THE EFFECT OF SOLIDITY ON COMPRESSOR PERFORMANCE AND STABILITY

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The solidity in a compressor is the ratio of the aerodynamic chord over the peripheral distance between two blades, also called the pitch. The solidity must be selected early in the design process. However, there does not exist any general rule to help the designer in this choice because the impact of solidity on the compressor performance and stability is not fully established. In that prospect, the following PhD proposal aims at investigating numerically and experimentally the effect of the solidity on both compressor performance and stability. As a support to this investigation, the low-pressure compressor stage studied at VKI within the framework of the DREAM project is considered. The stage has been designed and manufactured by TechSpace Aero and is representative of a state-of-the-art booster. Their performances have been assessed both numerically and experimentally at VKI.

The first part of the work gathers all the existing compressor correlations and tries to characterize the influence of solidity on deviation, incidence and losses. The influence of the chord is isolated from the influence of the pitch. The role played by solidity on the blade loading is addressed and existing optimum solidity criteria are presented.

The effect of solidity must also be assessed by CFD. Typical DCA or NACA65 compressor blades are implemented into cascade configurations and investigated through CFD in order to be compared with empirical correlations. Hub, tip and mid-span profiles taken from TechSpace Aero's booster are used to provide data more representatives of present low-pressure compressors. The same study is achieved in 3D using the complete geometry and design conditions of the DREAM project. Different stage configurations are analyzed by changing the blade number of both rotor and stator. The data are then analyzed and compared to infer an optimum solidity criterion.

The final part of the work consists of the validation of the numerical investigation through high-speed cascade tests representative of flow conditions in a low-pressure compressor. Compressor blades are tested at different solidities in order to build a empirical database and to validate the 2D numerical calculations. The focus must be set on the relation with both 2D and 3D CFD results and on the quality of the performance and stability prediction.

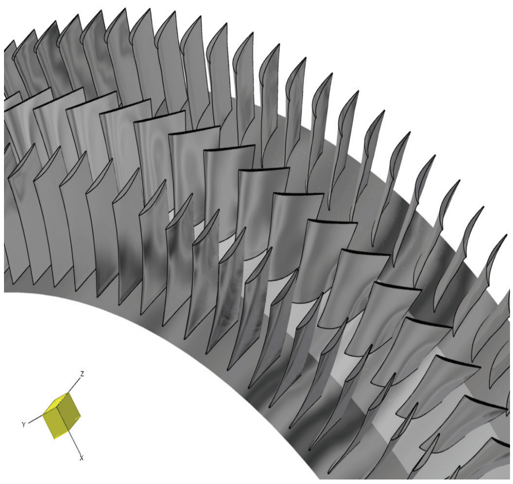

Figure 1 : 3D view of the DREAM project booster

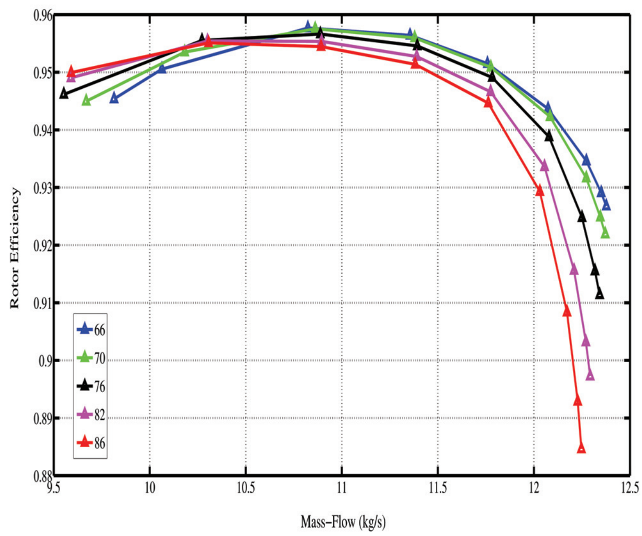

Figure 2 : Effect or rotor blade number on rotor efficiency