UNIVERSITY OF CALIFORNIA,
IRVINE

The Effect of Turbulence on the Average Heat Transfer from a Cylinder in Crossflow

THESIS

submitted in partial satisfaction of the requirements for the degree of

MASTER OF SCIENCE

in Engineering

by Sean Peter Burns

Thesis Committee:
Professor John LaRue, Chair
Professor Carl Friehe
Professor Dimitri Papamoschou

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The thesis of Sean Peter Burns is approved:

Committee Chair

University of California, Irvine
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DEDICATION

To
my parents

(for everything)

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ABSTRACT OF THE THESIS

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by

Sean Peter Burns

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Professor John LaRue, Chair

The effect of variation of the free-stream turbulent intensity and integral scale on the heat transfer rate from a cylinder in crossflow is considered. The investigation includes a review of previous work and provides new experimental measurements of the average heat transfer rates.

The Reynolds number range of the present study is from $1.7 \cdot 10^3$ to $8.0 \cdot 10^4$ which corresponds to the subcritical flow regime. The turbulent intensity, Tu, is varied from 0.25% to 7%, and the ratio of the integral length scale to cylinder diameter is varied from 0.19 to 4.5.

The present experimental results with a background turbulent intensity of 0.25% are, in general, between the resulting established correlations of Žukauskas and Žiugžda (1985) and Hilpert (1933). For the Reynolds number range from $1.0 \cdot 10^3$ to $1.0 \cdot 10^4$ there is slightly better agreement with Hilpert (1933) but for the Reynolds number range from $1 \cdot 10^4$ to $8.0 \cdot 10^4$ there is slightly closer agreement with Zukauskas and Žiugžda (1985). The relationship between the average Nusselt number and the Reynolds number, for the present data set, is found to be:

$$\overline{Nu} = 0.164 \cdot Re^{0.632}$$

The presence of turbulence shows that increasing the turbulent intensity increases the average heat transfer rate from the cylinder which is qualitatively similar to but quantitatively different from previous results. For a Reynolds number of $1 \cdot 10^3$, as the free-stream intensity is increased from 1% to 5%, there is a corresponding 5% increase in the average Nusselt number. Previous experiments by Žukauskas and Žiugžda (1985) and Boulos (1972) have found, for similar conditions, an increase in the average Nusselt number of 20% and 15%, respectively. The reason for these differences is not apparent from the present data set.

For the present experiment, the dependence of the average Nusselt number on the ratio of the integral length scale to cylinder diameter is found to be less than the nominal experimental uncertainty of ±4%.