

On the Calculation of Steady Laminar Boundary Layer Flows with Continuous Suction

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In Memoriam HERBERT BILHARZ (1910–1956)

1. Introduction. We consider the plane and steady laminar boundary layer flow of an incompressible viscous fluid around a cylinder in the general case of arbitrary outer velocity distribution $U(x)$ and arbitrary suction velocity distribution $v_0(x)$ along the wall. (x denotes the distance along the wall from the forward stagnation point or, in case of a flat plate or cuspidal leading edge, from the leading edge; for $v_0(x) < 0$ we have suction, but $v_0(x) > 0$, blowing out, will also be permitted.)

It is the aim of this paper to give a formally exact solution of the boundary layer equations for this very general problem in the form of an infinite series and, furthermore, to show how a method for the numerical evaluation of such flows can be derived from this series. The main practical result will be that the application of this method to any special problem will prove to be extremely simple. The amount of work involved in calculating the boundary layer flow for any given $U(x)$ and $v_0(x)$ will, in fact, be comparable with that of the non-rigorous and unreliable parameter methods of the momentum integral type. The reason for this simplicity of application is the fact that the method allows the main part of the work to be carried out once and for all by preparing tables of certain universal functions. As soon as these are available the application of the method to any special problem will consist only in the introduction of the given data of the special case into given formulæ and the application of the tables. It is necessary to assume that certain rather general series expansions for $U(x)$ and $v_0(x)$ are possible, and the coefficients of these series are, together with the kinematic viscosity ν of the fluid, the quantities considered to be given in any special case of application.

Till now, exact solutions of the problem of boundary layer flow with suction have been found only for a few special cases, special with respect to the given outer velocity $U(x)$ and suction velocity $v_0(x)$; *cf. e.g.* [1] or [2]. Thus, for outer velocities of the form $U(x) = \text{const.} \cdot x^m$ and suction velocities prescribed accord-