

# **The 16th Symposium on Measuring Techniques in Transonic and Supersonic Flow in Cascades and Turbomachines**

**CAMBRIDGE, UK – September 2002**

## **Foreword**

The Sixteenth Symposium on Measuring Techniques in Transonic and Supersonic Flows in Cascades and Turbomachines was held on the 23<sup>rd</sup> and 24<sup>th</sup> of September, 2002 at the Whittle Laboratory, Cambridge. Forty-three participants attended the symposium and twenty-four papers were presented. The contributions were split into six topics: optical methods, high frequency instrumentation, sensor technology and signal processing, performance measurements, heat transfer and cooling effectiveness and design and validation of test facilities.

The symposium has always been viewed as an occasion for researchers from Universities, Research Institutes and Industry to get together to discuss problems and share experiences involved in making measurements in turbomachines. To ensure the maximum attendance and to allow people to stay for the whole symposium it was decided that it would be limited to two days. To promote discussion the time given for each presentation was limited to 15 minutes with a 10 minutes gap. To encourage discussion and interaction between participants, an extended abstract of 500 words, including one figure, was introduced. This gave participants an overview of the range of research activities and problems encountered by the participants. The emphasis has been moved this year from the hard copy of the proceeding to a web electronic copy. It is hoped that a web-based archive of papers from the symposium will continue to be available for use by the wider turbomachinery community. The organisers were pleased to see that the papers and presentations concentrated on the problems encountered with the measurement and analysis of data.

In addition to the usual areas of research presented at the symposium, the conference organisers were keen to encourage papers in the area of engine sensor technology and engine monitoring. A small number of papers were presented on this subject and it is hoped that the number of papers presented on this subject will increase at the next symposium.

Special thanks must be given to Lorraine Baker without whose hard work this symposium would not have been possible. Finally we would like to thank the authors for their hard work in preparing the papers and presentation and for their enthusiastic participation in the symposium.

The Seventeenth Symposium on Measuring Techniques in Transonic and Supersonic Flows in Cascades and Turbomachines will be held at KTH, Sweden in 2004.

Dr Robert Miller  
Professor Howard Hodson

# The 16th Symposium on Measuring Techniques in Transonic and Supersonic Flow in Cascades and Turbomachines

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## Optical Methods

Chairman: Professor P Bryanston-Cross

### *Paper 1-1*

Optical Measurement Techniques in Engines: PIV and OET

*P. Dunkley, M. Burnett, P. Bryanston-Cross, E. Moll & B. Timmerman, Optical Engineering Lab, University of Warwick. J. Black, Strategic Research Center, Rolls-Royce Derby*

### *Paper 1-2*

Records of Unsteady Transonic Flow Past Blade Cascades by Means of Optical Methods

*J. Ulrych, J. Benetka, Aeronautical Research and Test Institute, Prague.  
P. Šafařík, Czech Technical University in Prague.*

### *Paper 1-3*

Reynolds Stress Measurement with a Single Component Laser Doppler Anemometer

*R. D. Stieger, H. P. Hodson, Whittle Laboratory, University of Cambridge Department of Engineering.*

## Development of High-Frequency Instrumentation

Chairman: Professor C Sieverding

### *Paper 2-1*

Dynamic Analysis of a Fast Response, Air-to-Fuel Equivalence Ratio Sensor

*M. J. Brear, M. Jones, Department of Mechanical and Manufacturing Engineering, University of Melbourne, Australia.*

### *Paper 2-2*

***Withdrawn***

### *Paper 2-3*

Accuracy of Fast-Response Aerodynamic Probes in Unsteady Turbine Flows

*R. J. Miller, Whittle Laboratory, University of Cambridge Department of Engineering and R. W. Ainsworth, Southwell Laboratory, University of Oxford Department of Engineering.*

### *Paper 2-4*

Precise & Rapid Unsteady Pressure Transducer Signal Processing Using a Transfer Function Modeling Technique

*F. Rottmeier, A. Bölc, LTT-ISE-STI, EPFL, Swiss Federal Institute of Technology, CH-1015 Lausanne, Switzerland.*

## **Sensor Technology and Signal Processing**

Chairman: Professor H P Hodson

### *Paper 3-1*

On The Use of Hot Film Sensors in the Investigation of Fluid Dynamic Phenomena in the Near Wall Region

*P. C. Griffin, M. R. D. Davies, Stokes Research Institute, Mechanical & Aeronautical Eng. Dept., University of Limerick, Limerick, Republic of Ireland.*

### *Paper 3-2*

A New Probe for the Measurement of High-Temperature Gases

*X. Yang, R. J. Miller, H P Hodson, Whittle Laboratory, University of Cambridge Department of Engineering.*

### *Paper 3-3*

Experiences in the Application of Intermittency Detection Techniques to Hot-Film Signals in Transitional Boundary Layers

*E. Canepa, M. Ubaldi, P. Zunino, Universita di Genova.*

### *Paper 3-4*

Tip Timing Techniques for Turbomachinery HCF Condition Monitoring

*P. C. Ivey, K. R. Grant, C. Lawson, Cranfield University.*

## **Performance Measurement**

Chairman: Dr R J Miller

### *Paper 4-1*

Performance Measurements in a Transient Turbine Test Facility- Preliminary Instrumentation Development

*N. R. Atkins, R. W. Ainsworth, S. J. Thorpe, Department. of Engineering Science University of Oxford.*

### *Paper 4-2*

Turbine Stage Mass Flow Evaluation in a Compression Tube Facility

*L. Porreca and R. Dénos, von Karman Institute for Fluid Dynamics, Turbomachinery and Propulsion Department, Chaussée de Waterloo, 72, 1640 Rhode Saint Genèse, Belgium.*

### *Paper 4-3*

Determination of the Efficiency of a Cooled Turbine Stage Tested in a Compression Tube Facility

*L. Porreca and R. Dénos, von Karman Institute for Fluid Dynamics, Turbomachinery and Propulsion Department, Chaussée de Waterloo, 72, 1640 Rhode Saint Genèse, Belgium.*

## **Development of High Frequency Instrumentation II**

Chairman: Professor R Ainsworth

### *Paper 5-1*

Virtual Four Sensor Fast Response Aerodynamic Probe (FRAP<sup>®</sup>)

*A. Pfau, J. Schlienger, A. I. Kalfas, R. S. Abhari, Turbomachinery Laboratory, Swiss Federal Institute of Technology, Zuerich, Switzerland.*

### *Paper 5-2*

High Frequency Effects in Unsteady Entropy Measurements

*S. J. Payne, University of Oxford.*

### *Paper 5-3*

Single Pressure Transducer Probe for 3D Flow Measurements

*J. Schlienger, A. Pfau, A.I. Kalfas, R.S. Abhari, Laboratory for Turbomachinery, ETH Zurich, Switzerland.*

### *Paper 5-4*

Pressure measurements at a nozzle guide vane edge using embedded fibre optic sensors

*M J Gander, W N Macpherson, J S Barton, R L Reuben, J D C Jones, Heriot-Watt University, K S Chana, S J Anderson Qinetiq, Pyestock, R Stevens, Rutherford Appleton Laboratory. T V Jones, University of Oxford.*

## **Heat Transfer and Cooling Effectiveness**

Chairman: Professor M Davies

### *Paper 6-1*

Pressure Sensitive Paint (PSP) and Transient Liquid Crystal Technique (TLC) for Measurements of Film Cooling Performances

*G. Wagner, EPFL, Lausanne.*

### *Paper 6-2*

Data Reduction and Thermal Product Determination for Single and Multi-Layer Thin-Film Gauges

*N. Billiard, V. Iliopoulou, F. Ferrara, R. Dénos, Von Karman Institute for Fluid Dynamics, Turbomachinery & Propulsion Department, Chaussée de Waterloo, 72, 1640 Rhode Saint Genèse.*

### *Paper 6-3*

Experimental Technique for Evaluation of Heat Transfer Coefficients with a Thermocamera in a Plexiglas Model

*P. M. Magnusson, J. Hylén, ALSTOM Power Sweden AB, Dep. of Research & Development, S-612 82 Finspong.*

### *Paper 6-4*

Heat Transfer Measurements on a Sidewall and Blade Surface of a Large Scale NGV with Leakage Flow

*A. Dannhauer, German Aerospace Center, DLR.*

## **Design and Validation of Test Facilities**

Chairman: Professor T Fransson

### *Paper 7-1*

**A New Turbine Cascade for Aero-mechanical Testing**

*D. M. Vogt, T. H. Fransson, The Royal Institute of Technology, Chair of Heat and Power Technology, Stockholm, Sweden.*

### *Paper 7-2*

**Low-Speed vs High Speed Testing of LP Turbine Blade Wake Interaction**

*M. Vera, H. P. Hodson, Whittle Laboratory, University of Cambridge Department of Engineering.*

### *Paper 7-3*

**A New Test Facility for Investigating Fluid-Structure Interactions Using a Generic Model**

*D. Allegret-Bourdon, D. M. Vogt, T. H. Fransson, The Royal Institute of Technology, Chair of Heat and Power Technology, Stockholm, Sweden.*

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