NUMERICAL INVESTIGATION OF THE UNSTEADY FLOW FIELD IN ONE AND A HALF STAGE HP TRANSONIC TURBINE

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In a turbine environment the most significant contributions to the unsteadiness of the flow field are the periodic interactions of the wake, the secondary flows vortices, the potential flow field and, in the case of this transonic turbine, the shocks from the upstream blade row impacting on the downstream rotor row. This is the so-called rotor/stator interaction. In the case of two successive stages, there will be also a stator/stator interaction i.e. the flow field will depend on the relative circumferential position of the second stator with respect to the first. This is the so-called "clocking effect". Modern design philosophies require lighter engines with higher blade loading and smaller inter stage gaps that stress the importance of all the above-mentioned effects. These interactions can cause significant mechanical and thermal high cycle fatigue and affect the life duration of the component.

The objective of this project is to characterize and understand the unsteady flow field in a one and a half stage turbine using an existing unsteady quasi_3D unstructured Navier & Stokes solver developed by *F. Martelli*, *P. Adam* and *E. Belardini* at the University of Florence.

First, the code has been validated against existing time-resolved measurements of the static pressure around the rotor blade (see Figure1). The observed static pressure variation is due to the passage of the rotor across the first stator trailing edge shock wave. The interaction of the rotor with the stator wake follows a different timing and is investigated thanks to iso-contours of turbulence level (Figure 2) and plots of time-resolved eddy viscosity in the vicinity of the rotor endwall (Figure 3).

Finally, unsteady computations were performed for 4 clocking positions of the second stator. The time-resolved second stator static pressure field is dependent on the clocking position as shown in Figure 4. To a smaller extent, this influence is also felt on the time-averaged quantities such as the total pressure downstream of the stator (Figure 5).

Figure 4: Static pressure fluctuation on the suction side of the 2nd stator wall at DIFFERENT CLOCKING

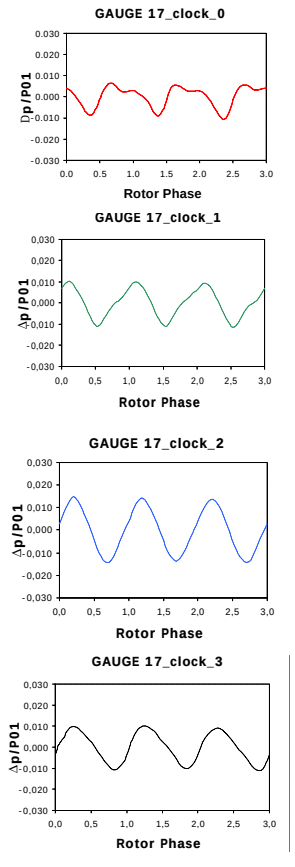

Figure 6: AVERAGE PITCH WISE ABSOLUTE TOTAL PRESSURE downstream the 1&1/2 stage

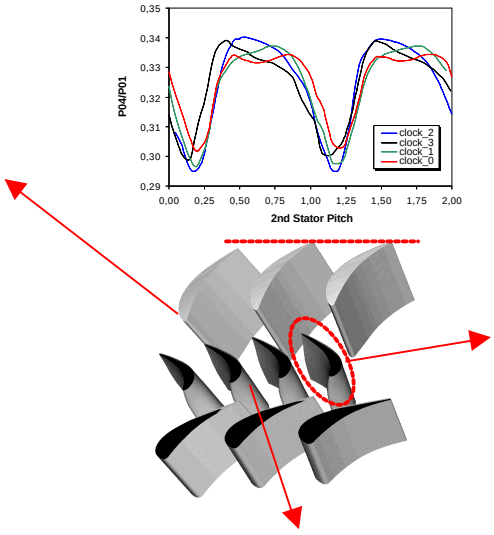

Figure 1: Static pressure fluctuation on the leading edge of the rotor wall (GAUGE4)

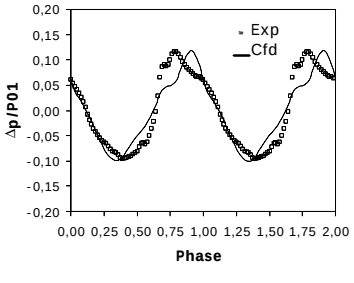

Figure 3: EDDY VISCOSITY distribution at 0.882mm from the rotor wall

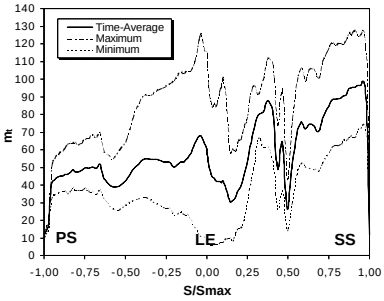

Figure 2: Instantaneous TURBULENCE LEVEL distribution