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THERMODYNAMIC ANALYSIS OF RECUPERATIVE AIR PREHEATER

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ABSTRACT

This paper present an approach for the optimization of air preheater for inline tube arrangement.Poor performance for air preheater is a reason for higher unit heat rate & deterioration for boiler efficiency due to losses of flue gas temperature as a sensible heat loss. Here two different size of tube diameter is analysed on CFD. & it shows that lower diameter tube there is considerable reduction in tube material which further reduce structural cost.

KEYWORDS: Recuperative Air Preheater, CFD, Creo Parametric, Mass Flow Rate .Flue Gas Temperature.

INTRODUCTION

This study was carried out in “Ruchi Soya India Ltd” Haldia,durgachak Bengal,india [Public Limited Ltd] ruchi group of industries is a well known Indian conglomerate with business interests in diverse field like FMCG, oil, cement, power, real estate, dairy products,agro commodities,logistics,and warehoushing.the group has its corporate headquarter in indore,with offices and plants located at major business centers in the country[1]This paper address the recuperative air preheater In such type of air preheater heating medium is on one side and air on the other side of the tube or plate and the heat transfer is by conduction through the material,which seperates the media. These are of static construction & hence there is only nominal leakage through expansion joints, acess door, casing etc. In Tubular Air Preheater type energy is transferred from the hot flue gas flowing inside thin walled tubes to the cold combustion air flowing outside the tubes.The unit is consist of nest of straight tube that are rolled or welded into tubesheets & enclosed in a steel casing or gas passing outside of the tubes & has both air and gas inlet & outlet openings. In the vertical type tubes are supported from either the upper or lower tubesheet while the other (floating) tubesheet is free to move as tubes expand within the casing.an expression joint between the floating tubesheet and casing provides an air/gas seal.intermediate baffle plates parallel to the tubesheet are frequently used to separate the flow path & eliminate tube damaging flow induced vibration. carbon steel or alloy corrosion resistant tube material are used in the tubes which range from 38 to 102 mm in diameter & have wall thickness of 1.24-3.05mm.In such type, variety of single & multiple gas & air path arrangements can be used to optimu performance.erosion of air preheater parts can be controlled by reducing velocities removing erosive elements from the gas stream or using sacrificial material.[4]

IDENTIFICATION OF PROBLEM

Air is supplied through FD & PA fans and is measurable and controllable. However over & above this air some additional air ingresses in the boiler due to negative draft maintained in the boiler.thus air ingress causes increased mass flow of flue gas resulting into increased in flue gas velocity which in turn is responsible for erosion in 2nd pass.APH ducts, ESP & I.D fans.since carbon on ignition forms CO_2. Sulphur on ignition forms SO_2 & hydrogen on ignition forms forms H_2o.in order to achieve this excess air is supplied to the furnace.finer coal particle with correct coal particle with correct velocity & with correct quantity of secondary air can achieve this.reducing atmosphere create high flue gas temperature at furnace exit with presence of CO & it results into clinker formation. [5]

LITERATURE REVIEW

1) M.Nageswara rao et al; The tubular preheater ducts for cold and hot air require more space and structural supports than a rotating preheater design. Further, due to dust-laden abrasive flue gases, the tubes outside the ducting wear out faster on the side facing the gas current[10]
2) SCAPH is used to heat atmospheric air to the required process temperature by means of saturated steam. It heats air entering the air heater recuperative or regenerative type, in order to raise the average cold end temperature to prevent acid dew point corrosion[6]
3) A Wienese et al; The furnace pressure is controlled by altering the speed of the ID fan. Both a positive and a negative pressure reduce boiler efficiency. Ideally the pressure should be just below atmospheric. In some boiler installations the air to fuel ratio control operates on the ID fan while the furnace pressure is regulated by the FD fan.[7]
4) Sreedhar Vulloju et al;If the length of path of air travel through the element is more, then the contact of air surface area through element increases and residual Time through the element is also increased. If surface area increases, then heat transfer co-efficient increases. So, If residual Time is more, elements have more heat transfer coefficient so these elements transfer more heat to medium or absorb more heat from medium and vice-versa[8]
5) Al Hovland,Et Al;The finned tube air preheaters often fouled after a few years of plant operation. fouling restricted combustion airflow . This reduced airflow through the air heater often limited power output during certain weather and other operating conditions. The NitroLance cleaning system delivers pressurized liquid nitrogen to the cleaning surface and rapidly removes deposits .[9]

MODELING PLATEFORM OF RECUPERATIVE AIR PREHEATER

Creo Parametric 2.0

In Creo Parametric, the parametric part modeling process involves the following steps:

1. Set up Units and Basic Datum Geometry.
2. Determine the type of the base feature, the first solid feature, of the design.

Note that Extrude, Revolve, or Sweep operations are the most common types of base features.

3. Create a rough two-dimensional sketch of the basic shape of the base feature of the design.
4. Apply/modify constraints and dimensions to the two-dimensional sketch.
5. Transform the two-dimensional parametric sketch into a 3D feature.
6. Add additional parametric features by identifying feature relations and complete the design.
7. Perform analyses/simulations, such as finite element analysis (FEA) or cutter
8. Document the design by creating the desired 2D/3D drawings.

The approach of creating three-dimensional features using two-dimensional sketches is an effective way to construct solid models Many designs are in fact the same shape in one direction. Computer input and output devices we use today are largely two dimensional in nature, which makes this modeling technique quite practical. Creo Parametric provides many powerful modeling and design tools, and there are many different approaches to accomplish modeling tasks. The basic principle of feature-based modeling is to build models by adding simple features one at a time.[2]

Computational Fluid Dynamics: ANSYS CFX and FLUENT CFD Software

ANSYS provides a comprehensive suite of computational fluid dynamics software for modeling fluid flow and other related physical phenomena. It offers unparalleled fluid flow analysis capabilities, providing all the tools needed to design and optimize new fluids equipment and to troubleshoot existing installations. The primary ANSYS products in the fluids area are ANSYS Fluent and ANSYS CFX. With these solutions you can simulate a wide range of phenomena: aerodynamics, combustion, hydrodynamics,mixtures of liquids/solids/gas,particle dispersions, reacting flows, heat transfer, and much more. Steady-state and transient flow phenomena are easily and quicd flow, particle flow, heat transfer, chemical reactions,[3]

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RESULT

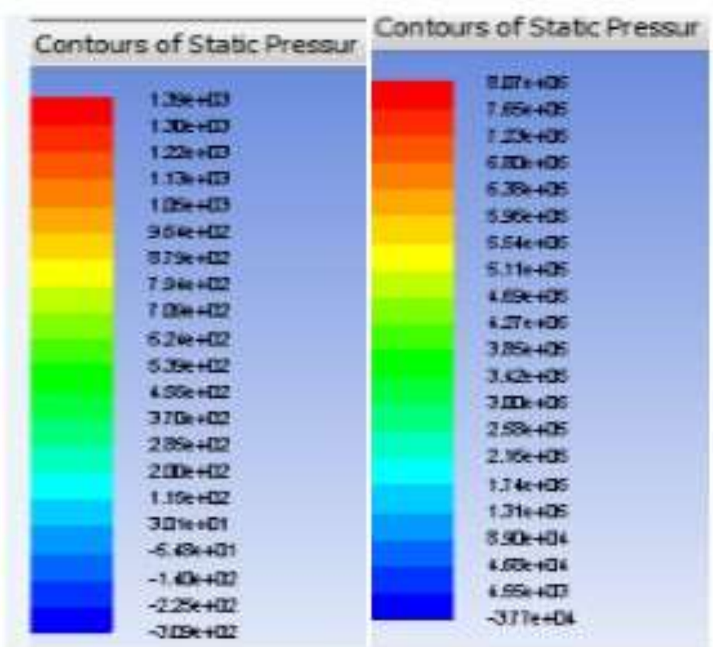

Fig No: 1- Contours of Static Pressure

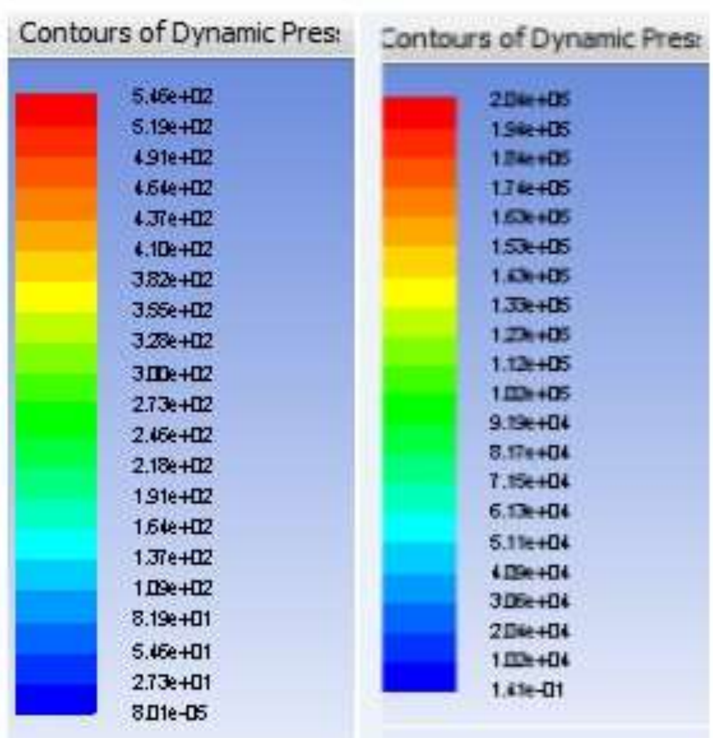

Fig No:2 Contours Of Dynamic Pressure

Table :1Parameters Of Air Preheater

Sr.No.	Parameters	Symbol	Unit	Quantity
1.	Heat transfer	Q	KW	1488.55
2.	Flue gas outlet temperature	T_2	°C	156
3.	Density of flue gas	ρ_g	Kg/m^3	0.752
4.	Specific heat of gas	C_{pg}	Kcal/ kg °C	0.2596
5.	Thermal conductivity of flue gas	K_g	Kcal/ mh °C	0.0303
6.	Viscosity of flue gas	μ_g	Kg/m h	0.0848
7.	Air oulet temperature	t_2	°C	150.2
8.	Width of air preheater	W	m	2.82
9.	Depth of air preheater	D	m	2.286
10.	Specific heat of air	C_{pa}	Kcal/ kg °C	0.2418
11.	Thermal conductivity of air	k_a	Kcal/ mh °C	0.0253
12.	Viscosity of air	μ_a	Kg/m h	0.0723
13.	Density of air	ρ_a	Kg/m^3	1.287

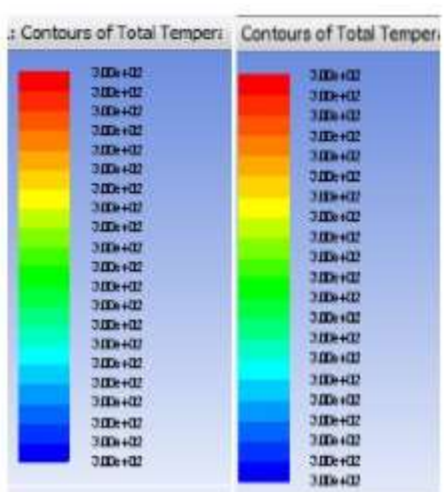

Fig No:3 Contours Of Total Temperature

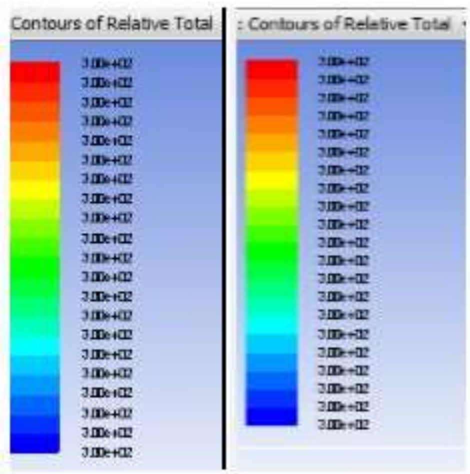

Fig No:4 Contours Of Relative Total Temperature

Table :2 Boundary condition for case –I

Sr.No.	Parameters	Unit	Value
1.	Pressure at outlet	Gauge	0
2.	Velocity at inlet for flue gas	m/s	15
3.	Wall		No slip & escape
4.	Default interior		Fluid(flue gas)
5	Diameter of tube	mm	28.1
6.	Gas mass flow	kg/hr	54628
7.	Temperature at inlet	(T_1)	526K
8.	Air mass flow	kg/hr	47000
9.	Temperature at inlet	(t_1)	309 K
10.	Velocity at inlet	m/s	6

Table :3 Boundary condition for case –II

Sr.No.	Parameters	Unit	Value
1.	Pressure at outlet	Gauge	0
2.	Velocity at inlet for flue gas	m/s	15
3.	Wall		No slip & escape
4.	Default interior		Fluid(flue gas)
5	Diameter of tube	mm	53.5
6.	Gas mass flow	kg/hr	54628

7.	Temperature at inlet	(T_1)	526K
8.	Air mass flow	kg/hr	47000
9.	Temperature at inlet	(t_1)	309 K
10.	Velocity at inlet	m/s	6

CFD RESULT

Table :4 Comparision On Two Difference Tube Diameter

Parameters	**Dia 28.1 mm**		**Dia 53.5mm**	
	MIN.	**MAX.**	**MIN.**	**MAX.**
Static Pressure	-3.09E+02	1.30E+03	-3.77E+04	8.07E+05
Dynamic Pressure	8.01E+05	5.46E+02	1.41E+01	2.04E+05
Relative Temperature	3.00E+02	3.00E+02	3.00E+02	3.00E+02
Total Relative Temperature	3.00E+02	3.00E+02	3.00E+02	3.00E+02

CONCLUSION

CFD analysis shows that for both the cases relative temperature & total relative temperature is same, but difference in static & dynamic pressure.Any change in tube diameter will result in saving of tube material.which further reduce structural cost.CFD can be used as a tool for substantial reduction of lead time & cost of design.

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