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APPLICATION OF ACTIVE FLOW CONTROL IN AEROENGINE COMPRESSORS

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ABSTRACT

Compressor stall and surge is particularly dangerous for aeroengines, because it may result in engine flame out. For this reason, care is taken to operate the compressor with an adequate stall margin, in order to secure healthy operation during all flight conditions. This results in increased compressor volume and weight. On the other hand, active flow control, applied on compressor bladings, or at the inlet of the compressor module, increases stage (blading) aerodynamic load limit and displaces the compressor stall limit towards lower mass flow rates correspondingly.

Flow control benefits were studied first by Prandtl in 1904 (elimination of turbulent boundary layer separation). The corresponding study for compressors was initiated in the early seventies. Work was performed first experimentally and, more recently, computationally, both towards understanding and simulating the flow separation phenomena in compressor and turbine bladings and compressor modules without and with active flow control present. Although detrimental effects are related to flow separation, the details of the physical phenomena are different in compressors and turbines. This presentation deals exclusively about compressors, where two active flow control techniques are in use. The first one concerns separation elimination along the suction side of the compressor blading and the second, elimination of unsteady flow detrimental phenomena (compressor rotating stall and surge).

Simulations of such phenomena may be incorporated within the compressor design system existing in each aeroengine manufacturing company providing evaluation capabilities of configurations with and without flow control presence.

The presentation will first introduce briefly the physical phenomena under consideration. Then, a review of the simulation capabilities available and the advances made until to day will be presented. The various types of problems will be examined, along with simulation results, which demonstrate the level of maturity of today's simulation tools, as well as their contribution to the physical understanding of the related flow phenomena.

Unfortunately, implementation of these innovative techniques is imminent, presently, only for the airframe part of the aircraft. Applications at the engine level are still somewhat lagging behind, because of lack of satisfactory mechanical systems, which will combine the necessary efficiency and reliability.