that the present study yields similar results to those of the previous studies about the wake effect, despite the large difference in the geometric conditions.

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DISCUSSION

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Even the simplest physical consideration concerning the effect of passing wakes in the free stream on heat transfer indicates that the correlations given in Eqs. (15) and (16) cannot be generally valid. In particular, neither correlation contains any quantity related to the individual wakes. To illustrate the wake's role, if Nu_0 is the Nusselt number for a position on the surface without passing wakes and Nu_w is a representative Nusselt number in the wake, then the time-averaged Nusselt number for a flow with periodically passing wakes is $\overline{Nu} = Nu_0 + (Nu_w - Nu_0)(\tau_w/\tau)$, where τ_w is a representative passing time for the wake over any point on the surface and τ is the period between wakes. For no wake, $\tau_w = 0$, or no augmentation caused by the wake, $Nu_w = Nu_0$, the time-averaged Nusselt number is, as expected, Nu_0. For a completely wake saturated flow, $\tau_w = \tau$, and $\overline{Nu} = Nu_w$ as expected.

Introducing your definition of the Strouhal number, $S = fD/U_{in}$, the above expression becomes $\overline{Nu} = Nu_0 + (Nu_w - Nu_0) \times (U_{in}\tau_w/D)S$, which clearly indicates that the coefficient of the Strouhal number (which you consider constant in Eqs. (15) and (16)) really depends on wake-related quantities. Such quantities are wake turbulence level and length scales, which affect Nu_w, and the wake width, which affect τ_w. Since different experiments have different wake characteristics, wake passing times, and periods, all which affect the coefficient of S in this simplest of models, the poor comparisons shown in Figs. 20 and 21 should not be surprising. For details regarding a more realistic model for the effect of passing wakes on laminar heat transfer, you are referred to Dullenkopf and Mayle (1994).

Author's Closure

The author would like to acknowledge the comment from Mayle and Dullenkopf. As described in their comment or in their paper (Dullenkopf and Mayle, 1992), it is necessary to take account of several factors of the wake characteristics in order to gain a thorough understanding of how the wake passage affects the heat transfer around stagnation regions. In particular, much attention must be paid to wake structure and its turbulence length. The author also agrees with the viewpoint of Dullenkopf and Mayle, which implies that wakes at higher turbulence levels would produce heat transfer enhancement, almost independent of the wake generation. The author believes this could be applied to the present case.

Although Dullenkopf and Mayle (1992) proposed a simple but useful method for predicting wake-affected heat transfer around the stagnation region, the author has not been fully contented with their method because there was no information given to evaluate the Nusselt number Nu_w or the wake duration τ_w. This situation directed the author to start the present study. Since effects of free turbulence are not included in his experiment, this paper does not provide a general correlation on the wake-affected heat transfer for the readers. Therefore, the author has proceeded with his research to investigate effects of free-stream turbulence upon the wake-affected heat transfer, which also discusses how Nu_w or τ_w should be specified (Funazaki, 1994; Funazaki et al., 1995). Despite this study, much remains to be done for further understanding of this complicated phenomenon.

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