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CFD Analysis of Concentric Cylinder with and without Internal Fins

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Abstract: ***The purpose of this paper is to investigate in three-dimensional steady state natural convection fully developed heat transfer in a horizontal annuli in which the inner cylinder consisting working fluid hotter than the cylinder material. This simulation related to the mode of natural convection turbulence flow heat transfer in annuli for primitive variables pressure, velocities and temperature. The objective of this research is to further investigate numerically and the effect of internal fins on the heat transfer between concentric horizontal cylinders. Also studied about turbulence Rayleigh number how effect on annuli's. Fins are employed to increase the heat transfer area, leading to an increase in the heat transfer between the cylinders so its use make consistent or not. Apart from there are many studies on convection mode due to subject of interest and engineering application on it.***

Keywords: Annuli's, Convection, Fin, Heat flux, Computational Fluid Dynamics.

1. Introduction

In heat transfer the driving potential is the temperature difference. Convective heat transfer is one of the major types of heat transfer, and convection is also a major mode of mass transfer in fluids. The natural convection heat transfer occurs when convective fluid motion is induced by density differences that are caused by heating. It should be noted that the density difference is caused by temperature fluctuation, while the body force is practically the same as buoyancy force. Although the heat transfer rate of natural convection is lower than that for forced convection, it plays a key role in the design and operation of thermal and fluid components including transmission lines and pipes, electronic equipment and heat exchangers as in forced convection transfer takes place with the help of external agency such as pump. In the study of heat transfer, fins are surfaces that extend from an object to increase the rate of heat transfer to or from the environment by increasing convection. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. Increasing the temperature gradient between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer sometimes it is not feasible or economical to change the first two options. Thus, adding a fin to an object, increases the surface area and can sometimes be an economical solution to heat transfer problems. Fins are most commonly used in heat exchanging devices such as radiators in cars, computer CPU heatsinks, and heat exchangers in power plants Most of the fins remove the heat from the source by means of conduction and the fluid surrounding the fin removes the heat by convection. Maintained at constant temperature so there is no conduction heat transfer take place. The purpose of the fins is to increase the heat transfer by convection and mainly control the fluid matter. The fin here is to limits to increase heat transfer by increasing the heat transfer coefficient (h). In current study the effect of fins internally was numerically simulated and due to presence of fins the result was compared to without fin annuli. Apart from it help to increase rate of heat transfer in longitudinal direction. The previous study shows the fluid flow in natural convection with laminar flow conditions with limited Rayleigh number. Most of the researchers make it to study of interest of this topic.

2. Computational Methodology

The schematic of three dimensional annuli with fins on the inner surface and the coordinate system is shown in Fig.1. The system consists of two concentric cylinders with inner and outer dai. are D_o and D_i, respectively. The fins, whose height is given in table. Where $L=R_o-R_i$, are attached on the surface of inner cylinder of fins. The inner cylinder wall is kept at a constant high temperature of T_h, whereas the outer cylinder wall at a constant low temperature of T_c.

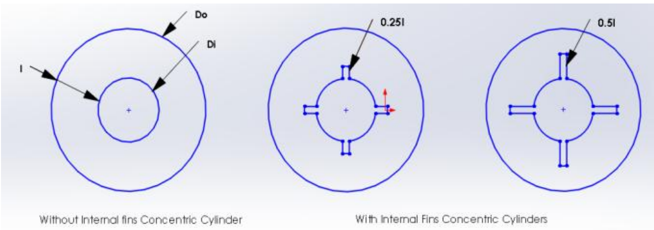


Figure 1: Schematic representation of Annuli's

2.1 Assumptions were made

The problem is to be solved with some assumptions that are made different than other researcher's,
1) The flow is 3-dimensional (i.e. T=φ(r,,x)).
2) The flow is steady (i.e. time=constant).
3) The flow is incompressible (i.e. ρ=ϕ(T)).
4) The flow is Turbulence (Rayleigh number is 10^6) .
5) The working fluid considered is 'Air'.

According to this assumptions the problem is to be solve by using ansys fluent with boundary conditions.

Table 1: Parameters of Annuli

Outer Diameter (Do)	9.25mm
Inner diameter (Di)	3.56mm
Length of Annuli	1m
Numbers of fin used	4

Length of fin (L)	1m
Thickness of fin (b)	0.4mm
Inerwall temperature (Th)	373k
Outerwall temperature (Tc)	323k
Gap width (l=DO-Di)	5.69mm
With fin having lengh L=25%l	1.42mm
With fin having length L=50%l	2.845mm

2.2 Governing Equations

The most important thing to solve the problem in numerical way is to the governing equations related to the problem. The geometry is to be studied in 3 dimensional way on which boundary conditions are imposed on it and its constrains also. As we know due to temperature difference the convections can happen and there are some dimensional quantity such as Prandtl number (Pr), Grashof number (Gr), Nusselt number (Nu) and Rayleigh number (Ra). This terms can be specified as,

$$P_r = v/\alpha$$

$$D_h = 4A/p \text{....(Hydraulic Diameter)}$$

$$Gr = \frac{g\beta\Delta T D h^3}{v^2}$$

$$Ra = \frac{g\beta\Delta T D h^3}{v\alpha}$$

$$Nu = \frac{hD_h}{K_f}$$

Continuity equations:

$\partial u/\partial r + \partial v/\partial x + \partial w/\partial \theta = 0$.

Momentum equations:

$U\,(\partial T/\partial r) + V\,(\partial T/\partial x) + W\,(\partial T/\partial Y) = (\kappa/\rho C_p) + [T_r + T_x + T_Y]$

Navier stokes equation:

$\rho[u(\partial u/\partial r) + v\,(\partial u/\partial x) + w(\partial u/\partial Y)] = -(\partial p/\partial r) + u\,(U_r + U_x + U_Y)$ …….. Navier Stokes in r directions.

$\rho[u(\partial v/\partial r) + v\,(\partial v/\partial x) + w(\partial u/\partial Y)] = -(\partial p/\partial x) + u\,(V_r + V_x + V_Y)$ ………Navier Stokes in x direction.

$\rho[u(\partial w/\partial r) + v\,(\partial w/\partial x) + w(\partial w/\partial Y)] = -(\partial p/\partial Y) + u\,(W_r + W_x + W_Y)$ ………Navier Stokes in Y direction.

2.3 Grid Study

As the accuracy of your result is totally depends on how you studied your grid sizing and it is most important step to measures the result.

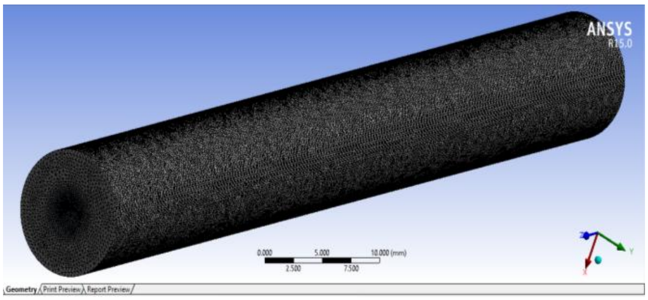


Figure 2: Grid study

Table No. 2: Grid Sizing

Coarse	Medium	Fine	Refine
1753	17045	90249	275852

3. Result and Discussion

The Numerical experiment were conducted for turbulence natural convection in horizontal annuli the result is obtained shown on different fig at the use of Rayleigh number 10^6.

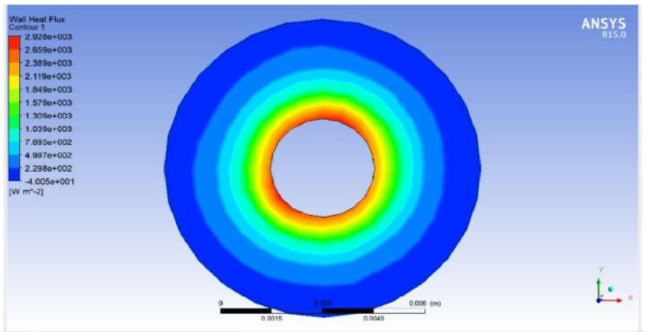


Figure 3: Without fin cylinder

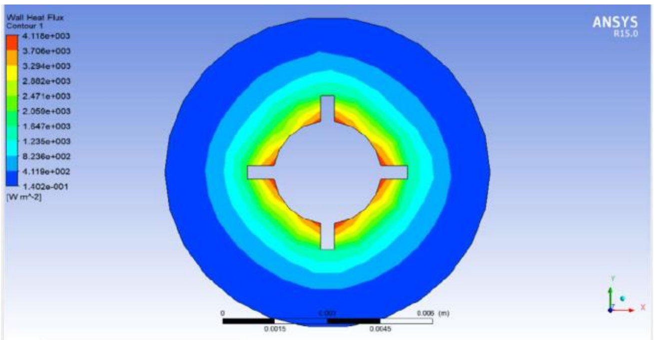


Figure 4: When fin length 25 percent to L

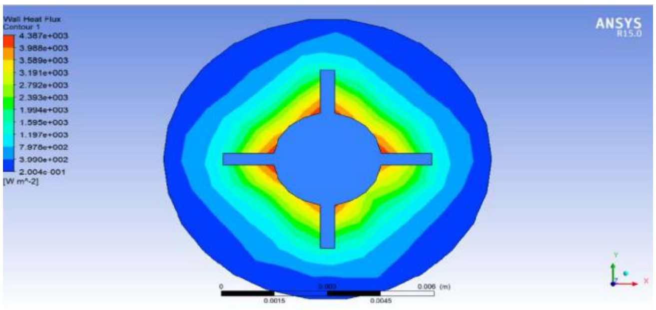
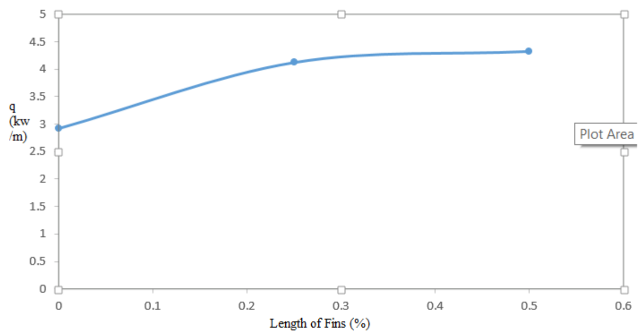


Figure 5: When fin length 50 percent to L



Graph No. 1: heat fluxes Vs length of fins

4. Conclusion

The results for the case with internal fins are compared with those without internal fins, to see the effects of the presence of fins. The simulations were conducted at Rayleigh numbers of 10^6. The results suggested that an increase in fins length led to greater convection heat transfer rate. It was also observed that the fins are used to increase rate of heat transfer that were proved and the quite use of internal fins in annuli makes good as for applications, as the rate of heat transfer increase that may be affected by the temperature differences and the thermal conductivity of the working fluid and the material of wall. Although the convection heat transfer coefficient decreases, larger amount of heat is transferred from the inner surface of annular cylinders due to higher contact area created by fins. In future to be solved this problem by increasing number of fins, and also improved in Rayleigh number.

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