**Instrumentation improvements for NGV AERODYNAMIC characterization at high Mach numbers**

|  |  |
| --- | --- |
| Andoni PuenteCentro de Tecnologías Aeronáuticas | Guillermo García-ValdecasasITPAERO |

Abstract

One of the most important new engine concepts is the Geared turbofans. In these engines a gear box allows the decoupling between fan and turbine rotational speeds, due to this decoupling, the separate aerodynamic optimization of both components becomes possible leading to an increase in engine bypass ratios, higher propulsive efficiency and lower specific fuel consumption.

The multi-stage intermediate pressure turbine (IPT) is one of the key parts of the thermodynamic cycle in geared turbofan architectures. Because of the aerodynamic differences with conventional low pressure turbines (LPT),during the characterization of an LPT NGV row, is important to have detailed pressure losses measurements as accurate as possible, this becomes mandatory when the NGV is designed for an IPT. The main error sources are related to circumferential anisotropy, to repeatability of US and DS measurements, to effects of instrumentation in 2D losses and to static pressure measurement in the probe environment.

introduction

From an aerodynamic point of view, the combination of high Mach number and low Reynolds number (below 105) was considered to be the main challenge in some previous studies [4,5], in these studies it was considered that the potential decrease in aerodynamic efficiency would be close to the benefits associated to higher rotational speeds**.** However, there is another study (Vazquez and Torre [6]) about the benefits of Higher Mach numbers in row losses comparing two designs with the same loading distribution and different exit Mach numbers: 0.61 and 0.88. They concluded 14% reduction on profile losses and a 7% reduction on overall losses due to the higher pitch-to-chord ratio required in the high Mach number case. Reducing the airfoil count was identified as one of the benefits of the IP turbines due to the aerodynamic losses but also because of weight and cost savings.

Detailed NGV row characterization at a higher (>0.88) design Mach number could be a good approach to explore the limits of the Mach number at which the detriments are more than the benefits from the aerodynamic efficiency standpoint.

RESULTS and DISCUSSION

In the present job, instrumentation improvements are described as a solution to some of the main error sources when measuring the NGV row pressure losses at high Mach number. From the accuracy and repeatability point of view a 360º rotating case has been designed and manufactured to be able of measure at the same time US and DS the NGV row. Regarding the static pressure measurement in the probe environment a 6-hole probe has been designed and manufactured. To be able of comparing different NGV designs with slight differences between them, the rainbow configuration, different NGV designs assembled in different sections of the same row, joined to the 360º rotating case allows to measure US and DS at the same time in the same condition thus reducing errors coming from repeatability of the test facility and optimizing test time.

|  |
| --- |
| Vista previa de imagen |
| **Figure 1. Detail of rotating case with probes installed** |

References

[1] Hancock, P.E., 1988. A theoretical constraint at M = 1 for intrusive probes and some transonic calibrations of simple static-pressure and flow-direction probes. In Proceedings of the 9th Bi-Annual Symposium on Measuring Techniques in Transonic and Supersonic Flow in Cascades and Turbomachines, Oxford, UK.

[2] Pinilla, V., 2016. Manufacture, assembly and calibration of fast response probes. ITP Aero Technical Report, number VPL/AS/ITA/T0931.

[3] ANSI/ASME, 2013. “Test Uncertainty.” PTC 19.1-2013, American Society of Mechanical Engineers, New York, NY, USA.

[4] Giovannini, M., Rubechini, F., Marconcini, M., Arnone, A. and Bertini, F., 2016. “Analysis of a LPT rotor blade for a geared engine: Part I – Aero-mechanical design and validation.” In ASME Turbo Expo 2016: Turbomachinery Technical Conference and Exposition. Paper No. GT2016-57746.

[5] Malzacher, F.J., Gier, J. and Lippl, F., 2006. “Aerodesign and testing of an aero-mechanically highly loaded LP turbine.” Journal of turbomachinery, 128(4), pp. 643-649.

[6] Vázquez, R. and Torre, D., 2012. “The effect of Mach number on the loss generation of LP turbines.” In ASME Turbo Expo 2012: Turbine Technical Conference and Exposition (pp. 1131-1142). Paper No. GT2012-68555.

[7] Vázquez, R., Iturregui, J.J., Arsuaga, M. and Armañanzas, L., 2003. “A new transonic test turbine facility.” In XVI International Symposium on Air Breathing Engines (ISABE), Cleveland, Ohio, August.

[8] Vázquez, R. and Sánchez, J.M., 2003. “Temperature measurement system for low pressure ratio turbine testing.” In ASME Turbo Expo 2003: Power for Land, Sea, and Air. Paper No. GT2003-38685 (pp. 527-539).