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سامية محمد مصطفى

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FACULTY OF ENGINEERING

TURBULENT BOUNDARY LAYER AND HEAT TRANSFER CHARACTERISTICS OVER A ROUGH FLAT PLATE IN PRESSURE GRADIENTS.

By

Eng. Ahmed Reda Mohamed EL-Shamy
B.Sc. Mech. Power Engineering
M.Sc. Mech. Power Engineering

A Thesis

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Supervisors

Prof.Dr. M.S. Abdel-Salam	Prof.Dr. M.F. Abd-Rabbo
Mech. Power Engg. Dept.	Mech. Engg. Dept.
Faculty of Engineering	Faculty of Engineering, Shoubra
Cairo University	Zagazig University

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ABSTRACT

TURBULENT BOUNDARY LAYER AND HEAT TRANSFER CHARACTERISTICS OVER A ROUGH FLAT PLATE IN PRESSURE GRADIENTS

ABSTRACT

In the present work, the turbulent convective heat transfer characteristics over a rough flat plate in both zero and adverse pressure gradient flows were investigated. Experimental and theoretical investigations were performed. A test set-up was designed and constructed for this investigation. A flat plate of 320 mm length and 120 mm width, made of brass was taken as the heating surface. The heating surface was placed at a distance of 1130 mm from the beginning of the test section. The heating plate was heated by means of electric heaters. The heating condition was adjusted to supply uniform heat flux to the plate. The roughness elements were taken as rectangular brass ridges. The ridges height must be sufficiently small compared with the local boundary layer thickness for the ridges to lie in the logarithmic part of the undisturbed velocity profile. The ridges were equally spaced along the heating surface to obtain uniformly distributed roughness arrays. The equivalent sandgrain roughness was calculated. For the equilibrium adverse pressure gradient flow, the freestream velocity was varied as $U \propto x^{-0.215}$.

For the turbulent boundary layer over the smooth test surface in both pressure gradients, the two-dimensionality of the flow was verified by seeking to satisfy equality between the two sides of the integrated two-dimensional Von Karman momentum equation. The drag coefficient for the turbulent boundary layer flow over a single ridge as well as ridge arrays for both pressure gradients was determined by the momentum defect method. The present results for the drag coefficient showed good agreement when compared with the available previous results.

A new correlation for the average heat transfer coefficient was obtained for the smooth heating surface. Correlations given by previous investigators for the smooth plate were compared with the present results. The comparison showed that the present results are considered to be a substantial verification of the apparatus design, instrumentations and the method of calculation.

A series of experiments for the heating rough surface subjected to both pressure gradients was carried out at different roughness densities. The equivalent sandgrain roughness was calculated and it was varied in the range of 0.77 to 12.1 mm. Generally, both the local heat transfer coefficient and the local Stanton number increases with the equivalent sandgrain roughness for both pressure gradients. The values of the local heat transfer coefficient and the local Stanton number for adverse pressure gradient flow are