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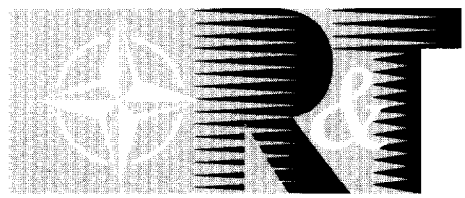

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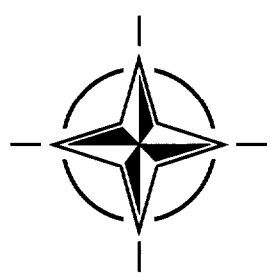
RTO LECTURE SERIES 217

Planar Optical Measurement Methods for Gas Turbine Components

(Méthodes de mesure optiques planaires pour organes de turbomoteurs)

The material in this publication was assembled to support a Lecture Series under the sponsorship of the Applied Vehicle Technology Panel (AVT) presented on 16-17 September 1999 in Cranfield, UK and 21-22 September 1999 in Cleveland, USA.



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To all recipients of RTO publication EN-6 for Lecture Series 216 on "Planar Optical Measurement Methods for Gas Turbine Components".

Paper 6 – "Planar Laser Induced Fluorescence for Investigation of Scalars in Turbulent Reacting Flows"

The author would like to make the following corrections:

Page 6-2, Figure 1

- The concentration on the lower energy level is $N_1(t)$.

Page 6-3, Left-hand column, 3rd paragraph

- ... the steady state balance equation is dN2/dt=...

Page 6-3, Right-hand column, 3rd paragraph

- In the equation for P(t) the right hand term must be divided by c.

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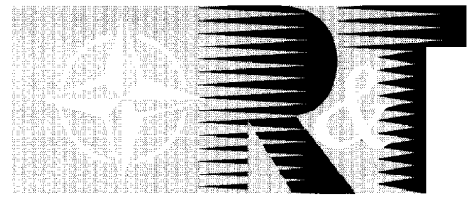

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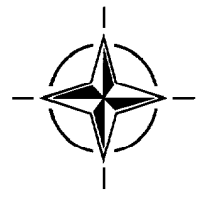

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- IST Information Systems Technology
- AVT Applied Vehicle Technology
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- MSG Modelling and Simulation

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Planar Optical Measurement Methods for Gas Turbine Components

(RTO EN-6)

Executive Summary

Future generations of aircraft and missiles require advances in propulsion engines. The demands are higher specific thrust, lower specific fuel consumption and lower development costs while maintaining a high level of security, durability and life time. Because of the need for reduced costs, these advances can be achieved most effectively by cooperative efforts aimed at the improvement of both the numerical simulation methods and the experimental test and measurement techniques.

By comparing theoretical and experimental results it is possible to validate both the physics and the models employed to approximate the physical process. With regard to the measurement techniques the requirements are: non-intrusive measurements, high accuracy and complete data (instationary and 3D).

During the last years much progress has been achieved in various known techniques, and new methods have been developed from which a significant increase of the experimental output of propulsion tests and therefore remarkable cost reduction can be expected. The aim of this lecture series is to bring this status to the knowledge of the propulsion specialists. Its theme is focused on laser measurement methods for the analysis of the internal flow and reaction processes in propulsion engines. It will address techniques for the measurement of flow velocity, flow density, pressure, temperature and species concentration. Only those methods are introduced which are far enough developed to be applicable to the rough test conditions of propulsion experiments. The course will inform the audience about the fundamentals of the advanced measurement techniques, as well as demonstrate their use in the context of practical applications.

The material in this publication was collected from the research centers of the different NATO nations. It will transfer to the propulsion engineers in a condensed manner the information of the newest capabilities of modern test techniques thus providing the knowledge base for tomorrow's measurement instrumentation of propulsion test facilities. NATO's specific interest in sponsoring this event is based on the requirement for engines of extreme performance characteristics which cannot be realized without further improvements of both CFD and measurement technologies.

The material in this publication was assembled to support a Lecture Series under the sponsorship of the Applied Vehicle Technology Panel (AVT) and organised by the Consultant and Exchange Programme of RTA, and presented on 16-17 September 1999 at Cranfield University, UK, and on 21-22 September 1999 at Ohio Aerospace Institute, USA.

Méthodes de mesure optiques planaires pour organes de turbomoteurs

(RTO EN-6)

Synthèse

Pour réaliser les prochaines générations de missiles et d'avions de combat, des améliorations sont nécessaires dans le domaine de la conception des propulseurs. Les exigences peuvent être résumées ainsi : une poussée spécifique importante, une consommation spécifique de carburant réduite, et une diminution des coûts de développement, avec un haut niveau de sécurité, de longévité et de durée de vie. Étant donnée la nécessité de réduire les coûts, les projets de coopération destinés à améliorer les méthodes de simulation numérique, ainsi que les techniques de mesure et d'essais expérimentales, se présentent comme la meilleure façon de réaliser les avancées nécessaires.

La comparaison des résultats expérimentaux avec la théorie permettra de valider en même temps les principes physiques et les modèles utilisés pour la représentation des procédés physiques. En ce qui concerne les techniques de mesure, les spécifications sont les suivantes : – des mesures non intrusives, une grande précision et des données complètes (instationnaires et en trois dimensions).

Au cours des dernières années, des progrès considérables ont été réalisés en ce qui concerne les techniques déjà connues et de nouvelles méthodes ont été développées, qui devraient permettre de tirer plus d'avantages des essais de propulsion, et, par conséquent, d'obtenir des diminutions de coûts appréciables. L'objectif de ce cycle de conférences est de porter ces techniques à la connaissance des spécialistes de la propulsion. Le programme est axé sur les méthodes de mesures au laser pour l'analyse des flux internes et des procédés de réaction dans les propulseurs. Des techniques pour la mesure de la vitesse, la densité, la pression et la température de la veine, ainsi que la concentration des espèces seront abordées. Seules les méthodes suffisamment développées pour être applicables aux conditions d'essais éprouvantes des expériences de propulsion sont abordées. Le cours permettra aux participants de s'informer des principes fondamentaux des techniques de mesures avancées, et fournira la démonstration de leurs applications pratiques.

Les textes contenus dans cette publication viennent de différents centres de recherche des pays membres de l'OTAN. Ils doivent permettre le transfert aux motoristes, sous forme condensée, des dernières informations sur les possibilités des techniques d'essais modernes, ainsi que l'établissement d'une base de connaissances pour l'instrumentation des essais de propulsion de demain. Cette manifestation a été organisée par l'OTAN en raison de l'intérêt porté aux moteurs ayant des caractéristiques de fonctionnement très poussées dont la construction passe par de nouvelles améliorations des techniques de CFD et des technologies de mesure.

Cette publication a été rédigée pour servir de support de cours pour le Cycle de conférences 217, organisé par la Commission RTO sur les technologies appliquées aux véhicules (AVT) du 16 au 17 septembre 1999, à Cranfield, (Royaume-Uni) et du 21 au 22 septembre à Cleveland, (États-Unis).

Contents

List of Authors/Speakers

Lecture Series Director: Dr Richard SCHODL
Postfach 906958
German Aerospace Centre (DLR)
Institute of Propulsion Technology
51170 Cologne
Germany

AUTHORS/LECTURERS

Dr Mark WERNET
NASA Glenn Research Center
MS 77-1
21000 Brookpark Road
Cleveland, Ohio 44135
UNITED STATES

Professor D. STEPOWSKI
University of Rouen
Ura CNRS 230/Coria
Place Emile Blondel
76821 Mont Saint Aignan
FRANCE

Professor J.P. SULLIVAN
School of Aeronautics and Astronautics
1282 Grissom Hall
Purdue University
West Lafayette
IN 47907-1282
USA

Professor Douglas GREENHALGH
School of Mechanical Engineering
Applied Energy & Optical Diagnostic Group
Cranfield University
Bedford MK 43-OAL
UK

Ingo ROEHLE (Dipl.-Phys.)
German Aerospace Centre (DLR)
Institute of Propulsion Technology
Linder Höhe
51170 Cologne
GERMANY

CO-AUTHORS

Mr. Tianshu LIU
School of Aeronautics and Astronautics
1282 Grissom Hall
Purdue University
West Lafayette
IN 47907-1282
USA

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Paints
Pressure sensors
Temperature measuring instruments
Laser induced fluorescence
Fuels
Drops (liquids)
Soot
Tests
Test facilities
Cost engineering

14. Abstract

This lecture series covers the recent advances of planar optical measurement techniques with respect to their applicability to gas turbine component tests.

During the last years much progress has been achieved in various known techniques, and new methods have been developed from which a significant increase of the experimental output of propulsion tests and therefore remarkable cost reduction can be expected. To bring this status into the knowledge of the propulsion specialists is the aim of this lecture series. Its theme is focused on laser measurement methods for the analysis of the internal flow and reaction processes in propulsion engines. It will address techniques for the measurement of flow velocity, flow density, pressure, temperature and species concentration. Only those methods are introduced which are far enough developed to be applicable to the rough test conditions of propulsion experiments. The course will inform the audience about the fundamentals of the advanced measurement techniques, as well as demonstrate their use in the context of practical applications.

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This publication was prepared to support the Lecture Series 217 organised by the Applied Vehicle Technology Panel (AVT).

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