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APPROPRIATE TRANSITION MODELLING FOR THE DESIGN OF LOW PRESSURE TURBINES

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ABSTRACT

A modern transition model is presented in this contribution, which is adapted to turbomachinery with the focus to low pressure turbine design. The new model can be classified as an integral method based on experimental and analytical correlations, and incorporates all relevant modes of transition.

With the objective as an industrial design tool for turbomachinery components the transition model is validated for a range of relevant test cases, from generic configuration up to full LP turbine components. A representative selection of examples is presented in this contribution.

The development of the presented method followed partially from the European Reseach Project *TATMo* (**T**urbulence **a**nd **T**ransiti**o**n **Mo**delling), funded by the European Commision in the Sixth Framework Programme. Focus of the *TATMo* project is the improvement of calculation capabilities by a better modelling of the flow with respect to very low Reynolds numbers.

One of the main aspects for the development of transition criterion was the extension of the LP turbines operation range towards very low Reynolds numbers coming up in very high altitude flight conditions. “State of the Art” correlation based transition criteria achieve acceptable results for the loss prediction of LP profiles, when applied to high or moderate Reynolds number flows. Decreasing Reynolds numbers leads to a development and growth of a separation bubble. In extreme conditions the separation bubble extends over the the profile’s trailing edge with the consequence of no reattachment of the flowfield. Based on a database of “low reynolds number” turbine cascade experiments carried out in TATMo project, new transition correlations are developed to capture strong separation effects. As example Figure 1 shows the isentropic machnumber distribution for a LP turbine profile with a Reynolds Number of Re_{2th} = 80k. Solutions of the Standard transition model and the extended formulation are compared to the measurements.

The second development aspect was the incorporation of unsteady wake effects in a steady state simulation. This extension is of a large practical relevance, since it overcomes the necessity to perform very extensive unsteady computations while retaining the unsteady wake induces transition in steady state calculations. This

approach modifies the intermittency function of the transition model, depending on the local blade row interaction parameter (Strouhal and Reynolds Number).

The qualification of the presented method to the industrial design of turbo components is demonstrated for a range of testcases. Parameter studies for turbine cascades show the wide application range, but will also point out the limitation of the actual transition modelling. Results of full LPT component simulations (Configuration shown in Figure 2) reveal the maturity of the presented method for the jet engine turbines. Detailed comparisons of simulation and experiment for a highly equipped turbine rig demonstrate the actual state of modern cfd methods.

FIGURES

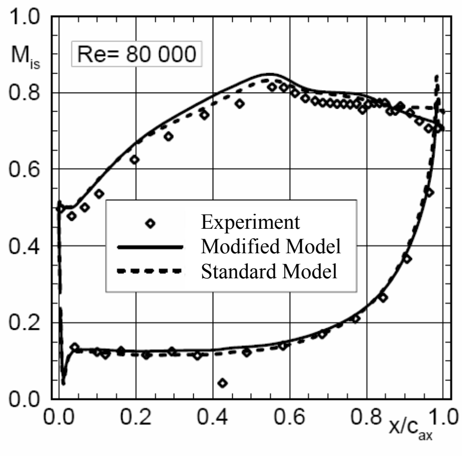

Figure 1: Mach number distribution for a LP turbine profile

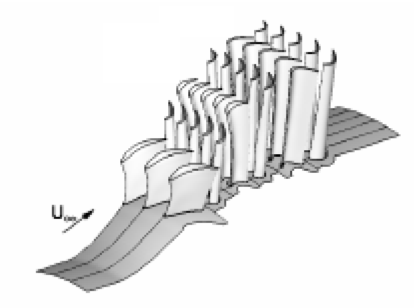

Figure 2: sketch of a real Jet Engine LP turbine

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