ACCURATE TURBINE EFFICIENCY MEASUREMENTS IN A BLOW-DOWN FACILITY

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In the search for higher performances, the accurate determination of the efficiency of a turbine is a fundamental issue.
Turbine stage efficiency is usually determined in continuously running facilities with steady conditions and under thermal equilibrium. The project intends to determine with a good accuracy the efficiency of a cooled turbine stage tested in a blow-down wind tunnel with a running time of 0.3 s.
The experiments are carried out in the large VKI-CT3 short duration facility, able to simulate the operating conditions of modern HP turbine stages. In this blow-down type test rig, by contrast to a continuously running facility, the accurate estimation of the efficiency is still a challenge because of the short test time, the non adiabatic state and the difficulty on the evaluation of the mass flow.
The present work addresses the determination of the main sources of uncertainties on the determination of the efficiency and aims to minimize them.
The mass-flow has been determined directly from the measurements of total pressure and total temperature at the inlet of the stage. Provided that the stator vanes are choked during a test, a zero-dimensional model of the facility has been used to determine the throat dimensions in the stator vanes to allow to calculate the mass-flow through the chocked throat.
A new system to monitor the RPM, sampling at 80 MHz, has allowed to drastically decrease the uncertainty on the RPM and on the acceleration.
To minimise also the bias error component, the mechanical losses have been evaluated again, as well as the Inertia of the rotor. For the latter, two different methods have been adopted but only one of them has led to improvements on the uncertainty level (~1.1%).
An uncertainty analysis has been performed based on both random error and systematic errors. All the quantities appearing in the definition of the efficiency have been considered, finding for each of them its contribution on the overall uncertainty.
Finally, for nominal operating conditions, the efficiency is: 88.44%, with an uncertainty based on bias error of 1.23%, and a precision uncertainty of 0.78%.