

Preface

The boundary-layer flow past bodies of finite lengths has a long history as old as the concept of boundary-layer itself. Such kind of flows had completely been explored till the completion of first fifty years of the boundary-layer theory. In contrast, the boundary-layer flow due to moving continuous surfaces was first introduced in 1961, almost six decades later to the idea of boundary-layer. Besides the interesting nature of this flow, it has so far not been explored in complete. Even the two-dimensional self-similar case of this flow cannot be claimed to be fully explored and understood, despite the presence of hundreds of published research papers on this flow. The biggest misfortune with this flow is that it had never been studied completely; rather, the developments on this flow had been contributed in bits. The situation is far worse in the cases of axisymmetric and three-dimensional flows of this class. Only the self-similar laminar flows of this type have so far been investigated in literature, and no attention has been given to the non-similar and turbulent flows at all.

A critical review of the published literature on this topic reveals the presence of huge number of those published research papers which do involve incorrect and misleading analyses. Unfortunately, after getting published, such researches become an authentic reference regarding the further propagation and justification of such misleading erroneous analyses. In this way, the research on this topic has, by a lot, went rotten because of the publication of huge number of erroneous research papers. Unfortunately, the published wrong results are immediately adopted by the others instead of correcting them. In such a messy situation, it is really quite hard to correct all such erroneous literature by making all the audience aware of such mistakes.

A thorough review of the available literature on this topic concludes that the majority of the errors have arose due to the incorrect self-similar formulation of the governing systems; examples can be given of the problems concerning shrinking surfaces or those involving local parameters in the governing equations. Therefore, it seems that if the concept of self-similarity could be explained in detail and the construction of self-similar variables of these flows could be made available, then the errors are expected to be minimized to an appreciable extent. Such an

elaboration can further be expected to be helpful to the researchers in the exploration of further self-similar flows of this class.

After having a realization of the above facts, the author had continuously been worried, since last few years, regarding the correction of aforementioned incorrect analyses. Writing a correction or comment to every such paper was, however, quite inconvenient in this regard. Finally, it was decided to identify the root causes of such incorrect analyses and the way out toward their correction and to report this all in the form of a book at once. In this regard, the incomplete understanding of the self-similarity was identified to be the major root cause behind all such incorrect analyses, at the most, as pointed out in the above paragraph. In view of these facts, the primary objective of this book is threefold: first, to elaborate the general criterion of self-similarity by reporting the general self-similarity criterion for the planar and the axisymmetric cases; second, the presentation of correct shrinking surface flow analysis which could negate most of the “mysterious” facts associated with this flow; and third, to introduce the non-similar flows of this class in the said two cases, namely the planar and the axisymmetric ones. In this regard, the self-similarity criterion for this class of flows has completely been determined and the associated self-similar governing systems have been developed. Correct self-similar formulation of the shrinking sheet flow has been reported, and the self-similar shrinking sheet flow has been discussed in detail. A comparison between the current and the already existing formulations has been made in order to clarify the situation. The non-similar flows of this class have been formulated in general; some particularly chosen non-similar flows in the planar and axisymmetric cases have also been discussed. The identification of temporal self-similarity and the criterion of semi-similarity have been included. Finally, the turbulent flow due to stretching surfaces has also been considered.

Fundamental knowledge of fluid mechanics and the boundary-layer theory is essential for the understanding of the presented material. This book particularly focuses the students and the initial researchers in this field. Therefore, the presentation of the material is quite straightforward with a bit detail and sufficient explanation. However, the presented material is also expected to be of equal importance for the specialized and established researchers in this field.

This book has mainly been distributed into four major parts. The first part includes some fundamental essential knowledge and the explanation of the concept of self-similarity. Part II contains the self-similar flows due to moving continuous surfaces including the planar and axisymmetric flows. Spatial and temporal non-similarity has been modeled in Part III, whereas the turbulent flows due to moving continuous surfaces have been considered in Part IV.

First four chapters constitute the Part I of this book. Boundary-layer character of the flows due to moving continuous surfaces has been explained in Chap. 1. The governing boundary-layer equations and the momentum integral equations corresponding to the planar and axisymmetric flows have been developed in Chap. 2. The concept and restrictions of self-similarity have been explained in detail in Chap. 3, whereas an introduction to the suitable solution techniques has been given in Chap. 4. The criterion of self-similarity for the wall velocities has been

determined in detail for both the planar and axisymmetric flows in Chap. 5. Flows due to stretching and shrinking surfaces have been discussed in Chaps. 6 and 7, respectively. The restriction on the wall suction/injection velocities and on the variable thickness of the continuous surfaces, in view of self-similarity criterion determined in Chap. 5, has also been determined in these chapters. Similarity criterion of the unsteady flows due to moving continuous surfaces has been derived in Chap. 8. The aforementioned Chaps. 5–8 have been included in Part II. Non-similar flows due to moving continuous surfaces have been introduced in Part III consisting of Chaps. 9–11. The planar and axisymmetric non-similar flows have been considered in Chaps. 9 and 10, respectively, whereas the temporal non-similarity has been considered in Chap. 11. The Part IV includes only one chapter (Chap. 12) concerning the turbulent flow due to moving and stretching continuous surfaces.

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Viscous Flows

Stretching and Shrinking of Surfaces

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2017, XXVII, 193 p. 73 illus., 2 illus. in color., Hardcover

ISBN: 978-3-319-55431-0