ANALYSIS OF THE UNSTEADY OVERTIP CASING HEAT TRANSFER IN A HIGH SPEED TURBINE

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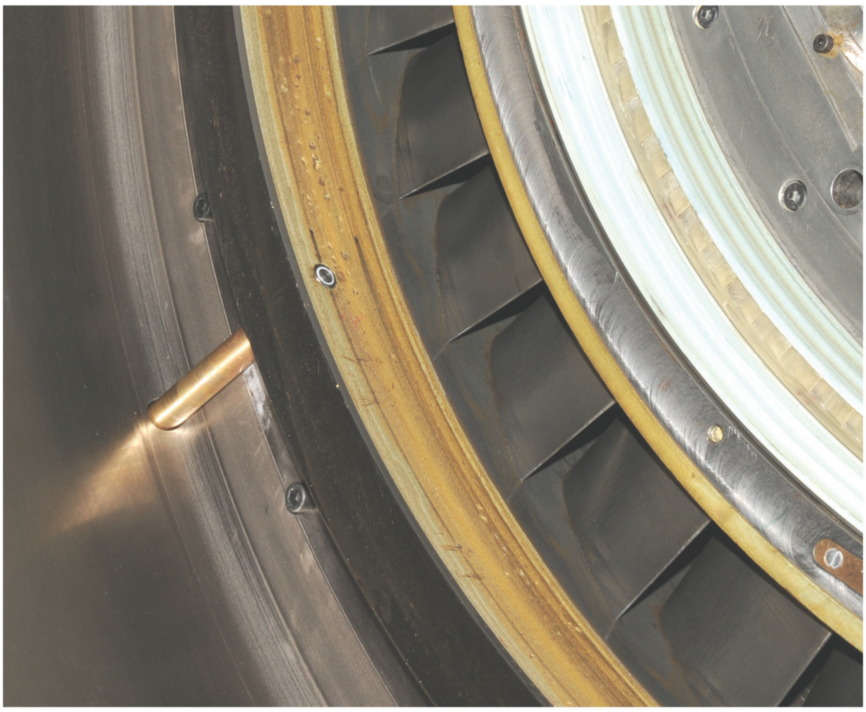
In modern gas turbine engines, the rotor casing is vulnerable to thermal failures due to large unsteady heat fluxes. The rotor tip flow unsteadiness is induced by the periodic passage of the rotor blades, with an intensity dependent on the tip gap geometry. Hence, the understanding of the physics is of paramount importance to develop appropriate predictive tools and improve the cooling schemes. The present research aims at providing essential information on the flow conditions, which should serve to assess the relative impact of the overtip flow, tip gap magnitude and work extraction processes on the casing thermal load. This paper presents simultaneous measurements of steady and unsteady heat transfer, pressure and rotor tip clearance in the casing of a transonic turbine stage. The research article was tested in a compression tube facility operating at engine representative conditions (vane Mach number 1.07, vane outlet Reynolds number 1.3×106, pressure ratio is 2.92, at 6790 RPM). The rotor blade geometry has a flat tip with a nominal tip clearance of 0.2% blade height. The heat transfer, pressure, and tip clearance data were obtained at three circumferential positions around the turbine casing. The heat flux was monitored using a single-layered thin film gauge able to resolve with high-fidelity the wall temperature fluctuations. The heat flux sensor was mounted on a probe equipped with a heating device that allows varying the wall temperature. A series of experiments was performed at different heating rates to derive the local adiabatic wall temperature and the adiabatic convective heat transfer coefficient. A high bandwidth capacitive sensor provided the instantaneous value of the single blade tip clearance. A simple zero-dimensional model has been proved effective to predict the local flow temperature while the rotor spins up prior to the test, and explain the observed large temperature fluctuations induced by the tip leakage flow during a test.



View of the instrumented casing of the high-pressure turbine stage.