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Test Bench Configuration to Facilitate Gas Turbine In-Situ Combustion Experimentation

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Abstract

The present technology in gas turbine engines is to burn fuel in the combustion chamber and occasionally in the postcombustion chamber. Current conventional developments of gas turbine aero-thermodynamics provide small efficiency and power increase, because with the present technology one reached an asymptotical convergence to the upper limit of the gas turbine performance. An interesting and almost unexploited possibility is to continue combustion in the turbine, option that, up until recently, has been considered undesirable for a number of reasons. A turbine-combustor is defined as a turbine in which fuel is injected and combusted. The process of combustion in the turbine is called in situ reheat. Thermodynamic cycle, (a hybrid between the Ericsson and Brayton cycles) analyses have demonstrated the benefits of using reheat in the turbine in order to increase specific power and thermal efficiency. [1]

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Keywords: in-situ combustion; gas turbine; specific power increase

1. Introduction

The work presented in this paper is carried out at the Romanian Research and Development Institute for Gas Turbines COMOTI within the ongoing TURIST (Gas Turbine using in situ combustion –TURIST) project, aiming at developing the required dedicated test rig in order to perform combustion in a turbine (in-situ reheat), including the

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adaptations required for the coupling with the detonation chamber inlet (integrated in COMOTI's gas turbine experimentation facility) and the adaptations to the turbine and instrumentation system.

The experimental program for the TURIST project takes into consideration, in the initial phase, two experimental campaigns. The first, integrates the experimentation of a turbine sector consisting in 2 stator blade passages and 3 rotor blade passages, in order assess the details from an intermediate burning in the turbine point of view and the second refers to the experimentation of the entire gas turbine in order to obtain the global image over the modifications occurred in turbine performance when subjected to this supplementary burning. The experiments focus on the first stage of the TV2-117 gas turbine engine's power turbine.

The rise in technological level of a turbine can be achieved by intensive experimental studies conducted in dedicated test benches. The turbine is the part of a gas turbine which has the most complex stresses from both thermal and mechanical points of view. For testing a turbine stage under conditions close to those encountered while functioning at nominal regime on an actual gas turbine, it requires very high inlet temperature and pressure, high mass flow rate and rotational speed. All these parameters are extremely difficult to be achieved simultaneously on a test bench, both from a technological and a financial point of view. Such a test bench would require an hot air / burnt gases at high pressure source, as well as a dynamometer, either hydrodynamic, electric or pneumatic, to act as a power consumer. At the same time, testing the rotor under rotating conditions makes it extremely difficult to properly instrument it in order to acquire relevant data for assessing the performances.

Only a select group of universities or research institutes worldwide have developed such experimental facilities, such as: AneCom AeroTest GmbH, Germany; Stuttgart University, Germany; Cambridge University, Great Britain; CONCEPTS NREC, SUA; NASA Gleen, SUA; Royal Institute of Technology, Sweden; MTU Aero Engines, Germany; National Aerospace Laboratory, Netherlands; National Research Council (NRC), Canada.

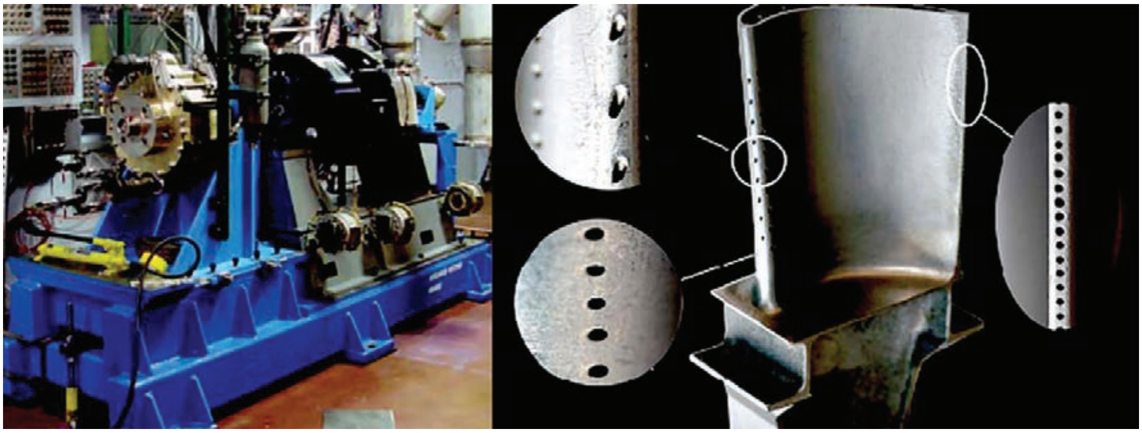

Fig. 1. Turbine testing facilities at CONCEPTS NREC, USA[2]

All the above, make a strong case for developing a methodology which to allow the testing of a rotor cascade under static conditions, while still reproducing the actual engine working conditions and allowing collecting relevant data of its performances under these conditions. Such a study has not been identified in the dedicated literature. At the same time, this testing methodology for a rotor cascade would be of outmost importance for the interested scientific community in turbines, as it would allow for less consuming tests, both in terms of financial and technical resources and would allow turbine applications to be developed by a less exclusive scientific community. In time, this can translate in a more rapid development of the turbine technology, as more studies are encouraged.

2. Experimental setup

The experimental facility integrates an existing tri-sonic air blowing station, equipped with 2,000 m^3 air tanks, capable to supply air up to a pressure of 12 bar and a mass flow up to 5 kg/s. The maximum value of the temperature