Experimental determination of the aero-thermal performance of high pressure gas turbine blades

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Modern gas turbines work today at temperature levels far above the metal melting limit. In order to maintain reliability and life time, an accurate assessment of the operating conditions and of their consequences in terms of aero-thermal performance is an absolute requirement. Engine parts are hard to instrument; measuring details into the engine is difficult because of the limited space available and because of the local very harsh environment. An alternative approach is therefore needed. A lot of information is still expected from the experimental approach; proper turbulence and transition modelling, to only mention these two challenges, do still request extensive attention and validation.

This paper addresses a number of experimental attempts in order to accurately quantify the aero-thermal performance of a blade row or of a stage in a model high pressure, high speed turbine stage. The contribution starts with a discussion of the various options available to properly model the engine conditions, namely Mach and Reynolds numbers, temperature ratios and turbulence intensity. Measurements techniques are then discussed with their advantages and limitations. The paper mainly addresses the gas side of the airfoil; some comments will however concern the internal heat transfer, as this problem is part of the overall solution. The main emphasis is put on the use of short duration facilities, i.e. the compression tubes, and the associated instrumentation (Fig. 1)

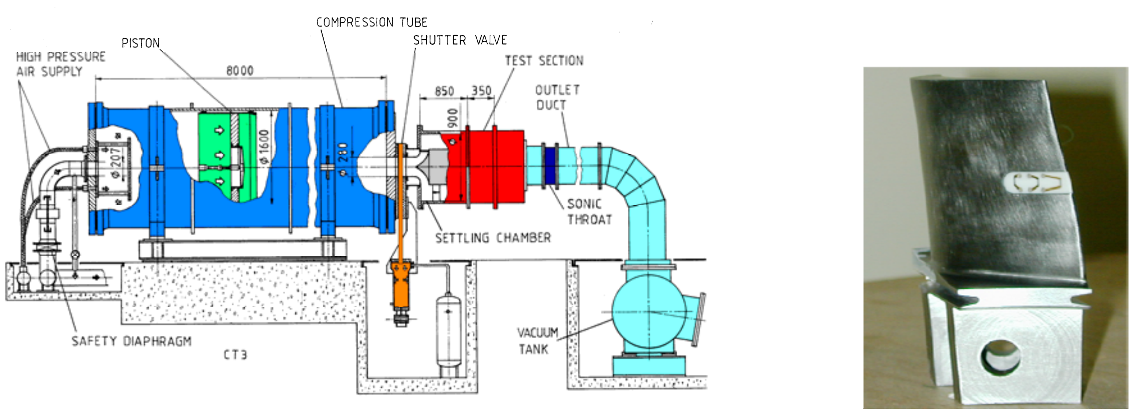

Fig. 1 – The VKI isentropic compression tube CT-3

A number of results are first discussed in an isolated blade row configuration with steady inflow conditions, looking at the effect of the main flow parameters or at the effect of several geometrical features, also in the tip area. In addition to look for a correct understanding of the flow physics, these data are also used for extensive CFD validation.

A HP stage configuration is then presented. The measurements are mainly performed on the rotor blade. Emphasis is put on the strong interaction between vane and blade and the corresponding impact on the aero-thermal performance. A typical example of blade Nusselt number distribution is shown in Fig. 2

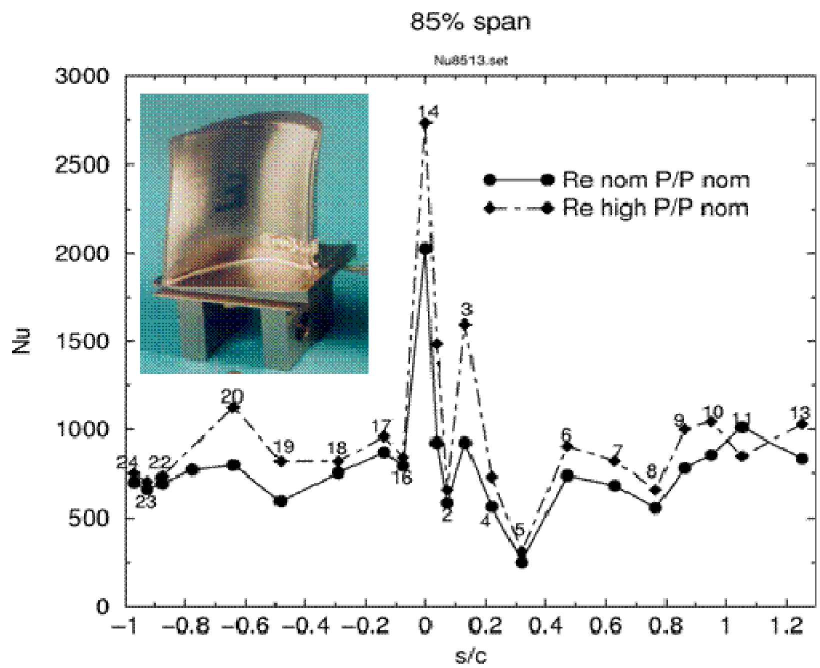

Fig. 2 – Blade Nusselt number distribution

Results are finally shown and discussed on a 1 ½ stage configuration, looking, among other aspects, at the influence of clocking on aerodynamics and heat transfer.