3D-NUMERICAL STUDY OF THE EFFECT OF FIN DISCONTINUITY ON HEAT TRANSFER AUGMENTATION IN PIPES HAVING INTERNAL LONGITUDINAL FINS FOR TURBULENT COMPRESSIBLE FLOW

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Outlines

Pipes with internal longitudinal fins are ideal to be utilized in flow-based waste heat recovery applications. They provide significantly higher heat transfer coefficient than plain pipes, and lower pressure drop than helically finned pipes. This study investigates the effect of fin discontinuity on the convective heat transfer coefficient. A 3-D finite volume numerical solution of Reynolds- Averaged Navier-Stokes equations for steady, compressible and turbulent flow is presented. The effects of both continuous and discontinuous fins on heat transfer are elucidated. A new correlation to predict the temperature drop per unit length as a function of discontinuity offset distance is obtained.

Effect of fin discontinuity of heat transfer augmentation

The change in pipe geometry, which is represented in the fin discontinuity, when it is introduced at a larger repetition rate it increases the flow turbulence near the pipe walls. This turbulence enforces the thermally conductive boundary layer to be collided on the fins causing the convective heat transfer coefficient to increase substantially. On the other hand, a smaller repetition rate (i.e. larger offset distance) would allow the thermal conductive boundary layer to develop near the pipe walls. This thermally conductive fluid layer demonstrates insulating behavior, as heat is transferred through it by means of conduction, which is insignificant when it comes to fluids, air in this sense.

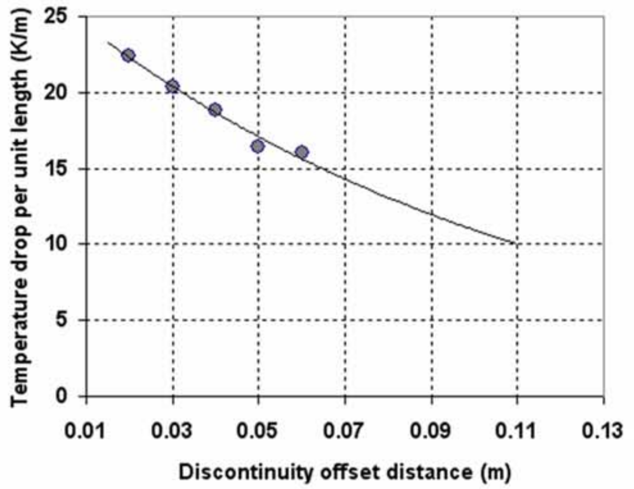

Fig 3. Temperature drop per unit length at different offset distances

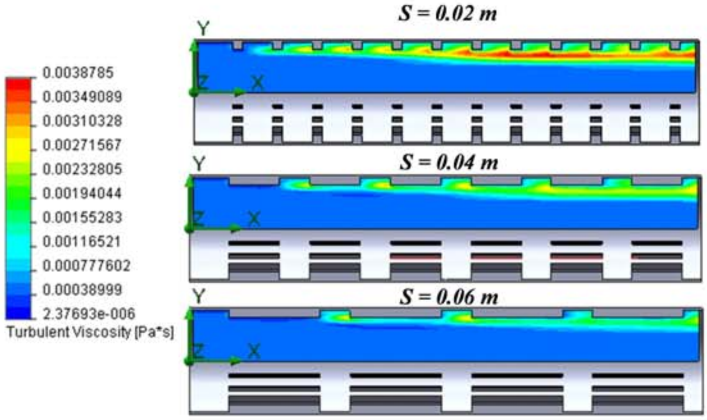

Fig 1. Turbulent viscosity at different discontinuity offset distances

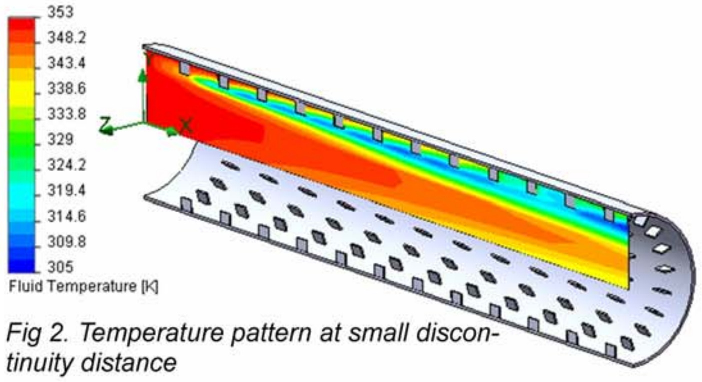

Fig 2. Temperature pattern at small discontinuity distance

It is obvious that the augmentation in heat transfer is fairly significant compared to the change in offset distance. A pipe with the same number of continuous fins demonstrates an air temperature drop per pipe unit length of 7.4 K/m, at the same boundary conditions. A new correlation was derived to predict the temperature drop per unit length as a function of the discontinuity offset distance, for pipes having discontinues longitudinal fins. The correlation is:

$$\frac{dT}{L} = 26.62\ e^{-8.8876\ S}$$

Where S is the discontinuity offset distance. This correlation is valid for a ratio of the discontinuity distance to discontinuity offset distance of 1.33 to 0.136, and for a (S) value of 0.01 o 0.13 m.

Conclusion

A numerical investigation of the effect of continuous and discontinuous internal longitudinal fins on heat transfer augmentation for steady state, axisymmetric turbulent compressible flow has been conducted. The numerical model and solution were validated against established empirical correlations. Repetitive discontinuity along the fin profile showed to have radical effect on the internal convective heat transfer coefficient. It was found that the smaller the discontinuity offset distance, the higher the convective heat transfer coefficient. The main contribution of this study is the derivation of a new correlation to express the heat transfer augmentation in terms of temperature drop per unit length as a function of the fin discontinuity offset distance. Future work should verify the accuracy of this correlation, as well as its geometric limitations.

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