STEADY AND UNSTEADY PRESSURE MEASUREMENTS IN A TRANSONIC TURBINE STAGE

Baris Adiloglu, Turkey
Supervisors: G. Paniagua & T. Yasa

A highly loaded high pressure turbine stage is the design alternative in order to reduce the weight of HP turbines. This results in transonic flow regimes for both the stator and the rotor. In this particular study, the objective is to understand the impact of the vane and rotor shocks on the performance loss and the rotor forces. Indeed, vane shocks are a major source of aerodynamic loss and high cycle fatigue problems resulting in unpredicted failures of the engine.

In this experimental project, tests have been performed in the compression tube facility CT3 that allows simulating the operating conditions of modern aero engines. Three different pressure ratios have been investigated resulting in Mach numbers at the vane exit ranging from 1.07 to 1.25 and in the rotor outlet varying from 0.8 to 1.17. The stator outlet static pressure has been measured at hub and tip endwalls. The rotor flow field has been investigated at three spans with fast response pressure transducers. All sensors have been corrected for the effect of the temperature and RPM. Measurements in rotation also require special care to minimize electrical noise.

The periodic unsteadiness in the flow is dominated by the vane trailing edge shock waves and the rotor blockage. The figure below represents the time-averaged isentropic Mach number distribution at the vane outlet at hub. A sketch with a vane trailing edge shock system is proposed to explain the steep decreases in the pitch-wise direction. The strength of the shocks increases with the increasing pressure ratio. The vane trailing edge shocks has a clear effect on the rotor surface pressure field on the front suction side. The fluctuations of static pressure at mid-span amounts to 27% of inlet total pressure in this region. The unsteady forces on the rotor blades and the rotor disk were calculated by integrating the static pressure field on the rotor surface. The correlation between the stage design characteristics and the blade forcing is essential in order to foresee undesired vibrations.