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Title : Numerical Analysis of Temperature Distribution Enhancement in Conical and Annular Diffusers Fitted with Swirl Generators

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Diffusers are essential components for turbo machines aircraft inlets, combustion chambers, etc. They serve as a converter of the flow dynamic head to static pressure. This is achieved by small angle divergent walls. In combustion chamber, good mixing is essential for high burning rate. The attainment of a satisfying temperature distribution in the exhaust gases is very dependent on the degree of the combustion mixing. As long as temperature distribution enhancement has an important role to achieve good mixing, different enhancement methods have been developed by introducing a secondary flow and increasing of turbulence intensity. Swirl flow generator is one of the essential methods that are utilized to enhance the distribution rate. It can be produced by swirl generators such as helical screw-tapes, twist tapes, dimples, fins, struts etc. These generators create turbulent flow and swirling motion that can force the fluid to move in the direction of the flow and in the radial tangential direction. Helical screw-tape and twisted tape insert are an active area for the researchers to study their effects; hence they increase the turbulence intensity and have a dominant role in enhancing heat transfer and temperature distribution. In this research study, a numerical simulation analyses were undertaken in two different types of diffusers; one was a conical diffuser and one was an annular diffuser to enhance heat transfer rate by enhancing temperature distribution in a turbulent flow with air as the working fluid. This aim was achieved by using different geometric models of swirl generators such as helical screw-tape, helical screw-tape hub, pimpled hub and twisted square hub with different pitch lengths and different height lengths. The study was conducted with inlet Reynolds number 4.3 x 104 based on the hydraulic diameter and a heat source of 10 kW. The numerical analyses were carried out with the commercial software NUMECA FINETM /Open v3.1 as the Computational Fluid Dynamics tool. They were performed in three dimensional domains applying standard k-ε model as a turbulence model. Temperature distribution was evaluated in the proposed diffusers fitted to the swirl generator models to assess the real benefits of using those types of inserts in compared to the plain diffusers at constant inlet conditions. The results show that the proposed swirl generator models have a good influence on the temperature distribution in both diffusers. It shows that the temperature distribution rate is increased with decreasing pitch length under the same operating conditions. The best temperature distribution is provided by introducing a helical screw-tape hub and a helical screw-tape in the annular and the conical diffusers respectively. The numerical simulation findings were compared with those obtained from plain diffusers and they were confirmed by experiment. Finally, correlations based on the data generated from this work to predict the temperature distribution for turbulent flow through the proposed diffusers in terms of Eckert number, pitch length ratio and height length ratio were reported. From the correlations, the best temperature distribution is achieved by the insert of helical screw-tape hub and twisted square hub in the annular diffuser.