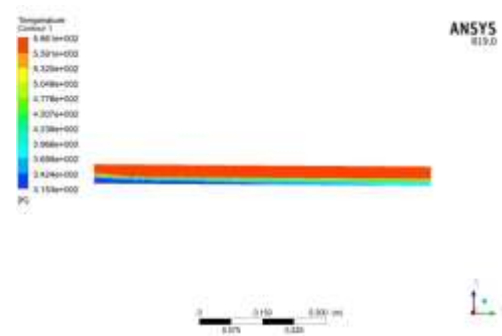


Fig.12- Temperature contour of ACE

## 5. Conclusion

In this research work, Optimization and CFD analysis on profile elements of Ljungstrom air-preheater.

- 1) Heat exchange of air preheater mainly depends on the element profile.
- 2) Advanced Clear Element (ACE) model-5 shows the good results when compared to the outlet temperature of both hot flue gases and air.

In future, this study can be applied for different materials and at different temperatures.

## 6. References

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