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RESEARCH FRONTIERS FOR COMPRESSORS IN AERO-ENGINES

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In the context of air transport, propulsion has a direct impact on emissions and costs. The increase of the performances of jet engines follows different trends, among which the increase of the by-pass ratio, the increase of the pressure ratio and the reduction of the number of components (and weight). The compressor is deeply involved in these evolutions, which notably require an increase of the aerodynamic loading of the blades.

A particular attention is currently put on the unstable operating conditions of the compressors. A better understanding and control of the flow instabilities would allow extending and taking benefit of the nearby stable operating conditions, which are characterized by high pressure-ratios and efficiencies. The presentation will show that significant progresses have been achieved in the experimental characterization of those powerful (and possibly destructive) phenomena [1][2]. These experiments now accompany the development of numerical simulation in these regimes. The instabilities can involve interactions with the surrounding system, and this must be appropriately represented in the simulation. For illustration, a 1D/3D coupling strategy [3] will be presented, allowing a detailed description of the source mechanisms within the compressor, together with the response of the whole test-rig. These simulations give a complementary insight into the phenomena and are expected to guide the conception of machines with extended stable conditions.

Furthermore, the prediction of separated and unstable flows requires a turbulence modelling able to represent the three-dimensional unsteady dynamics of the turbulent eddies. On this aspect, the standard RANS approach (Reynolds averaged Navier-Stokes) faces inherent difficulties. The direct description of the largest turbulent eddies, known as LES (large-eddy simulation), appears as a promising perspective, in either its full-form or coupled with RANS (hybrid). Illustrations of the capabilities of LES in the context of compressors will be presented on two different configurations: a cascade configuration (focus on corner separation) and a laboratory-scale fan (focus on the tip-leakage flow). On the former configuration [4], full-LES results are compared with RANS, and detailed analyses of turbulence are carried out (anisotropy, budget…). On the latter configuration [5], a hybrid RANS/LES approach is employed, and the phenomenon of vortex wandering is evidenced and analysed.

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