EXPERIMENTAL STUDY AND MODELING OF THE UNSTEADY TRANSITIONAL FLOW IN AXIAL TURBOMACHINES

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Considering the present evolution of the modern aircraft engines, it becomes more and more difficult to increase their efficiency. Therefore, in order to lower their operation costs, the manufacturers try to reduce the engine weight as well as the production and maintenance costs. This goal can be achieved by reducing the number of blades per row, keeping constant the total amount of work done by the blade rows. The increase of the blade individual load leads to a new concept: the high lift design. By itself, the low pressure turbine contributes for almost one forth of the total engine weight. In this engine part, the boundary layer develops as laminar along a large part of the blade profile and does not always withstand the strong adverse pressure gradient on the rear suction side. If a heavy separation occurs, the level of the losses increases drastically. To avoid this unacceptable situation, the transition of the boundary layer from laminar to turbulent must be controlled.

The purpose of this thesis is to experimentally study the influence of artificial roughness or/and passing wakes on the boundary layer transition phenomenon for flow conditions similar to those encountered in real engines. All the collected data will allow the development of unsteady transition models. They will also be used to validate numerical predictions codes that are essential for the entire engine design.

In order to achieve these objectives, one of the elbows of the continuously running, high speed facility S1 was replaced by a cascade test section composed up to now of six T106C passages with an increased pitch-to-chord ratio of 0.95. Many measurements have been done to assess the upstream flow uniformity and the downstream flow periodicity. Then, several experiments have been lead for the smooth and the rough blades at various downstream Mach (3) and Reynolds (8) numbers, ranging respectively from 0.6 to 0.7 and from 80000 to 250000. A downstream pneumatic probe measured the blade performance (losses and angle). The evolution of the mean outlet flow angle as a function of the Reynolds number is shown on Figure 1. The static pressure measured at the blade surface provides the Mach number distribution as represented on Figure 2 for the smooth blade and a few Reynolds numbers. TRAF is the fully turbulent numerical simulation of the flow development. Surface mounted hot films give the evolution of the wall shear stress along the blade. Some post processing should lead to the determination of the intermittency factor. All these results were used to design a new blade profile even more loaded. Experiments with this profile will start when the T106C unsteady case will have been investigated.

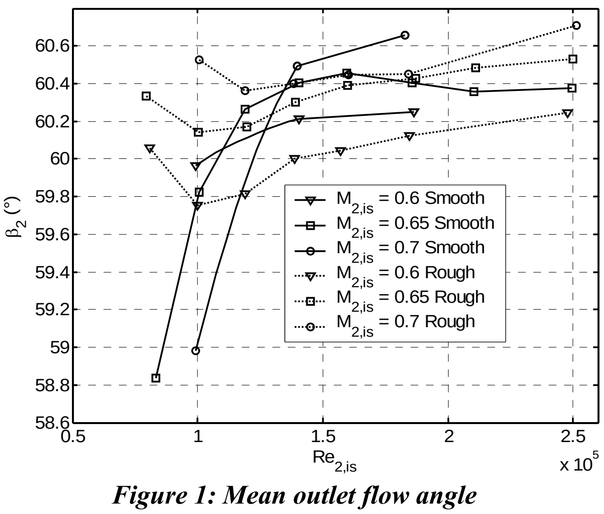

Figure 1: Mean outlet flow angle

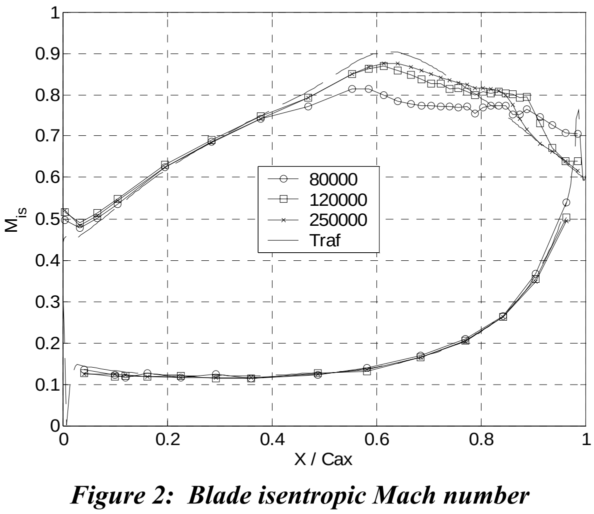

Figure 2: Blade isentropic Mach number distributions for several Reynolds numbers