FORCED RESPONSE COMPUTATION FOR BLADED DISKS APPLICATION: RESEARCH CASES AND INDUSTRIAL PROBLEMS

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1. Introduction

The forced response of bladed disk is a key point to improve their aeromechanical design compromise. Various simulation techniques are being developed or are already used as shown in the VKI lecture series "forced response computation for bladed disk. Industrial practices and advanced methods". This previous lecture series objective was to present synthetically some of the approaches for forced response computation and how to use them it in the design process. In the current document, some applications of forced response computation are proposed on experimental cases for which response levels have been measured.

The industrialisation of forced response simulation tools has necessitated many experimental validations. Indeed, some specifically dedicated experiments have been conducted, on one isolated bladed disk with fully characterised parameters in order to assess the prediction tools accuracy. But in the industrial cases, many parameters being unknown, the way to compute the forced response levels is necessarily different. As a consequence, forced response computation for industrial cases does not necessarily provide the same information level than in the case of laboratory testing.

A correct level of accuracy can be reached if the set of influent parameter is properly characterised:

- Steady flows must be measured (pressure, temperature, flow rate) in order to update the CFD steady computation and the operating point.
- Some unsteady parameters are also of first interest in order to update the forcing function level. But unsteady pressures on the blade surface are, of course, much more difficult to capture.
- The structural dynamics must be updated with component testing, in terms of frequency and modeshape.
- The total damping, due to aeroelastic damping, material non linearity of contact surface is a first order of influence parameter. But once again, it is difficult to estimate in a fully predictive way.
- Mistuning pattern must be known because is can more than double the tuned forced response level.

If these parameters are not well identified, the accurate absolute response level will be impossible to determine. Nevertheless, computation results can be compared relatively, even if there accuracy is perfectible. These relative approaches can be of first interest for the designer.

Different types of application will be presented in this document, both for compressor and turbine bladed disks, accounting for various parameters, in laboratory environment or for whole engine application:

- laboratory experiment on a HP turbine: forced response without and with mistuning
- industrial application on a HP turbine design
- Laboratory experiment on a HP compressor stage: forced response with/without mistuning
- Fan forced response to the air inlet flow distortion
- HP compressor stage excited by upstream stator vane.

2. Laboratory experiment on a HP turbine

2.1. Test case presentation

This experiment has been performed in a European project involving all the European aeroengine manufacturers. The object of the project was to performed tests in order to provide a reliable experimental database for forced response of turbine bladed disks.

The study concerns a 64 blades HP turbine excited by the upstream stator vane. The modal and aerodynamic behaviour of the structure is representative of a HP turbine even if the test is performed at ambient temperature. Different configurations have been studied, varying the upstream stator vane number, the axial gap between the stator and the rotor and the operating point (rotation speed, pressure ratio). A heavy onboard instrumentation was used with a signal transmission system, as shown on the following Figure 1.

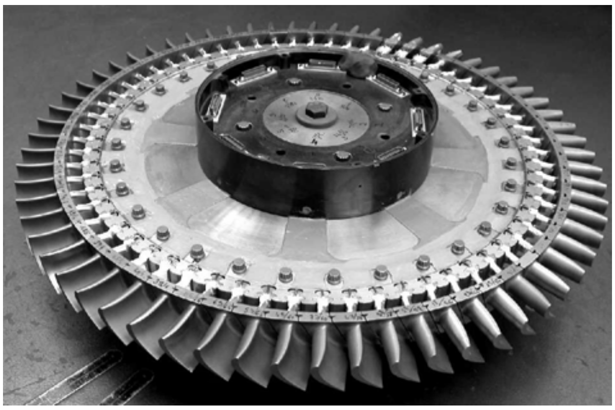

Figure 1 - View of the turbine rotor

2.2. Aerodynamic characterisation

A complete steady flow characterisation has been performed for the different operating points in order to be able to guarantee the quality of CFD steady state analyses. Since the excitation is due to the upstream stator vane, a good accuracy is required for the steady state computations.