# Aircraft Engine Efficiency Improvement through an Innovative Active Clearance Control System

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# Aircraft Engine Efficiency Improvement through an Innovative Active Clearance Control System


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# Summary

The concept at the base of the newest aircraft engines is to improve the efficiency as much as possible. These innovations are mainly aimed at reducing the environmental impact and the fuel consumption, and at producing more durable engines. Due to the already very high degree of optimization achieved in current engines, the introduced technological improvements usually have a limited impact in terms of overall efficiency. However, their contribution in terms of fuel savings is still significant, since the larger engines are capable to develop very high amounts of power. Consequently, the optimization of those engine elements, whose impact was once considered negligible, has become crucial in the last years.

One of these tasks is the control of engine clearances in Low Pressure Turbines (LPT). The clearances are the gaps occurring between static and rotating parts that change during the several flight phases, due to the different thermal loads on the stator and the rotor and to the other forces (i.e., thrust, inertial, centrifugal and aerodynamic loads) acting on the engine. Although a clearance between the rotor blade and the turbine shroud is necessary to avoid damage to the blade of the tip, the presence of too large gaps leads to undesirable energy losses and higher fuel consumption. A solution to reduce these losses is the installation of Active Clearance Control (ACC) systems.

A typical ACC system for LPTs of large aircrafts maintains the clearances at an optimal value, by means of the impingement cooling method: when the gaps are larger than needed, a proper amount of cold air is blown by impinging jets. In this way, the turbine casing undergoes a thermal shrinkage and, after a certain response time, the clearances are closed. The cold air is delivered by means of a duct system that behaves as a plenum.

The main goal of this research is to define a solution that allows improving the performance of current ACC systems. First of all, a detailed literature review

has been accomplished to point out the state of the art and the future perspectives about the ACC design.

Then, a flow network analysis of the entire ACC system has been performed by using a DoE, which included several design parameters. The impact of each analyzed parameter in terms of available mass flow rate for the jet impingement has been evaluated, in order to characterize the robustness of the ACC system when its main design parameters are changed.

Also the next phase is focused on the air delivering system and couples the previous fluid-dynamic studies with the heat pick-up, i.e. the increase in temperature of the cold air, due to the proximity of hotter engine components. In order to carry out these analyses, a 1D analytical tool has been developed. This tool has allowed simulating the entire ACC system with a reasonable accuracy, reducing the computational time, in comparison to a complete 3D model. Moreover, the significant circumferential non-uniformity in terms of mass flow rate and temperatures has been pointed out.

The last part of the present research concerns the impinging jets. In particular, the configurations, which have been investigated, aim to improve heat transfer adding elements that increase the roughness of the turbine case. The Computational Fluid-Dynamics (CFD) method has been applied to carry out this activity, comparing a jet impinging on a flat target surface to other geometries and considering the possible presence of a cross flow. The CFD results, in the case of the flat target surface, have been validated on the literature data.