

# DETERMINATION OF THE EFFICIENCY OF A COOLED TURBINE STAGE TESTED IN A COMPRESSION TUBE FACILITY

Luca Porreca, Italy

Supervisors: R. Dénos & G. Paniagua

Turbine stage efficiency is usually determined in continuously running facilities with steady conditions and under thermal equilibrium. This 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. Due to the uncertainty associated with gas temperature measurements, the mechanical method is preferred to the thermodynamic method.

One of the key quantities to evaluate is the stage mass flow. For this purpose, an existing model of the blow-down facility is adapted to take into account the coolant flows. Then it is used to mimic the behaviour of the test rig and validated with a large number of test data. This allowed to determine the mass flow very accurately.

The turbine power delivered is derived from the acceleration of the rotor during the blow-down and the inertia of the rotating parts. The inertia of the cooled rotor is determined by monitoring the rotor acceleration when applying a known torque.

Then the mechanical losses are evaluated. In this case the free deceleration of the rotor at different pressure levels is analysed. A mathematical model is used to predict the different losses due to the bearing friction, the windage of the blades and the disk ventilation. Afterwards, the heat transferred from the fluid to the endwalls is estimated because this energy does not produce any useful work. This calculation is based on the heat transfer rates determined experimentally in the turbine stage.

Finally, the overall procedure is applied to a number of tests providing a value of efficiency for each test with an uncertainty of  $\pm 1.76\%$ . The analysis of the results shows that a further reduction of the uncertainty can be achieved by improving the accuracy on the stage downstream total pressure and on the acceleration of the rotor during the blow-down.

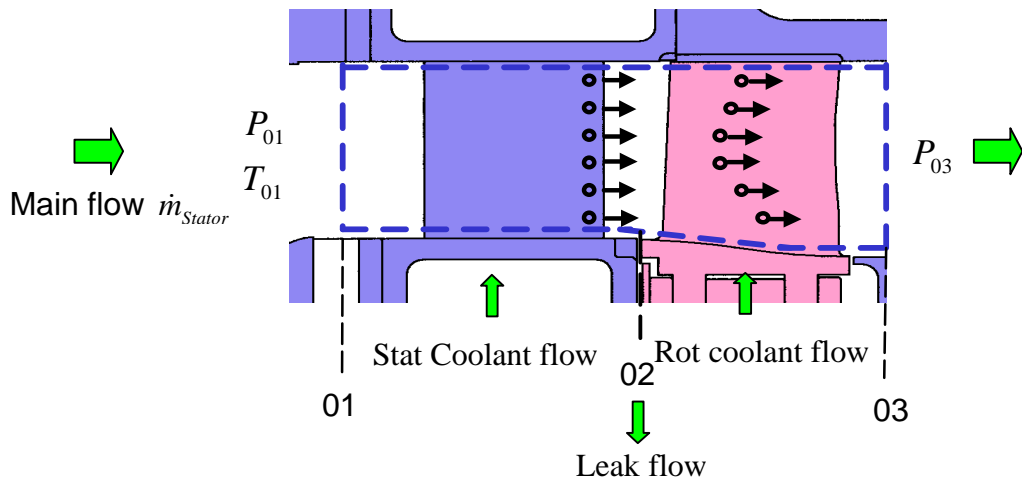


Figure 1: Turbine stage control volume