Flow Controlled Core Concept

In order to meet the ACARE 2020 objectives, strong improvements on engine component efficiencies are required in addition to new engine architectures. The VITAL program evaluates new high BPR architectures (such as CRTF, see Fig. 14) involving limited pressure ratio from the booster (low speed) and resulting in very demanding pressure ratio requirements from the core engine to reach a high OPR.

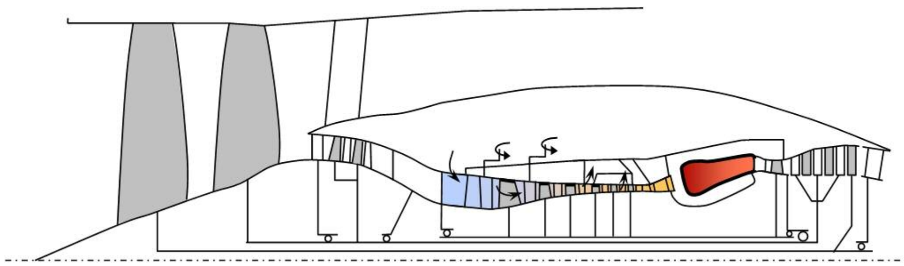

Fig. 1: Schematic of engine with flow controlled core in CRTF architecture

The Flow Controlled Core approach focuses on the compressor module by developing and integrating innovative technologies, providing a significant increase of efficiency and stall margin in the highly loaded HPC.

The strategy is based on the implementation of innovative concepts capable of local control of the compressor flow field. The optimised design of the compressor in association with the integration of these aero-oriented technologies leads to a global benefit. The Flow Controlled Core can also be applied to more conventional high BPR turbofans.

More precisely, these new and significant progresses in the field of highly loaded compressors will be made possible through the combination of several approaches. Implementation of breakthrough technologies able to control the flow locally, either near the operating line or near the stall line, associated with an adapted and suited advanced aerodynamic design for both improved efficiency and stall margin. Among these technologies, advanced casing treatment specifically designed for HPC will be considered, as well as other more prospective concepts such as casing aspiration or air injection. Aspiration will be evaluated both on casing walls and blades profiles where innovation is a lot higher and can lead to new perspectives (see Fig. 2).

The objective will be to integrate and link as much as possible these different technologies of flow control, through the idea of aspiration concept, to the engine air system.

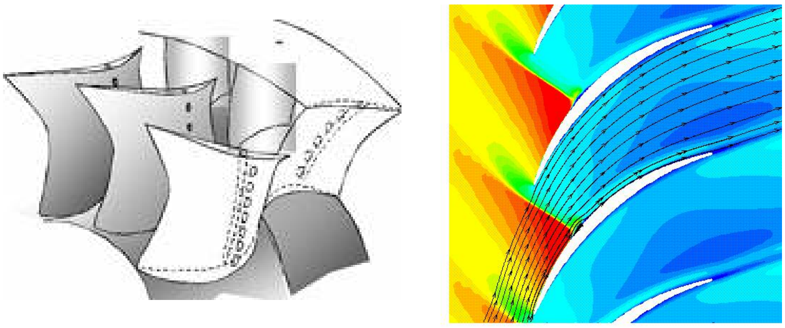

Fig. 2: Aspirated blade concept

Design advanced 3D aero suited to flow control devices: Taking into account past experience, multistage 3D CFD codes will permit implementation of 3D shapes and local optimisation such as non axi-symmetric inner end wall profiling, specific tip shape or local design of the outer flow path like trenches. The aim will be higher efficiency, stability and lower sensitivity to clearance opening.

Continue maturation of the stall active control system initially tested with success in the EEFAE-CLEAN program. The specific goal will be to integrate and optimise stall active control system, such as fast-opening bleed valves, into a real-engine environment for full benefit.

Blade casing rub management for tight tip clearances will also be addressed; the objective is to enable soft rub between blade and casing, free of secondary effects such as clearance opening due to unwanted rub-induced dynamic phenomenon or material transfer between abradable and blade. The development of sophisticated abradable and blade/casing contact modelling will lead to design guideline, Fig. 3. In parallel, the development of an improved abradable material more tolerant to contact will be carried out.

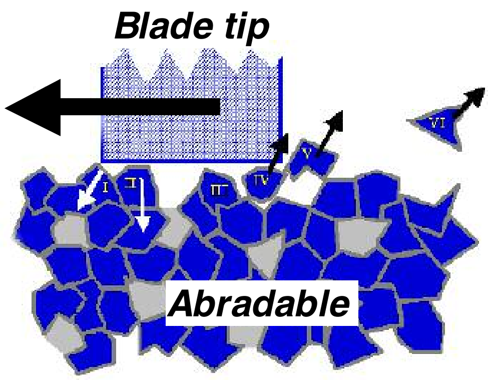

Fig. 3: Blade/casing rub advanced modelling

At last the integration of all the above technologies will be optimised in a consistent design for a “flow controlled core” concept.

The FCC focuses deeply on innovative HPC technologies, with the objective to increase strongly the state of the art in terms of polytropic efficiency (+2,5%), stall margin (+15%) and robustness toward degradation (–1/3).