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Cairo University
Faculty Of Engineering

EXPERIMENTAL INVESTIGATION OF TURBULENT HEATED FLOW IN AN ANNULAR SECTOR DUCT

Presented By

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In partial fulfillment of
master of science degree
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ABSTRACT

The continuing interest in compact heat exchangers has created the need for studying the effect of heat transfer parameters for different passage shapes . It has been recognized that generally circular tubes results are not applicable to non-circular passages even when the hydraulic diameter (D_h) is used as the characteristic dimension , therefore , design data should be generated for each passage shape individually . The new flow passage shape under investigation in the present work is the annular sector duct which is a non circular passage .

The major difference between the annular sector duct and non circular ducts of other geometry is that , the annular sector duct has both concave and convex boundaries . The combination of these combined boundaries would significantly affect the secondary flow pattern in the centrifugal force field .

In the current research , an annular sector duct of diameter ratio of 0.5 and a sector angle of 60 degrees is studied experimentally . The experimental test rig was of total length of 113 D_h , designed to have a starting unheated length of 65 D_h in order to ensure hydrodynamically fully developed flow in the downstream passage. It is followed by 48 D_h heated length to ensure thermally fully developed flow at the exit of the test section .

Twelve experimental runs were performed for measuring wall temperature , air mixing cup temperature and air velocity at several locations along the test section . Fluid velocity was measured at three axial locations , namely , at lengths equal to 48 D_h , 65 D_h (before the entrance to the test section) and 113 D_h (at the exit of the test section) .

Temperatures were measured at lengths equal to 66 D_h , 70 D_h , 76 D_h , 81 D_h , 86 D_h, 92 D_h , 97 D_h , 103 D_h and 113 D_h from the beginning of the annular sector duct .

Experimental runs correspond to Reynolds number , 22875 , 35329 , 37834 , 44404 , 49065 , 54631 , 59424 , 62965 , 66086 , 66965 , 68015 and 73766 . Results were carried out to obtain relation between local or average Nusselt numbers and Reynolds number.

The average Nusselt number is correlated with Reynolds number according to the relation ;

$$\overline{N}_{Nu} = 0.055 * (N_{Re})^{0.71}$$

Comparison between heat transfer characteristics in annular sector duct and that in other shaped ducts (such as circular , triangular , rectangular , square and trapezoidal ducts) indicated an improvement in heat transfer characteristics , even the heat transfer has been improved in annular sector ducts by an average value of 50% approximately more than the annular duct passage shape .

The resulting increase in heat transfer from the annular duct could be explained as a result of two main phenomena , The first is due to the corner regions , those are resulted in the new shape , which produce secondary flows , converting part of the main flow velocity to eddies which improve the heat transfer between the duct wall and the fluid , and the second is due to that the partitions act as fins to which the heat is conducted , and then convected to the fluid . The later mechanism improves the heat transfer between the heated wall and the flowing fluid , especially at low fluid velocities .

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