HOT-FILM MEASUREMENTS OF BOUNDARY LAYER SEPARATION ON A HIGHLY LOADED LOW PRESSURE TURBINE AIRFOIL AT LOW REYNOLDS NUMBERS

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LP turbine blades are typically of high aspect ratio (e.g., 5:1) and small chord length with respect to the blade height. As a result, the flow is dominantly two-dimensional and relatively little surface is covered by secondary flow. Hence, profile losses in the boundary layer are the main loss-generating mechanism. Profile losses include the losses generated in the boundary layers on the blade surface and at the trailing edge. A well-behaved blade pressure side flow contributes little to the total pressure loss. The magnitude of profile losses strongly depends upon the development of the boundary layer on the blade suction surface. Therefore, accurate prediction of flow separation, reattachment and transition on the suction surface in low Reynolds number conditions is crucial in order to improve LP turbine design.

The purpose of this project is to study the boundary layer development on the suction side of a high lift – high load low pressure (LP) turbine blade at low Reynolds number. The main measurements are done by means of two arrays of flush mounted hot-film sensors positioned on the suction side of two different blades. The measurements are performed on an existing VKI-designed profile in the C1 facility. The performance of this profile was already documented in previous projects. The hot-film technique is the new contribution of the present effort.

Hot-film measurements of boundary layer separation are done on the VKI low pressure incompressible turbine blade at low Reynolds numbers ranging from 50000 to 150000. In order to achieve suitable flow conditions, inlet flow uniformity and outlet flow periodicity are investigated via total pressure traverses after carefully setting the stagger angles of the blades in C1 facility.

Before quasi wall shear stress measurements, the effect of heating between hot-film elements is investigated by making use of infra-red thermography. IR measurements showed weak surface temperature interaction on the last four elements on aluminum blade.

Separation bubbles forming on the suction side were measured using hot-film data at each Reynolds number and compared with previous pressure distribution around the same airfoil. Hot-film data are investigated by means of raw data (see figure below), mean and non-dimensional root mean squares. Already existing pressure data are analyzed using three different methods and compared by the results of the present study. The separation points obtained by hot-films seem to occur earlier than that's predicted by pressure distribution. So as the reattachment points. The relative error in the estimation of the separation bubble location range between 2-13%. The bubble lengths measured seem to be in good agreement with pressure data. The relative error in the estimation of the separation size however range between 0.4-2.1%. From that point of view, the results are in good agreement with previous work.

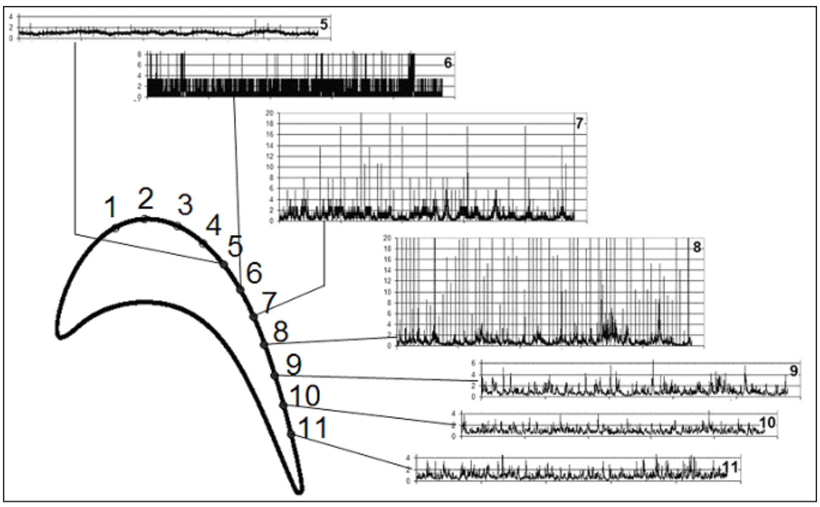

Figure 1: Hot-film raw data of 11 element array on aluminium blade.