

Measuring Techniques for Transonic and Supersonic Flow in Cascades and Turbomachines

Proceedings of 13th Symposium
September 5 - 6, 1996

Editors: C. Gossweiler, G. Gyarmathy

ETH Zürich
Institute of Energy Technology
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Foreword

For the ETH, the Swiss Federal Institute of Technology in Zurich, and especially for the Turbomachinery Laboratory of its Institute of Energy Technology, it was a great pleasure to host the Thirteenth European Symposium on Measuring Techniques for Transonic and Supersonic Flows in Cascades and Turbomachines.

These workshop-type bi-annual meetings of European specialists actively engaged in the field have a long and lively tradition. The variety of topics treated at the symposium reflects the diversity of experimental methods used in turbomachinery research and development.

- Cascade Testing
- Turbomachine Measurements
- Pneumatic Probes / Pressure Measurements
- Fast-Response-Aerodynamic-Probes
- LDAL2F
- Optical Measurements
- Hot Wire / Hot Film
- Heat Transfer / Film Cooling

The Symposium comprised 28 presentations and was attended by 48 participants coming from 9 countries and representing 23 organisations.

In order to maintain the dynamic and informal character of the workshop, contributions were not printed before the Symposium, but the authors had been encouraged to submit an up-to-date written version of their text afterwards. This year all authors have complied with this requirement.

The papers are printed in the same order as the oral presentations were given. No attempt has been made to give an account of the oral discussions.

Following established traditions, the Symposium volume is printed in a restricted number of copies for distribution among the participants. We hope that the volume will be a useful source of reference that will promote and encourage the permanent discussion among the various research groups.

The 14th Symposium (proposed date September 1998), will be hosted by Dr. M. Davies from the University of Limerick.

Zurich, March 1997

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Head of the Organizing Team

Professor Dr. George Gyarmathy
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Technology Zurich

List of previous symposia

- 1969 *von Karman Institute, Rhode Saint Genèse, Belgium*
Transonic cascades, Overpressure, Measurements behind cascades
- 1971 *DFVLR - AVA, Göttingen, Germany*
Choice of measurements location, Instationary effects due to shock/boundary-layer interaction
- 1974 *ONERA, Paris, France*
Comparison of probe types, Blockage problems due to probes
- 1976 *Ecole Polytechnique Fédérale, Lausanne, Switzerland*
Probes, Laser anemometry, New measuring techniques, Instationary effects
- 1979 *Central Electricity Research Laboratories, Leatherhead, United Kingdom*
Probe effects, Flow measurements techniques, Loss and deviation problems, Laser anemometer, Wet steam
- 1981 *Laboratoire Mécanique des Fluides, Ecully, France*
Probe calibration problems, Measurements and data reduction problems, Optical measurement techniques, Wet steam, Other measurement techniques
- 1983 *Institut für Strahlantriebe und Turboarbeitsmaschinen, RWTH Aachen, Germany*
Plane and annular cascades with fixed and vibrating blades, Compressor test rigs, Boundary layer measurements, Optical methods, Wet steam, Probe calibration channels, Probe calibration and probe measurements
- 1985 *Università Degli Studi di Genova, Italy*
Tunnels, Measurements on turbomachines, Optical techniques, Probe calibration
- 1988 *St Catherine's College, Oxford, United Kingdom*
Test facilities, Unsteady flow and high frequency measurements, Optical techniques, Wet steam, Measurement in boundary layers, Heat transfer measurements, Probes and probe calibrations
- 1990 *von Karman Institute, Rhode Saint Genèse, Belgium*
Cascade testing, Pressure Probes, Unsteady pressure measurements, Hot wire and hot film measurements, Heat transfer measurements, Optical measurements, Measurements in short duration wind tunnels, Wet steam
- 1992 *Universität der Bundeswehr, München, Germany*
Cascade testing, Pneumatic probe measurements, Fast-response probe measurements, Hot wire measurements, Optical measurement techniques, Special problems
- 1994 *Institute of Thermomechanics, Academy of Sciences of the Czech Republic, Prague*
Cascade Testing, Flow visualisation, Probe calibration and probe measurements, Wet steam, Fast response probe calibrations and measurements, Fast response temperature measurements, Heat transfer measurements, Optical measurements, PIV

Programme

Session 1 - Cascade Testing

- 1 *The Generation of Instationary Flow conditions in the high speed cascade wind tunnel*
Paola Acton, Leonhard Fottner
- 2 *Evolution of side-wall unsteady pressures produced by forced blade vibrations*
Magnus Norryd, Albin Bölcs
- 3 *WINPANDA - An enhanced PC-based data acquisition system for wake and profile pressure distribution measurements at the high-speed cascade wind tunnel*
Wolfgang Ganzert, Leonhard Fottner
- 4 *Data acquisition and control within the Zürich annular cascade test stand*
Michael Sell, Peter Althaus, Martin Treiber

Session 2 - Turbomachine Measurements

- 5 *Experience with installing a new steady state measurement system at an existing cold flow rotating turbine test facility*
S. Svensdotter, J. Fredriksson, T. Svensson, N. Wei, T.H. Fransson
- 6 *A new multi-stage compressor test facility for inlet distortion investigations*
Werner Jahnen, Leonhard Fottner

Session 3 - Pneumatic Probes / Pressure Measurements

- 7 *Measurement errors with pneumatic probes behind guide vanes in transonic flow-fields*
Frank Truckenmüller, Heinz Stetter
- 8 *Intermittent purging for pressure measurements at wet steam conditions*
Michael Marder, Claus Zimmermann, Wolfgang Steffens
- 9 *Investigations on a pressure sensitive coating measuring system at a straight turbine cascade*
C. Jakiel, K. Fiedler

Session 4 - Fast-Response Aerodynamic Probes

- 10 *An ultra-high speed traverse system for fast response aerodynamic measurements in transient flow facilities*
R.J. Miller, R.W. Ainsworth
- 11 *Fast-response total temperature probe experiments in a turbine facility*
D.R. Buttsworth, T.V. Jones, K.S. Chana
- 12 *Turbulence measurement with a calibrated pitot mounted pressure transducer*
John D. Wallace, Mark R.D. Davies
- 13 *Measurement techniques for instationary flow phenomena in axial compressors*
W. Riess, M. Walbaum

Session 5 - Optical Measurements

- 14 *Improvements in the application of laser-two-focus velocimetry to transonic rotor flows*
F. Kost
- 15 *Treatment of L2F measurement volume distortions created by curved windows*
X. Ottavy, I. Trebinjac, A. Vouillarmet
- 16 *Three dimensional laser two focus anemometry for turbomachinery applications*
S. Charpenel, A. Vouillarmet, P. Ulrych
- 17 *Experiences with the miniaturisation of a combined pneumatic-optical probe*
M. Renner, H. Stetter, X.-S. Cai
- 18 *Investigation of turbulent flow by means of the PIV method*
J. Schabacker, A. Bölcs
- 19 *Heterodyne laser interferometry for cascade flow investigations*
Jakob Woisetschläger, Herbert Jericha
- 20 *Experimental data from optical measurement tests on a transonic turbine blade cascade*
P. Safarik

Session 6 - Hot Wire / Hot Film

- 21 *Rotating hot-wire measurements in a model turbine stage*
C.D. Sheldrake, R.W. Ainsworth
- 22 *The dual hot wire aspirating probe*
Tony Arts, Rémy Dénos, Jean-François Brouckaert, Oliver Popp

Session 7 - Heat Transfer / Film Cooling

- 23 *The transient liquid crystal technique applied for investigations of flat plate and showerhead film cooling*
U. Drost, A. Bölcs
- 24 *Investigation of film-cooling effects on the flow of a transonic turbine blade in a steam test rig*
Martin F. Urban
- 25 *The application of thermal imaging techniques to determine heat transfer coefficients for slow thermal transients*
G.D. Lock, F. Daguze, B.J. Syson, J.M. Owen
- 26 *On testing the aerodynamics of film-cooled blades*
V. Dossena, C. Osnaghi, A. Perdichizzi, M. Savini
- 27 *Discharge coefficients of nozzle guide vane film cooling holes with engine-representative external flow*
D.A. Rowbury, M.L.G. Oldfield, G.D. Lock

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