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Reply to Prof. Persen's comment on the minimum stable slug length

(*Received* 18 *October* 1984)

Dear Sirs,

The figure, which is presented in Prof. Persen's note, relates to the entry region in pipes, where the physical picture is of a fluid flow over stationary boundaries. Indeed, this well-known problem has been treated widely in the literature. However, the recurrent redevelopment of the boundary layer in the slug core, as viewed in moving coordinates (for details see the full paper by the authors), is not fully analogous to boundary layer development at the entry region in pipes. As is indicated in Fig. 1(b) of the full paper, the boundary layer in the slug back redevelops on a surface moving with the slug translation velocity, V_t, while in entry problems, the wall is stationary.

The entrance length over stationary surface is larger than that over a moving surface. This is demonstrated in the following figure with respect to turbulent boundary-layer development over flat plate (utilizing the 7th power law velocity profile) as shown in Fig. 1.

Thus, the entrance length ratio over a flat plate is ~ 2.66 ($= 1.01/0.379$). In the more complicated situations of boundary layers development in pipe flows, this ratio is obviously different. As it has been obtained by the authors, the recovery distance in the slug core is smaller (by a ratio of ~ 3 for horizontal geometry) than the entrance length in pipes at identical Reynolds number, and is in agreement with experimental observations of average stable slug lengths.

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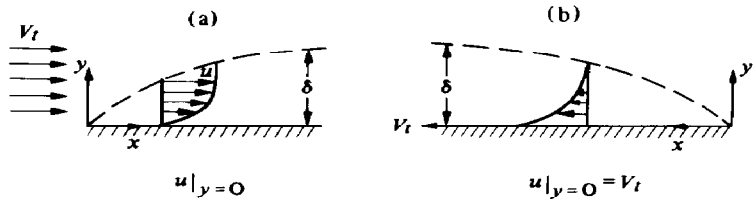

Fig. 1. (a) Stationary surface: $\delta/x = 0.379 Re_x^{-0.2}$. (b) Moving surface: $\delta/x = 1.01 Re_x^{-0.2}$ [1].