

PREDICTION OF TURBINE BLADE HEAT TRANSFER*

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INTRODUCTION

Although numerical computation of heat transfer has been attempted for at least the last twenty years, the current capability still requires considerable improvement and refinement. The reason that it is so difficult to predict the heat transfer on turbine blades lies in the simultaneous presence of many complicating factors such as transition to turbulence, relaminarization, free-stream turbulence, rotation, curvature, unsteadiness, generation of vortices, secondary flows, and three-dimensionality. Some of these aspects are discussed in references 1-4.

The purpose of the present project is to evaluate the current state of the art and to propose appropriate turbulence models for the prediction of the turbine blade heat transfer.

AVAILABLE EXPERIMENTAL DATA

The development of a satisfactory turbulence model is dependent on the availability of reliable and relevant experimental data. From a careful search of the literature, the experimental data given in references 5-9 are judged to be satisfactory for this purpose. The development of turbulence models will be done primarily by reference to these sets of data. Also, useful related information is available in references 10-11.

RELEVANT TURBULENCE MODELS

The main difficulty in the correct prediction of heat transfer on a turbine blade lies in the determination of transition to turbulence. Purely empirical criteria for transition cannot properly account for the influence of free-stream turbulence, curvature, and other factors. Only the low-Reynolds number versions of the differential turbulence models have, at least in principle, the ability to "predict" the transition. In these models, the turbulence parameters are computed even in the laminar-flow region. They have very small values as long as the flow remains laminar. When the conditions are right for transition, the imbalance between the generation and dissipation of the turbulence parameters leads to a rapid growth of the predicted turbulent viscosity, and the turbulent-flow region begins. Some of the relevant low-Reynolds-number turbulence models are described in references 12-15.

Since curvature is an important aspect of the flow over a turbine blade, the turbulence model should respond to the presence of the streamline curvature. References 16-22 present turbulence models with special emphasis on curvature.

PROPOSED WORK

It is planned to incorporate a number of low-Reynolds-number turbulence models in a general two-dimensional boundary layer calculation procedure. This will be applied to different flow conditions over turbine blades and the predictions will

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compared with experimental data. The prediction activity will lead to a recommendation about a satisfactory turbulence model for turbine blade heat transfer.

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