Laminar forced convective heat transfer

Science, Physics

Statement of the research:

We consider steady laminar and fully developed fluid motion in the annulus of two circular pipes with longitudinal fins attached to the outer surface of the inner pipe. The fins are straight, non porous and uniformly distributed around the region with parabolic cross section and are assumed to be highly conductive.

At the inner pipe wall the flow is subjected to be thermal boundary condition of uniform heat input per unit axial length with circumferentially uniform temperature at any cross section. Under highly conductive thin wall assumption, this boundary condition to be imposed at the interface of fluid and thin wall. Through numerical simulation of laminar convection in the annulus region we investigate the effect of parabolic fin configuration in the annulus region.

Introduction

Heat exchanger are used in a wide range of engineering areas of energy production and conversion for example the generation of electric power. Geothermal sources, chemical processing, space heating. All of these application involve heat transfer phenomena. The design of heat exchanger like boiler condenser and radiators, their size and performance analysis is necessary for heat transfer. The performance of heat exchanger system may be improved by employing various techniques. We can use the treated surface, rough surface, coiled surface, helical surface, surface variation and fluid variation etc.

The use of double pipe heat exchanger is very important it is simplest to all heat exchanger. Double pipe is also known as concentric pipe. Typically double pipe heat exchanger are design to provided counter current flow and also used for low heat duties. The inner pipe can be plan or have longitudinal fins are attached to increase the surface available for heat transfer.

The use of fins is very important. These fins are attached by welding. When we cannot increase the heat transfer coefficient and the temperature difference between object and fluid. Calculation of fin efficiency in heat exchanger engineering is very important because of the evaluation of the fin surface performance.

Aim of the research:

The aim of optimization is to find the number and shape of the fins and the way of placement beside each other in a way that achieve the most rate of heat transfer. We want to see that if we change the shape of fins what will be the effect on the rate of heat transfer.

Literature review:

Cuce, E, & et al (2017). A longitudinal cylindrical fin profile in under interest for the optimization research. The effect of longitudinal parabolic perforation on the fin parameters such as temperature distribution, effectiveness and efficiency in which the fin surface is cooled by convection and radiation.

CHO, H, & et al (2014). The effect of fin geometry on the performance of a concentric heat exchanger. The concentric heat exchanger consist of inner and outer tube. The inner tube has a lot of serrated fins manufactured on its surface to increase the heat transfer performance. Both inner and outer tubes have the same length. The fin height should be determined by the criteria of the pressure drop.

Iqbal, Z, & et al (2011). Parabolic fins have been investigated for maximum convection flow is considered to be steady, laminar, incompressible and fully developed subjected to constant flux boundary condition. Finite element method is employed to compute field variable for providing function values. A comparison of optimal configuration of parabolic fins with those of trapezoidal and triangular fins indicate no single fin shape.

Mohapatra, K, & et al (2015). To determine the heat transfer and fluid flow characteristic of an internally finned tube for changing the flow conditions

Oclon, p, & et al (2015). The heat exchanger is used to cool down the hot flue gas. The CFD (computational fluid dynamic) simulation were conducted in order to determine the velocity and temperature variations for flue gas flow in the inlet tubular space of a cross flow heat exchanger. The total heat transfer rate, outlet gas temperature and the maximum temperature of tube wall for various gas inlet velocities were determined.

Syed, K. S, & et al (2011). A steady and laminar flow has been numerically simulated in a fully developed annulus region of a finned double pipe subjected to the fixed boundary condition at the inner pipe wall, friction factor, Nusselt number flow characteristic against variation in the ratio of radii of inner pipe and outer pipe, fin height, fin half angle number of fins all of these shows the significant enhancement in the heat transfer in both cases. When sufficient pumping power is available or not.

Shah. R. K & et. al (2003). Double pipe heat exchanger are economical closed cycle cooling system where a suitable water is available at a reasonable cost to meet the water requirements. The design analysis and comparative study on different flow types is carried out theoretically and experimentally. The performance analysis is done by CFD (computational fluid dynamic) and the total effectiveness is determined.

Taler, D, & et al (2014) plate fin and tube heat exchanger operate in a cross flow. In order to determine the velocity field and heat transfer characteristic the numerical method must be used. The CFD (computational fluid dynamic) codes allows to obtain the local values of the heat transfer co efficient. these values of heat transfer co efficient can be obtained by the heat transfer formula for the nusselt number, determined with CFD simulation, that can be directly implemented in the thermal designing procedure of the flow heat exchanger.

Method /Approuch:

There are many choice of numerical method for solving partial differential equations. Which method is more efficient than the other method depending on the particular problem. We study the two numerical method. The finite difference method and the Discontinuous Galerkin method.

We use Discontinuous Galerkin Finite Element Method (DGFEM) as compared to finite difference method because the DGFEM (Discontinuous finite element method) is flexible with complex geometries it also overcomes the key limitation on achieving the high order accuracy on general grids. Moreover the discontinuous nature between the elements make the method suitable for multiphysics. DG (Discontinuous Galerkin) method are readily parallelized.

The finite difference method is conceptually simple and easy to implement. But has difficulties in handling complex geometries of the computational domain. Our problem is solving the effect of parabolic fin thickness and fin height laminar convection in the annulus double pipe heat exchanger. To solve our problem we will seek the efficient numerical method that most accurate approximation at low computational cost.

References

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