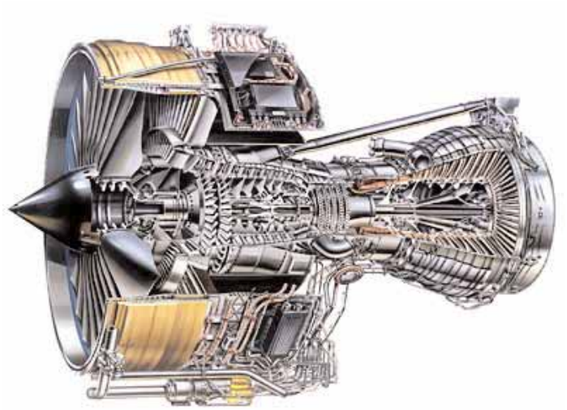
Please correct your address if necessary)

Lecture Series Secretary
von Karman Institute for Fluid Dynamics
72 Chaussée de Waterloo
B-1640 Rhode-St-Genèse
Belgium

von KARMAN INSTITUTE FOR FLUID DYNAMICS

AEROENGINE DESIGN: FROM STATE OF THE ART TURBOFANS TOWARDS INNOVATIVE ARCHITECTURES



March 3-7, 2008

von Karman Institute for Fluid Dynamics
72, Chaussée de Waterloo
1640 Rhode-Saint-Genèse, Belgium

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INTRODUCTION

The first lectures will focus on the **preliminary design** of state of the art turbofan engine for the propulsion of civil aircraft. Issues like thermodynamic cycle, mission analysis, and off design operation (operating line) will be addressed. Practical examples will be presented. Once this important phase is completed, the different design teams have the boundary conditions to start the design of each component.

This starts with the **fan** that must cope with a number of constraints in terms of mechanical resistance, noise and surge margin. The aerodynamic design involves both subsonic flow at the hub and supersonic flow at the tip. The design of the **booster** (low pressure compressor) will then be addressed where the multistage operation and the matching between successive stages are important concerns.

Moving to the **high pressure compressor**, the lectures will first describe the preliminary design based on throughflow calculations. Then, airfoil design, from 2D sections to stage matching optimisation will be addressed. Current trends for future HPC configurations will be outlined.

The design of the **combustion chamber** involves a number of disciplines such as aerodynamics, fuel atomisation, chemistry of combustion and combustor cooling as well as environmental regulatory issues for emissions (NOx, CO, UHC, soot) along with future combustor technologies. Each of these topics will be reviewed while addressing the design of the combustion chamber.

The **high-pressure turbine** has the particularity to be submitted to high levels of centrifugal force and exposure to very hot burned gases. The design process, involving successively 1D, 2D and 3D analysis is targeting the highest stage efficiency while accommodating for the cooling of the blades.

The **low-pressure turbine** design must satisfy high efficiency together with low weight, cost and noise. This is defined primarily by the load and flow coefficients and the number of airfoils. New lightweight/lowcost configurations tend to reduce the number of blades thanks to high lift designs that take advantage of the positive effects of the unsteady row interaction on the airfoil boundary layer behaviour.

Concerns related to fuel consumption and environmentally friendliness have pushed the engine manufacturer community to look into innovative architectures. Some of them are under investigation in the large European projects VITAL, NEWAC, and soon in DREAM. One possibility is to improve the **heat management** in the engine taking advantage of the available hot (turbine exhaust) and cold (external air) heat sources. This leads to an increase of the thermodynamic efficiency of the engine cycle.

Another alternative is to revise the approach to the main source of thrust and noise i.e. the fan. The **geared turbofan** provides lower fan tip speeds with a high speed booster and a high speed low pressure turbine opening perspectives for a more silent, compact and lighter engine. The **2 stage contra-rotating fan** targets similar objectives with a lower fan tip speed, a more compact nacelle (less drag) and a lighter engine. Finally the **open rotor** configuration opens an alternative for a significant reduction of the fuel consumption thanks to an improved propulsive efficiency.

The Lecture Series directors are Dr. R. Dénos, DG Research, 'Aeronautics' and Prof. G. Paniagua, Turbomachinery and Propulsion Department, von Karman Institute.

TIMETABLE

MONDAY MARCH 3, 2008

09:15 **Welcome address**
M. Carbonaro, von Karman Institute for Fluid Dynamics, Belgium

09:30 **Preliminary design**
J. Kurzke, GasTurb Software, Germany

11:15 **Preliminary design (Continued)**
J. Kurzke

14:00 **Fan**
N. Smith, Rolls Royce plc, United Kingdom

15:45 **Fan and booster**
N. Smith

17:00 **Reception**

TUESDAY MARCH 4, 2008

09:00 **HP compressor**
O. Domercq and T. Obrecht, Snecma, France

10:45 **HP compressor (Continued)**
O. Domercq and T. Obrecht

14:00 **Combustion chamber**
T. Doerr, Rolls Royce Deutschland Ltd, CoKG, Germany

15:45 **Combustion chamber (Continued)**
T. Doerr

WEDNESDAY MARCH 5, 2008

09:00 **LP turbine**
P. de la Calzada, ITP, Spain

10:45 **LP turbine**
P. de la Calzada

14:00 **Laboratory tour**

THURSDAY MARCH 6, 2008

09:00 **HP turbine**
F. Haselbach, Rolls Royce plc, United Kingdom

10:45 **HP turbine**
F. Haselbach

14:00 **Heat management**
G. Wilfert, MTU Aero Engines, Germany

15:45 **Geared fan**
G. Wilfert

FRIDAY MARCH 7, 2008

09:00 **Contra rotating fan**
N. Tantot, Snecma, France

10:45 **Open rotor**
N. Tantot

14:00 **VKI bus departure**

PRACTICAL INFORMATION

Lunch will be taken from 12h30 to 14h00. Coffee breaks are scheduled each morning and afternoon.

Programme

LECTURE SERIES
2007-2008

VKI LS

- ☐ BASICS OF AERO-ACOUSTICS AND THERMO-ACOUSTICS
  (3-7 December 2007)
- ☐ INTRODUCTION TO CFD
  (28 January-1 February 2008)
- ☐ POST-PROCESSING OF NUMERICAL & EXPERIMENTAL DATA
  (11-15 February 2008)
- ☐ EXPERIMENTAL DETERMINATION OF DYNAMIC STABILITY PARAMETERS
  (18-22 February 2008)
- ☐ 35TH CFD / ADIGMA COURSE ON VERY HIGH ORDER DISCRETIZATION METHODS
  (14 -18 April 2008)
- ☑ AEROENGINE DESIGN: FROM STATE OF THE ART TURBOFANS TOWARDS INNOVATIVE ARCHITECTURES
  (3-7 March 2008)
- ☐ LARGE EDDY SIMULATION AND RELATED TECHNIQUES. THEORY AND APPLICATIONS
  (10-14 March 2008)
- ☐ STRUCTURAL DESIGN OF AIRCRAFT ENGINES - KEY OBJECTIVES AND TECHNIQUES
  (13-16 May 2008)
- ☐ ATMOSPHERIC BOUNDARY LAYER FLOWS IN AIR POLLUTION MODELLING
  (19-23 May 2008)
- ☐ OPTIMIZATION AND MULTI-DISCIPLINARY DESIGN
  (2-6 June 2008)
- ☐ ADVANCES IN LAMINAR-TURBULENT TRANSITION MODELLING (RTO-AVT-VKI)
  (9-3 June 2008)
- ☐ NON-EQUILIBRIUM GAS DYNAMICS, FROM PHYSICAL MODELS TO HYPERSONIC FLIGHTS (RTO-AVT-VKI)
  (8-12 September 2008)

OTHER CONFERENCES:

- ☐ XIX BIANNUAL SYMPOSIUM ON MEASURING TECHNIQUES IN TURBOMACHINERY
  (7-8 April 2008)

COURSE FEE

The fee for the lecture series is 1180 euro, applicable to citizens of NATO countries contributing to the financing of the VKI (Belgium, Czech Republic, France, Germany, Hungary, Iceland, Italy, Luxemburg, Norway, Portugal, Spain and Turkey). For citizens of other NATO countries and of NATO partner countries, the fee is of 1545 euro. For non-NATO citizens, the fee is of 1665 euro. The prices are VAT included (VAT of 21%).The fee includes printed notes, transport between VKI and to the recommended hotels, lunches, beverages, and administrative costs.

FELLOWSHIPS

To encourage greater participation in our Lecture Series programme by university members, the Institute has established a limited number of VKI Lecture Series fellowships for citizens of NATO countries contributing to the financing of the VKI. The recipient of a fellowship is entitled to attend the VKI Lecture Series at a reduced fee, which will be of 595 euro for assistants not having a Ph.D. degree and for Ph.D. candidates, or 295 euro for undergraduate students. These reduced fees are also available for all NATO citizens coming from a university in a VKI financing country.

The request to be considered for an award must accompany the application to attend the Lecture Series, and the applicant must provide a recommendation letter from his or her professor; if not done so, the request will not be taken into consideration. All possible alternative sources of funding should be investigated before aid is requested under this scheme, so that those most in need will benefit.

METHODS OF PAYMENT

Payment 2 weeks prior to the beginning of the course (name and course title clearly indicated) by bank transfer to our account Nr 210-0315330-35 at Fortis Bank, avenue de la Forêt de Soignes 322, 1640 Rhode-Saint-Genèse, Belgium, IBAN BE57 2100 3153 3035 (strongly recommended). SWIFT BIC GEBA BE BB

Late registration can be paid cash in EURO, or by VISA or Eurocard at the beginning of the course.

PROCEEDINGS

Lectures will be given in English and printed notes will be distributed during registration. Proceedings of other non-RTO lecture series may be purchased at VKI (by e-mail: vanhaelen@vki.ac.be or by fax : 32 2 359 96 00). Information can be found on http://www.vki.ac.be.

HOW TO REGISTER

It is highly recommended to send the registration/hotel reservation form at the latest 15 days before the beginning of the course. A letter of acceptance and additional information will be sent on receipt of the application form.

ACCOMMODATION & TRANSPORT

Participants are advised to make their reservations as early as possible. VKI secretariat (secretariat@vki.ac.be) can book rooms upon request in the recommended hotels listed below. Daily rates include all charges and continental breakfast. These prices are indicative and could be subject to changes.

Hôtel des Colonies http://www.hotel-des-colonies.com	Single: 110 € / Double: 130 €
Hôtel Vendôme http://www.hotel-vendome.be	Single: 100 € / Double: 130 €
Thon Hotel Brussels City Centre http://www.thonhotels.be/	Single: 135 € / Double: 165 €
Hôtel Le Dôme http://www.hotel-le-dome.be	Single: 120 € / Double: 140 €
Hôtel Orts http://www.hotelorts.com	Single: 200 € / Double: 250 €
Progress Hôtel http://www.progresshotel.be	Single: 200 € / Double: 220 €

However, participants could occasionally find special offers on hotel websites.

A youth hostel, the Sleepwell is within walking distance of the recommended hotels. We invite you to make your own reservation through their website: http://www.sleepwell.be.

The hotels situated in Brussels are all within walking distance from the Gare du Nord and the Place Rogier. A train service links the airport with the Gare du Nord (15' journey). Complete your journey to the hotel/youth hostel on foot or by taxi. Each morning and evening, bus transport will be provided between the Place Rogier and the von Karman Institute, located in Rhode-Saint-Genèse, a suburb south of Brussels.

The following hotel, which is about 1.5 km from the Institute, is also recommended, particularly for those who travel by private car. The hotel is about 12km from the center of Brussels and a high standard of comfort is assured.

Auberge de Waterloo****
e-mail: aubergedewaterloo@skynet.be
Fax : +32 (0)2 358 38 06 - Tel: +32 (0)2 358 35 80
Chaussée de Waterloo 212 -
1640 Rhode-Saint-Genèse

For more information about the localization of the Institute and the hotels, please visit our website on http://www.vki.ac.be.

APPLICATION FOR ADMISSION TO VKI LECTURE SERIES

Lecture Series Title: .....

☐ Mr ☐ Mrs
Family name: ..... Firstname: .....
Name & full address of organisation, institution or university: .....
Phone nr: ..... Fax nr: .....
Position or title: ..... E-mail: .....
☐ Asking a reduced fee and joining a recommendation letter as: ☐ undergraduate student ☐ Ph.D. candidate or University assistant
Company / University VAT number: .....
VAT of the von Karman Institute: BE 0407 185 709

HOTEL RESERVATION *(if applicable)*

I require accommodation at Hôtel ..... for ..... person(s)
Single: ..... Double: ..... Date of arrival: .....
I shall require transport to and from the Institute ☐☐ Date of departure: .....
I do not require transport to and from the Institute ☐☐
Please indicate any special needs (e.g. vegetarian, ...): .....
.....
.....
Date: ..... Signature: ..... Nationality: .....

Please mail under-cover to VKI