FUTURE

Flutter-Free Turbomachinery Blades

State of the Art - Background

Flutter denotes a self-excited and self-sustained vibration phenomenon of turbomachinery blades that can lead to failure unless properly damped. The present trends in turbomachinery design to increase component loading while reducing structural weight can lead to critical situations from a flutter point-of-view. Articles from literature report that although 90% of the potential high cycle fatigue (HCF) problems are covered during development testing, the remaining few problems account for nearly 30% of the total development cost and are responsible for over 25% of all engine-distress events. Problems related to flutter therefore impose large costs and programme delays since they are encountered late in development when engines are tested at full power or in flight conditions.

Today, fundamental blade design with respect to flutter is still based to a large degree on relatively simple empirical criteria. These rules are mostly over-conservative and therefore not applicable to modern, highly loaded, lightweight components. On the other hand, analysis techniques have evolved considerably and allow for a detailed breakdown of unsteady aerodynamic phenomena. The foremost reason for still having these simple criteria in use today is the lack of proper validation data addressing complex 3D flows involving non-linear viscous effects, and real engine multi-row environments.

Objectives

One of the main objectives of FUTURE is to improve and validate the current state-of-the-art prediction tools. Secondly, the underlying reasons and vital parameters for the inception of flutter are neither completely identified nor fully understood - knowledge that within FUTURE will be gained through a combined experimental and numerical effort, including extensive free-flutter experiments. With the goal to obtain a comprehensive view of the main flutter physics in both the compressor and turbine modules, the FUTURE project has been designed with structural, cascade and rotating rig experiments for these two modules.

In detail, the scientific and technical objectives of the FUTURE project are the following:

- Improve understanding of flutter based on state-of-the-art component and engine relevant experiments;
- Define design rules and criteria for aggressive lightweight bladings;
- Develop and validate state-of-the-art measurement techniques for aeromechanic experiments;
- Establish a worldwide unique database with high quality experimental aero-elastic results;
- Establish 'CFD Best Practice Guidelines' for aero-elasticity in turbines and compressors;
- Establish 'Experimental Best Practice Guidelines' for aero-elasticity in turbines and compressors.

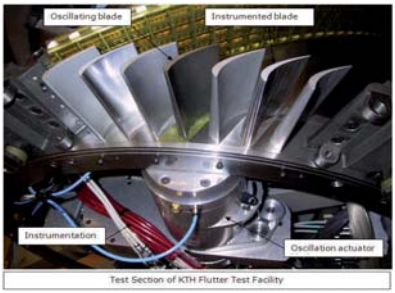
Description of Work

The FUTURE project is organised into four different work packages that are interconnected to give a coherent and clear progress of the state-of-the-art of aero-elasticity in turbomachines. The different activities can be summarised as:

- Eight interconnected turbine and compressor experiments (using rotating and static rigs) will be performed;
- These experiments will be combined with numerical modelling of vibrating blades together with the surrounding flow interfering with the vibrating structure.

Results from all the activities in the project will lead to a more coherent view and a better physical understanding of the flutter phenomena in turbomachines.

In the process to reach this unique knowledge status, a sophisticated, not yet available, measuring technique will be being developed, and two new excitation mechanisms will be implemented as back-up to the free-flutter experiments. Furthermore, a unique database with combined structural and unsteady aero-



Cascade flutter test facility at KTH

dynamic results will be established and made available for further dissemination among the partners. This database will, through the combined efforts of experimental and numerical aero-elastic experts that are gathered for the project, contain significantly more detailed data than any other existing database in the world.

Expected Results

By advancing the state-of-the-art in flutter prediction capabilities and design rules, the FUTURE project will lead to short-term benefits in terms of decreased development cost in current engine programmes, reduced weight and thus fuel consumption, and an increased ability for efficiently managing flutter problems occurring in engines in service.

In the longer term, improved analysis and design aeromechanical methods for aggressive lightweight blade design are an enabling factor for high efficiency, environmentally friendly aero engines and gas turbines with maintained safety. In combination with a reduced time-to-market the project outcomes will have a strong impact on the competitiveness for the European aero-engine module and stationary gas turbines manufacturers participating in the project. The project will give the partners access to experimental data not available in any other company in the world.

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	Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique	FR
	Techspace Aero SA	BE
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