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Abstract

The experimental investigation of the influence of one and two pair protrusions and vortex generators in a diffuser is carried out. Convergent, parallel and divergent cases of protrusion pair are looked into. The protrusion pairs with two angles of attack $\alpha = 35^\circ$ and $\alpha = 60^\circ$ are employed. The angle of attack of vortex generators ($\alpha$) varies from $19^\circ$ to $43^\circ$. Two diffusers with half angle of $5.7^\circ$ and $7.0^\circ$ are considered. For making the diffuser surface rough, one and two pair protrusions are placed near the inlet section, on the bottom or top side, while the heat flux is applied on the top one. In the next case, the one and two pair vortex generators are glued near the inlet section, on the bottom or top or vertical side walls and their effect is looked into. The Reynolds number based on the diffuser length is in the range $2.3\times10^5 - 3.6\times10^5$. The effect of protrusions and vortex generators on the heat transfer coefficient, diffuser efficiency, pressure loss coefficient and pressure coefficient is investigated. The static pressure is measured along the diffuser length. The stagnation pressure and temperature are measured at the outlet cross-section. The numerical integration of these yields the average velocity (mass flow rate) and the outlet bulk temperature. A known heat flux is given as input and the temperature is measured on selected points at the heated wall. The results are presented as the ratio of Nusselt number (rough case to the smooth one). It is seen that the convergent case yields the highest heat transfer enhancement, followed by the divergent case and then the parallel one at both unheated and heated side, for the protrusions. The enhancement is presented at the same Reynolds number, as well as at constant dissipation (pumping power). For one pair protrusion, the maximum enhancement occurs when the convergent angle is $35^\circ$ (for both cases, top and opposite sides). The maximum enhancement is around $20\%$ at the same Reynolds number and $14\%$ at constant dissipation for the opposite side roughened by one pair protrusion. The corresponding values for the top side are $53\%$ and $47\%$ respectively. The enhancement decreases with the diffuser angle.

The two pair protrusions yield a higher enhancement. Similarly, the top side case enhancements are higher than the opposite side cases. The enhancement decreases with the diffuser angle, due to the effect of adverse pressure gradient. The enhancement decreases with Re and this is also seen from the correlations. For the opposite side case,
the maximum enhancement with one pair is 20% at constant Re and 15% at constant dissipation. With two pairs, the corresponding values are 45 and 39%.

Similar to protrusions, vortex generators too exhibit significant heat transfer enhancement even when the opposite (unheated) side is roughened. As with protrusions, the two pair yields a higher enhancement. The same is with top side cases.

When the opposite (unheated) side is roughened, the maximum enhancement at constant Re is 50% with one pair and 66% with two pairs. At constant dissipation, the corresponding values are 32% and 40%. For the case where the top (heated) side is roughened, the enhancement values at constant Re are 77% (one pair) and 98% (two pairs). The corresponding values at constant dissipation are 58% and 70%.

The heat transfer enhancement is lower at the higher diffuser angle, due to the higher adverse pressure gradient.