NUMERICAL INVESTIGATION OF THE CLOCKING IN ONE AND A HALF STAGE HP TRANSONIC TURBINE

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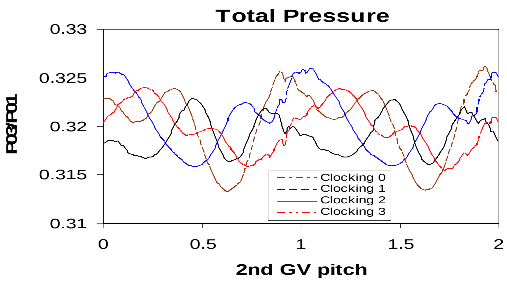
A big effort in terms of research and design is done to reduce the cost, size and weight of modern gas turbine engines for aircraft applications. In order to achieve these goals, the trend is to reduce the number of airfoils and to minimize the distance between blade rows. The immediate consequences are stronger unsteady blade row interactions. Moreover, it has been experimentally demonstrated that, in a one and a half stage turbine with the same number of blades in the 1^{st} and 2^{nd} stator, the aerodynamic performance is sensitive to the relative position between the stators, i.e. clocking. The objective of this project is to investigate numerically the effects of clocking at mid-span in the HP transonic turbine tested in the VKI Compression Tube Facility, CT3. For this purpose, quasi-3D Navier&Stokes unsteady computations have been run using HybFlow; a code from University of Florence. The computational domain is reduced to a theoretical stream-tube (whose height must be properly set) composed by two inlet guide vanes, three rotor blades and two second stator airfoils, to maintain the periodicity of the real machine.

The influence of the stream-tube height on the time and pitch-wise averaged values at different sections was analyzed systematically. The operating conditions of the machine have been matched by acting, not only on the stream-tube height, but also on the pressure ratio and on the peripheral speed. This allowed preserving the correct velocity triangles and the sources of excitation. The geometry of the 2^{nd} stator has been reconstructed using Non Uniform Rational B-Splines and its grid has been refined.

Four different clocking positions have been investigated, giving emphasis to the transport of the IGV trailing edge wake and relative total quantities through the rotor. Numerical and experimental results have been compared. It has been proved that the time-averaged pitch-wise static pressure distribution at the exit of the rotor is fixed by the 2^{nd} stator and, therefore, depends on clocking. On the other hand, it has also been proved that the time-averaged pitch-wise absolute total pressure distribution at the same location is fixed by the 1^{st} stator and does not depend on the Clocking (figure 1). Unsteady static pressure fluctuations around the rotor blade and the 2^{nd} stator airfoil have been also studied trying to understand the effects of shocks and wakes (figure 2).



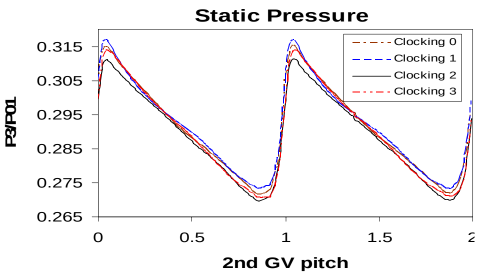


Figure 1. Total and static pressure downstream of the rotor.

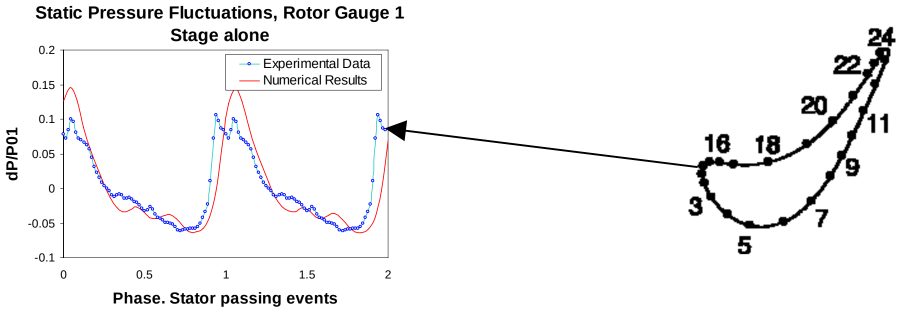


Figure 2.Static pressure fluctuations in gauge 1.Rotor blade.