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Thermal analysis of CFB boiler tube with inclined perforation of different configuration and fluid temperature to enhance heat transfer

Vikas Kumar[1], Dr. Shyam Kumar Birla[2]
M.tech Scholar[1],HOD[2]
Department of Mechanical Engineering[1, 2]
Oriental college of Technology, Bhopal, India.

Abstract

Three types of configurations of CFB boiler tube i.e. tube with inclined square, inclined circular, inclined elliptical inclined perforations have been used. An optimized model of CFB boiler tube has been developed with different tube profiles. The simulation of the optimized model gives higher value of temperature distribution with respect to heat transfer coefficient and thermal conductivity with constant temperature of 673K, 773K and 873K. It is also observed from present analysis that CFB boiler tube with inclined elliptical perforation at 673K gives higher thermal distribution also as increase in constant temperature of 873K maximum heat transfer coefficient is observed, Hence CFB boiler tube with circumferentially 12 degree inclined elliptical shaped perforation enhances maximum thermal performance. The configuration of 12 degree inclined elliptical perforated profile gives maximum convergence on all parameters amongst all the configurations used.

Key Words – Circulating Fluidized Bed, Temperature Distribution, Inclined perforations, Heat Transfer Coefficient, Thermal Conductivity, Inclined hole.

1.1 INTRODUCTION

In CFBC boiler is circulating fluidized bed boiler or the CFBC boiler is becoming more and more popular within the world. In general, CFBC Boiler takes the biomass or cinder yet other solid fuels as its fuels. Boiler of which coal yet biomass is burnt within a surroundings about excessive awareness of mattress material (mineral matter) derived from combustion concerning charcoal retained via the usage of cyclone / other means. This mattress material is fluidized by means of essential air (a section about combustion air). The excessive concentration concerning mattress cloth alongside together with staged air supply ensures up to expectation size combustion temperatures slave no longer better 950°C erection that surroundings friendly (lesser manufacturing concerning NOx) capability of using coal then biomass. In the CFBC boiler, ash leaving together with flue gasoline is recirculated to combustion zone. This ash reduces combustion temperature. Due in conformity with recirculating ash unburnt coal arrive burnt.

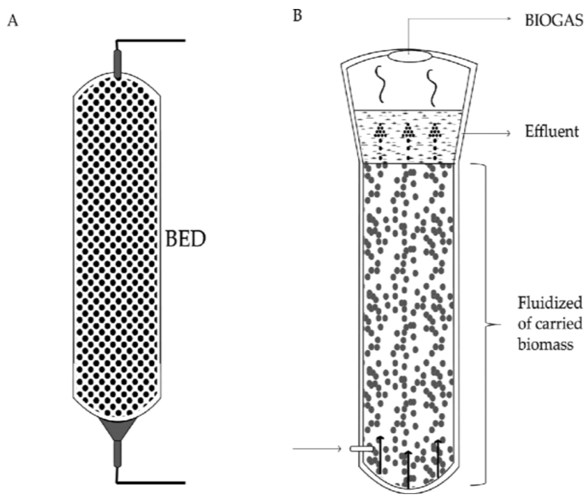

Figure 1 – Schematic of fluidized bed

1.2 RESEARCH METHODOLOGY

Procedure for Solving the Problem

- Create the geometry.
- Meshing of the domain.
- Steady state thermal solver.
- Set the material properties and boundary conditions.
- Obtaining the solution.
- Results.

1.3 Boundary conditions

Given the periodic structure of the CFB boiler tube, the two thermal parameter is investigated. Thermal domain employed. The material of the CFB boiler tube is 15crmo. The circumference of inside tube is heated at a constant heat transfer rate of 873K that is at different profiles of CFB boiler tube i.e. tube with square, circular, elliptical inclined perforations. The temperature is assumed to be constant Radiation effect is ignored.

1.4 RESULT

Validation of the Existing Simulation Results for Different Configurations of CFB boiler tube Models with Base paper Data:

The Existing simulation results are obtained for temperature distribution and heat transfer coefficients, constant temperature ranging from 673K to 873K. The results are in graphs show less than 15% deviations between existing simulation results. But the deviations are not so large, and thus the existing simulation results of different configurations of different CFB boiler tube models in the research work can be regarded as considerable.

Table 1 Temperature distribution and heat transfer coefficient in CFB boiler tube with fin (Validation model).

Validation			
Heat Flux	**Tf=673K**	**Tf= 773**	**Tf=873**
1000	4.4	3.5	2.4
1500	3.3	2.6	1.9
2000	2.7	2.1	1.5
2500	2.2	1.7	1.2
3500	1.9	1.3	0.9

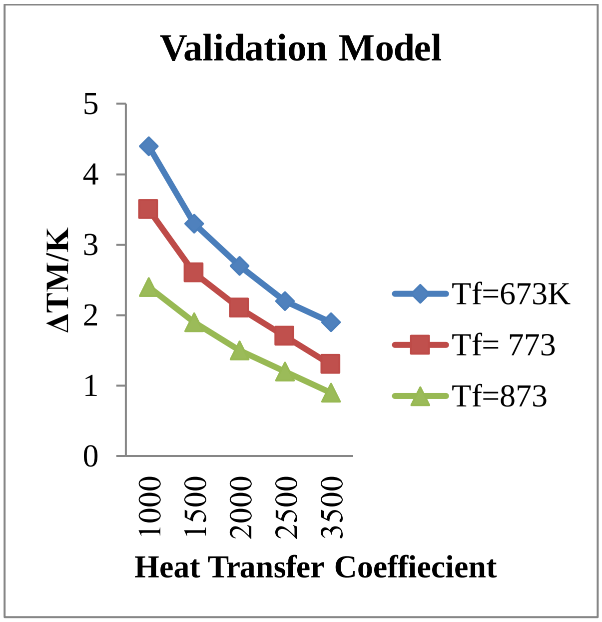

Figure 2 Temperature distribution and heat transfer coefficient in CFB boiler tube with fin (Validation model).

Table 2 Temperature distribution and thermal conductivities in CFB boiler tube with fin (Validation model).

Validation			
Thermal Conductivities	Tf=673 K	Tf= 773	Tf=873
24.33	3.6	2.9	1.9
23.38	2.5	2.1	1.2
22.34	1.9	1.3	0.9
21.48	1.4	0.9	0.6
20.4	1.1	0.6	0.4

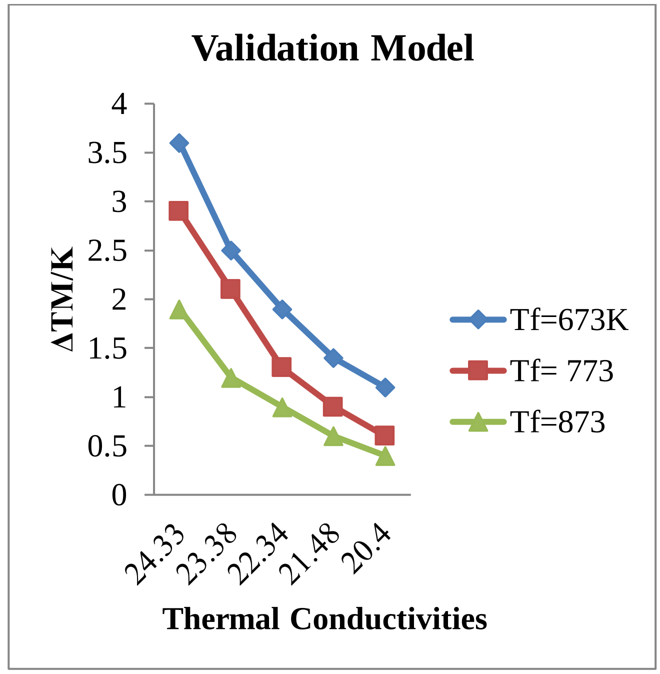

Figure 3 Temperature distribution and thermal conductivities in CFB boiler tube with fin (Validation model).

Optimization Results Analysis of Temperature Distribution with Heat Transfer Coefficient of CFB boiler tube with Square Inclined perforations:

Table 3 Temperature distribution and heat transfer coefficients in CFB boiler tube with square shaped inclined perforations.

Square Perforation			
Heat Flux	Tf=673K	Tf= 773	Tf=873
500	4.2	3.3	2.2
1580	3.1	2.4	1.7
3044	2.5	1.9	1.3
4568	1.9	1.5	1
5399	1.6	1.2	0.7

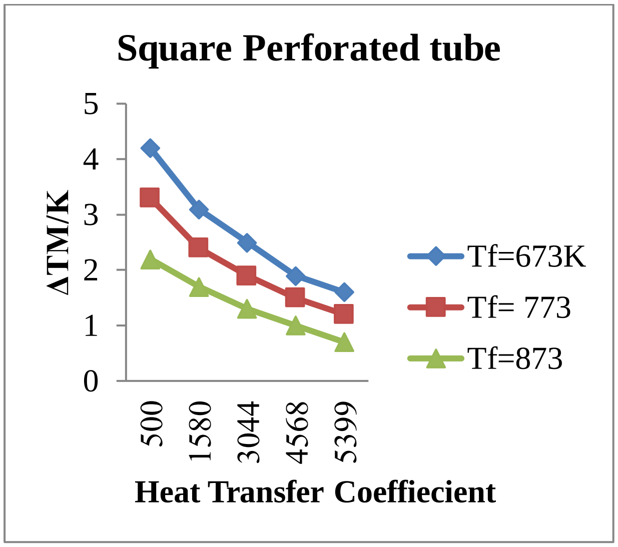

Figure 4 Temperature distribution and heat transfer coefficients in CFB boiler tube with square shaped inclined perforations.

Table 4 Temperature distribution and thermal conductivities in CFB boiler tube with square shaped inclined perforations.

Square Perforation			
Thermal Conductivities	Tf=673 K	Tf= 773	Tf=873
24.33	3.9	3.1	2.1
23.38	2.8	2.2	1.5
22.34	2.3	1.6	1.1
21.48	1.7	1.3	0.8
20.4	1.4	0.9	0.6

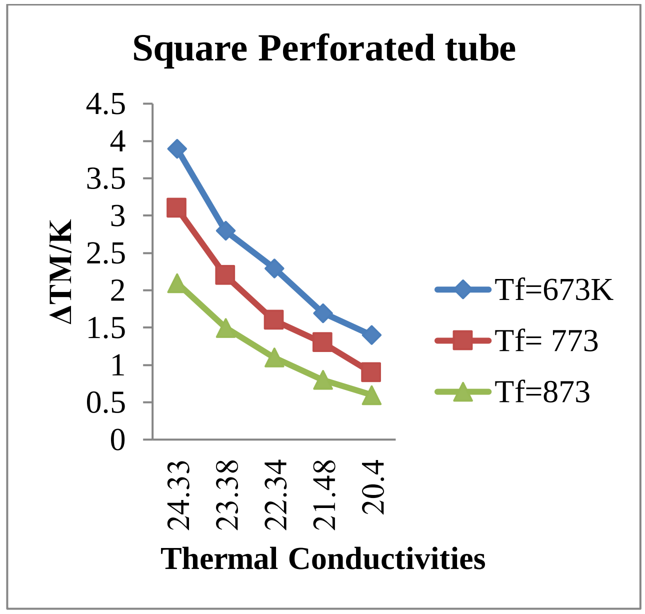

Figure 5 Temperature distribution and thermal conductivities in CFB boiler tube with square shaped inclined perforations.

Optimization Results Analysis of Temperature Distribution with Heat Transfer Coefficient of CFB boiler tube with Circular Inclined perforations:

Table 5 Temperature distribution and heat transfer coefficients in CFB boiler tube with circular shaped inclined perforations.

Circular Perforation			
Heat Flux	Tf=673K	Tf= 773	Tf=873
500	3.9	3.1	2.1
2578.9	2.8	2.2	1.5
5241.7	2.3	1.6	1.1
7825.3	1.7	1.3	0.8
9232.8	1.4	0.9	0.6

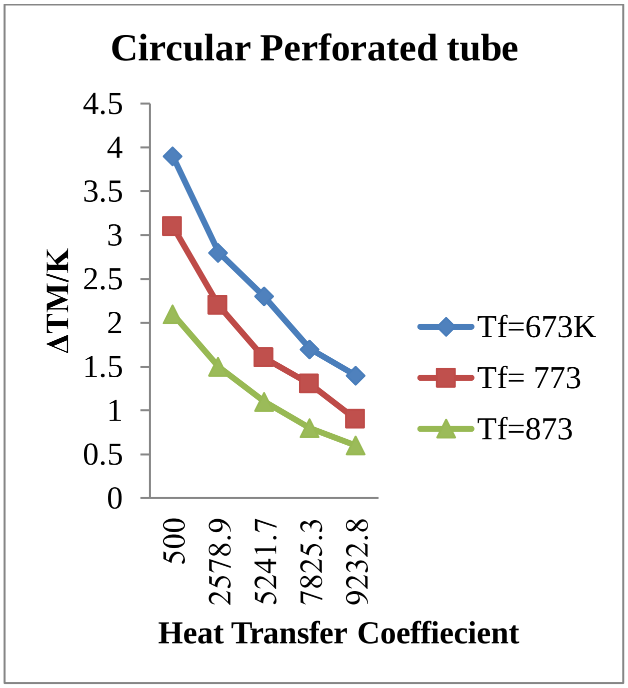

Figure 6 Temperature distribution and heat transfer coefficients in CFB boiler tube with circular shaped inclined perforations.

Table 6 Temperature distribution and thermal conductivities in CFB boiler tube with circular shaped inclined perforations.

Circular Perforation			
Thermal Conductivities	Tf=673 K	Tf= 773	Tf=873
24.33	4.2	3.3	2.2
23.38	3.1	2.4	1.7
22.34	2.5	1.9	1.3
21.48	1.9	1.5	1
20.4	1.6	1.2	0.7

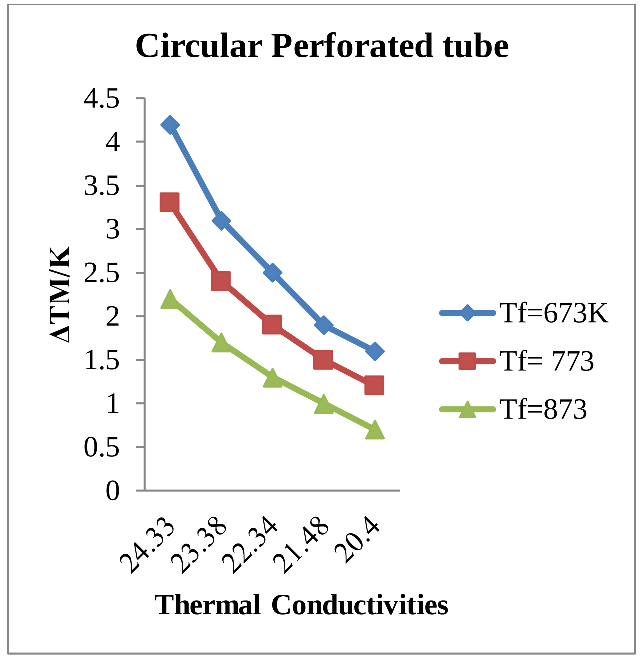

Figure 7 Temperature distribution and thermal conductivities in CFB boiler tube with circular shaped inclined perforations.

Optimization Results Analysis of Temperature Distribution with Heat Transfer Coefficient of CFB boiler tube with Elliptical Inclined perforations:

Table 7 Temperature distribution and heat transfer coefficients in CFB boiler tube with elliptical shaped inclined perforations.

Elliptical Perforation			
Heat Transfer Coefficient	Tf=673 K	Tf= 773	Tf=873
2000	3.6	2.9	1.9
4231	2.5	2.1	1.2
6879	1.9	1.3	0.9
8465	1.4	0.9	0.6
10129	1.1	0.6	0.4

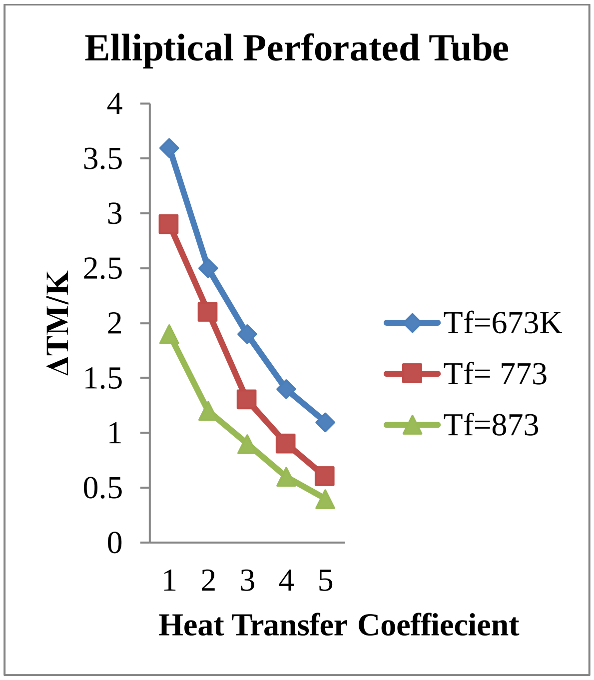

Figure 8 Temperature distribution and heat transfer coefficients in CFB boiler tube with elliptical shaped inclined perforations.

Table 8 Temperature distribution and thermal conductivities in CFB boiler tube with elliptical shaped inclined perforations.

Elliptical perforation			
Thermal Conductivities	Tf=673 K	Tf= 773	Tf=873
24.33	4.4	3.5	2.4
23.38	3.3	2.6	1.9
22.34	2.7	2.1	1.5
21.48	2.2	1.7	1.2
20.4	1.9	1.3	0.9

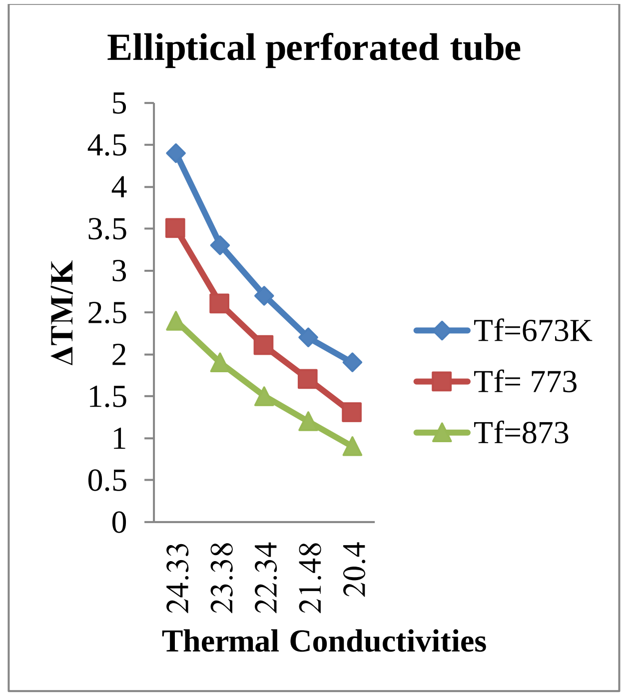

Figure 9 Temperature distribution and thermal conductivities in CFB boiler tube with elliptical shaped inclined perforations.

Conclusion

- The proposed three types of CFB boiler tube represented on results show that perforation increases surface area, and decreases the thermal barriers due to it can recognize that elliptical shaped inclined perforation is the best configuration.
- The difference in temperature constant heating power 873K, thermal resistance decreases and by these effects of heat

transfer coefficient increases, it is also observed as temperature increases the heat distribution is higher in elliptical perforated CFB boiler tube at each value of thermal conductivity.

- The simulations of CFD models of CFB boiler tube with different configurations show a good relation with base paper results presented in the literature.

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