AERODYNAMIC CHARACTERIZATION OF HELICOIDAL FIN ARRAYS IN TRANSONIC FLOW CONDITIONS

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Developments in ultra high bypass ratio engines aim to achieve higher performances while further decreasing specific fuel consumption over a wide range of missions. The evolution towards more efficient engine architectures requires advanced thermal management technologies to cover the increasing demand of refrigeration and lubrication. Fuel is traditionally the preferred oil heat sink but its capacity is limited by several well known factors, and also new limitations arising from the development of components in composite material. Air as a heat sink is extensively used in aeroengines, although within the oil systems the use of air coolers is generally limited to complement the capacity of fuel coolers in certain range of operations. The development of air coolers optimized for certain locations within the aeroengine would increase the required thermal capabilities.

The current research focuses on the aerodynamic investigation of the three dimensional turbofan bypass-flow and its interaction with a finned air/oil surface heat exchanger integrated at the inner wall of the secondary duct. The air-oil heat exchanger placed at the location of the air separator nose would satisfy needs for cooling the oil circuit while also preventing from icing, without decrement for the bypass engine flow.

In order to combine experimental, theoretical and numerical studies for a proper evaluation of the flow/finned heat exchanger interaction and its optimization, a new wind tunnel test facility has been specifically designed. The new blowdown wind tunnel allows the duplication of the flow in the region where the finned array will be located, thanks to the annular type test section shown in Figure 1. Numerical tools have been used to optimize the design and mathematical models computed to analyze the global wind tunnel behavior (Figure 2).

Aerodynamic characterization of the three-dimensional bypass-flow, with and without the presence of different finned array geometries, is performed by means of different experimental measurement techniques. Conventional intrusive aerodynamic instrumentation is used to perform map measurements at different locations along the 3D channel. Probe rakes have been specifically optimized for this application. Two different optical measurement techniques are used to provide more extensive information of the flow interaction with the optimal fin array. A new procedure based on the surface oil dot technique provides quantitative information of the wall shear stress, based on the dot deformation. Information on the flow field development will be provided by Particle Image Velocimetry measurements. The application of this technique to the present investigation is an ongoing challenge due to the complex 3D test section geometry. Experimental results will be supported by computational flow analysis within the test section domain. Numerical studies are carried out in the absence of the heat exchanger both on the clean channel flow and including the insertion of instrumentation. They allow studying the modification of the flow and the blockage effects caused by the presence of instrumentation, as well as understanding the 3D flow-field to be measured.

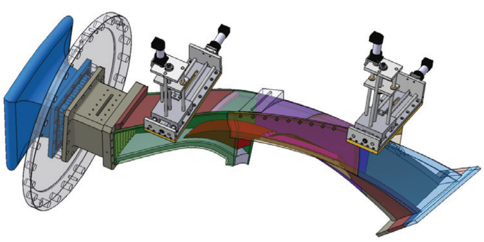

Figure 1 :3D Test Section

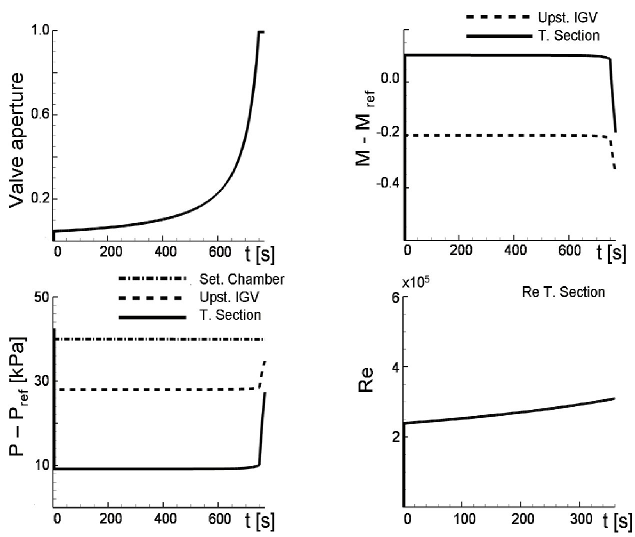

Figure 2 : Predicted Wind Tunnel Behavior