Abstracts
23rd Blade Mechanics Seminar

Tuesday, 11th September 2018

Eulachpassage, TN E0.58, Technikumstrasse 71, 8401 Winterthur, Switzerland

ZHAW Zurich University of Applied Sciences
IMES Institute of Mechanical Systems, Winterthur, Switzerland

Name:	***Company:***
Dr. Erica Vacchieri	Ansaldo Energia, Italy

Title key note presentation:

Development of a Creep-Fatigue Lifing Strategy and Small Punch Creep Testing Technique for Gas Turbine Hot Gas Path Components

Abstract:

The requirements of the energy market are driven by an increased flexibility due to the actual economic climate and the tendency for discontinuous use of conventional resources in favour of renewable energies. Their flexibility makes Gas Turbines (GT) the main source of electrical power in this highly intermittent energy market. This makes, however, great demands on the fatigue resistance of hot gas path blades and vanes (HGPB&Vs) and in particular on their ability to withstand the interaction of fatigue, creep and environmental damage. While these effects reduce the expected life, maintenance intervals and reparability of these components, continuous cost reduction initiatives for more competitive maintenance plans oblige GT OEMs to extend the life of these critically loaded components. An understanding of the behaviour of the critical parts in this environment is therefore key for GT OEMs to quantify residual component life after service and to rejuvenate HGPBs.

A new creep-fatigue design methodology has been developed for GT blades and vanes of two Ni based superalloys. This includes the definition of an advanced constitutive model able to characterise the critical locations and conditions in HGPB&Vs by FE simulation. Creep-fatigue experiments have then been designed that reproduce the service conditions in critical locations to understand and better describe the respective damage mechanisms. The effectiveness of the methodology has been verified using service-like Thermo-Mechanical Fatigue (TMF) benchmark tests that simulate the situation at critical locations of HGPB&Vs. Two case studies will be presented for which the new procedure has been applied. These results will be underpinned by available field feedback to validate the lifing method.

The assessment of operated components has been conducted not only through microstructural evaluation but also through a miniaturised testing technique that allows the sampling of material from real critical locations. Small punch creep testing has been evaluated for Ni based superalloys and applied for the determination of the residual creep life of critical HGPB&Vs after operation.

Finally, this testing technique has been exploited for the quantification of material recovery in SX blades as obtained through a newly developed rejuvenation heat-treatment process. Thereby, various components after service have been considered with different operating regimes.

Name: ***Company:***

Grzegorz Moneta Ansaldo Energia, Switzerland

Title:

Modelling of Compressor Blade Behaviour under Tip Rubbing Conditions

Abstract:

Blade-casing rubbing in compressors may cause tip wear, where a crack can be initiated (e.g. by cord-wise-bending modes). Extreme levels of rubbing can deform airfoils plastically and redistribute static stresses. Additionally, they can excite vibrations, increasing HCF failure risk. This phenomenon can be caused by several reasons: rotor misalignment, casing ovalisation, blade elongation (creep), etc. The presented analysis investigates the behavior of a compressor blade when tip rubbing occurs. FE simulation has been performed for a hypothetical rotor misalignment case using direct time integration solver. Results have been analyzed to predict the risk of HCF failure and crack initiation location.

Name: ***Company:***

Sebastian Willeke Leibniz University Hannover, Germany

Title:

Reduction of the Maximum Response Amplitude through Mode Localization

Abstract:

Component imperfections break the cyclic symmetry of bladed disks and lead to a local concentration of vibration energy. The forced response of such mistuned structures is often analyzed in search of a worst-case scenario which should be avoided.

In this talk, the underlying phenomenon of mode localization in mistuned structures is reviewed regarding its beneficial impact on the forced response amplitude. Through analyzing a harmonic mistuning pattern, various possibilities to reduce the maximum amplitude below the tuned response level are illustrated. The applicability of these concepts is assessed numerically by using a reduced-order model of a large-scale bladed disk model.

Name: ***Company:***

Dr. Jie Yuan Imperial College London, UK

Title:

An Overview of Reduced Order Modelling Techniques for Dynamic Analysis of Jointed Structures with Localized Nonlinearities due to the Contact Friction

Abstract:

This work presents an assessment of classical and state of the art reduced order modelling (ROM) techniques to enhance the computational efficiency for dynamic analysis of jointed structures with local contact nonlinearities. These ROM methods include classical free interface method (Rubin method, MacNeal method), fixed interface method (Craig-Bampton method), Dual Craig-Bampton (DCB) method and also recently developed joint interface mode (JIM) and trial vector derivative (TVD) approaches. A finite element jointed beam model is considered as test case taking into account two different setups: one with a linearized spring joint and the other with a nonlinear macroslip contact friction joint.

Name: | **Company:**

Thomas Hoffmann | Leibniz University Hannover, Gemany

Title:

Convenient Choice of Friction Test Parameters for Simulation of Turbine Blade Contacts

Abstract:

Friction contacts between turbine blades are commonly used to reduce resonance amplitudes. Usually friction tests on separate test facilities are carried out to determine parameters of contacts between turbine blades. Typical derived parameters are the friction coefficient and the contact stiffness. However, it remains unsolved under which conditions the friction tests have to be conducted to derive contact parameters which are meaningful and transferable to the operating condition of the contact to be simulated. A procedure based on dimensionless numbers of the blade friction contact area is shown which provides rules for the choice of friction test rig conditions.

Name: | **Company:**

Dr. Chiara Gastaldi, Prof. Dr. Muzio M. Gola | Politecnico di Torino, Italy

Title:

In Quest for the Best Performance Dampers

Abstract:

Finding the best performance of an underplatform damper (geometry, centrifugal force) matching with a blade (size, modal features) must be organized in steps:

A. Exclude damper geometries producing unwanted behaviours (pre-optimization).
B. For given platform displacements, isolate damper geometries whose performance (frequency shift, energy dissipation) satisfies user-defined criteria.
C. Determine the damper centrifugal load with due consideration of the blades' HCF safety

Step C requires a nonlinear coupled dynamic analysis of the system, while A and B are based on simple geometrical considerations. All steps however need knowledge on contact parameters, here taken from experimental investigations on rigs purposely developed at the AERMEC Lab, Politecnico di Torino.

Name: | **Company:**

Loris Simonassi | Graz University of Technology, Austria

Title:

Numerical and Experimental Study on the Influence of Inlet Distortion on the Aeroelastic and Aerodynamic Performances of a Low Pressure Turbine

Abstract:

This work presents the results of an experimental and numerical investigation on the influence of inflow inhomogeneity and circumferential pressure distortions on the aeroelastic performances of a low pressure turbine.

The measurements were carried out in the subsonic test turbine facility (STTF-AAAI) at the Institute of Thermal Turbomachinery and Machine Dynamics at Graz University of Technology. Aerodynamic measurements were performed with a fast response aerodynamic pressure probe (FRAPP) and the rotor blade vibration data were acquired using strain gauges in combination with a telemetry system.

The numerical investigation was carried out at Bionic Surface Technologies Gmbh using the commercial software ANSYS. The-flow field was solved using Reynolds-averaged Navier-Stokes (RANS) equations. For the flutter analysis, different Inter Blade Phase Angles (IBPA) were used to obtain the aeroelastic solution.

Name: ***Company:***

Yves Bidaut MAN Diesel & Turbo Schweiz AG, Switzerland

Title:

Numerical and Experimental FSI-study to Determine Mechanical Stress Induced by Rotating Stall in Open Impellers of Centrifugal Compressors

Abstract:

Unshrouded centrifugal compressor impellers operate at high rotational speeds and volume flow rates. At severe part load operating conditions, sub-synchronous rotating flow phenomena (rotating stall) can occur and cause resonant blade vibration with significant stress.

The experimental investigation of unsteady interaction between rotating stall cells and an un-shrouded impeller (presented at the 22nd blade seminar) was reproduced in a scaled model test facility to enhance the understanding of the FSI mechanisms. Measurements with strain gauges and pressure transducers identified the rotating stall patterns and the induced stresses. Rotating stall induced resonant blade vibration was discovered and quantified.

Unsteady CFD simulations predicted the same rotating stall pressure fluctuations as the measurements. The unsteady simulations were then used in FEA to predict the stress induced by rotating stall and to assess the associated aerodynamic damping.

Name: ***Company:***

Tobias R. Mueller University of Stuttgart, Germany

Title:

Influence of Intrarow Interaction on the Aerodynamic Damping of an Axial Turbine Stage

Abstract:

This numerical study aims at examining the influence of intrarow interaction effects on aerodynamic damping predictions of an axial turbine. Aerodynamic damping predictions are usually performed on isolated blade rows by applying truncated simulation domains that feature time-independent boundary conditions. This conventional modeling approach neglects intrarow interaction effects that originate from the rotor-stator interaction and are experienced as wake, potential, vortical and shock interactions. Another intrarow interaction effect is the reflection of acoustic waves from adjacent blade rows. The investigated operating point corresponds to a resonance crossing associated with the fundamental engine order of the stator blade row.

Name: ***Company:***

Mohamed Mohamed University of Manchester, UK

Title:

Development of a Finite Element Model Simulator For Blade Tip Timing Data Generation

Abstract:

Blade tip timing (BTT) simulators provide the best solution for the development and assessment of BTT algorithms since there is no direct alternative to BTT and they provide a low cost way of generating BTT data under controlled conditions. Most of the previously developed simulators were based on a simple mass-spring-damper system, and some of the ones currently in use have no physical basis. A novel BTT simulator based on an experimentally validated finite element (FE) model of a blisk is developed. The use of FE provides more realistic conditions, and enables the application of different sources of BTT uncertainty in a precise way.

Name: ***Company:***

Daniel Heller Imperial College London & Rolls-Royce VUTC, UK

Title:

Determination of Blade Vibration by Blade Tip-Timing Sensor Waveform Analysis

Abstract:

Reliable real-time monitoring of blades in turbomachinery is a desired aim of aero-engine manufacturers in order to understand blade dynamics during operation and to avoid damage from high-cycle fatigue. Blade Tip-Timing (BTT) has become the favoured measurement method for this purpose, having been constantly improved over the last decades. The inherent limitation of the BTT sampling frequency, however, still remains a significant issue and imposes strong restrictions on its applicability to being an independent measurement method. To mitigate this drawback, a novel methodology is proposed to extend traditional BTT data analysis to accommodate sensor waveform characteristics. These waveform characteristics can be used to determine the degree of sensor waveform modulation to estimate the level of blade vibration. In the present study, a numerical bladed disk and sensor model is used to simulate waveforms. A set of unconventional techniques is applied to post-process the signal data to obtain blade-vibration-related information. Results highlight the merit of analysing complete sensor waveforms.