KTH Industrial Engineering
and Management

MJ2241 Jet Propulsion Engines – General Course

Course PM 2012

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Introduction

The course MJ2241 Jet Propulsion Engines - General Course is taught in period 2 at KTH Energy Technology. It is conceived as a basic course serving as preparation for the subsequent more advanced courses:

- Thermal Turbomachinery MJ2430 (period 3)
- Airbreathing Propulsion Intermediate Course I MJ2244 (period 3)

Requirements for this course are basic knowledge in thermodynamics and fluid mechanics.

As turbomachines play a major role in (airbreathing) jet propulsion, the proper understanding of turbomachines is key to mastering the field of jet propulsion. The present course therefore shares a part of the lecture with the course MJ2429 Turbomachinery.

Syllabus

Jet propulsion is of paramount importance to air and space transport. In general, the type of propulsion can be split into airbreathing propulsion and rocket propulsion. In the former case, the surrounding air is used as oxidizer to fuel that is transported in the vehicle being propelled. In the latter case, the oxidizer and the fuel is transported in the vehicle. The focus of the present course lies on airbreathing jet propulsion.

Airbreathing propulsion is largely relying on turbomachines independent of propulsion concepts (propeller, ducted fan, future unducted fans). The reason is to be found in the unprecedented power density as well as reliability of these machines. In other words, modern air transport would not be possible without having turbomachine-powered propulsion devices in place.

The present course gives an introduction into (airbreathing) jet propulsion concepts with a clear focus on turbomachinery. It is an introductory course that optionally can be followed-up by more advanced courses on this topic.

The course corresponds to 6 ECTS Credits.

Course Overview

The course will start off with a general introduction into jet propulsion concepts. Early in the course the focus will be directed towards turbomachines given the important role they play in propulsion. The aero- and thermodynamic terminology and equations relevant for these machines are discussed extensively. The essential fundamental theory is explained in an interactive and animated way. Additionally, today's and tomorrow's need for turbomachines is discussed and the future development and research needs are also elucidated. The principles of various propulsion concepts and their impact on energy usage and consequently the environmental impact are treated. Calculations and laboratory exercises are performed with the aim to understand the physical relationship between the aero- and thermodynamics of the machine as a whole a well as specific components.

Course Objectives

The course aims at giving an overview of airbreathing jet propulsion concepts with a distinct focus on turbomachinery.

After completing the course the student will be able to:

- Understand airbreathing jet propulsion concepts
- Understand the role of turbomachines in jet propulsion
- Give detailed descriptions of the main elements and applications of turbomachines
- Recognize typical designs of turbomachines
- Explain the working principles of turbomachines and apply it to various types of machines
- Determine the velocity triangles in turbomachinery stages operating at design and off-design conditions
- Design the stages in axial turbines and axial compressors given the overall required pressure and temperature ratios with (1D) analytic theory
- Use design parameters for characterizing turbomachinery stages
- Determine and explain the losses in different turbomachines
- Explain the limits of safe and efficient operation of compressors
- Understand and discuss technically today's and tomorrow's needs for turbomachines
- Recognize and discuss today's and tomorrow's use of turbomachines in jet propulsion for enabling a sustainable society

Course Structure

The course is run side-by-side with the course MJ2429 "Turbomachinery" sharing part of the problem-solving seminars. In addition, a number of dedicated MJ2241 lectures are held that exclusively address propulsion concepts and cycle analyses.

The course is largely aligned around solving problems such as to teach the students the subject on a practical background. Each week, a new problem will be made available to the students and solved and discussed in class. The theoretical background for solving these problems is taught via recorded learning units that the students can follow at their preferred pace, time and place. These lecture units are directly accessed from the lecture notes (interactive e-book). The course schedule maintained in KTH Social contains references to the part of the learning material to be followed for a given problem. The problems do not need to be handed in.

In addition, weekly self-assessment tests are made available. These self-assessment tests contain questions and problems that examine the knowledge treated during the respective week. The questions are of similar type as during the exam and thereby prepare the students for the exam in a continuous manner. The self-assessment tests are not compulsory but can give the student one bonus point (one percentage point) for later use in the exam if performed successfully[1]. In addition, they allow the students to stay on the ball.

Two laboratory exercises are performed such as to allow the students to acquire real tests data in an interactive manner and to further analyze this data. The following laboratory exercises are performed:

- Measurements of the flow field downstream of a turbine cascade
- Preliminary design of a turbomachine-based propulsion device (analytical)

The laboratory exercises are performed remotely. Students following the course at KTH on-campus have the possibility to perform the lab on site while accessing the controls through the remote lab interface.

The following persons are involved in this course:

- Main lecturer/examiner: Assoc. Prof. Damian Vogt, damian.vogt@energy.kth.se
- Course/lab assistant: Lucio Monaco, lucio@kth.se

[1] A self-assessment test is considered successful if at least 75% of the answers are correct

Requirements to Pass

Exam (TEN1), 6 ECTS, entire course including laboratory exercises, grades A-E, FX, F[2]

Grading scale

From %	To %	Grade
92	100 (+ bonus points[3])	A
80	91	B
68	79	C
56	67	D
50	55	E
40	49	FX
0	39	F

Lab exercises:

- The active participation in the lab exercises is compulsory.
- All students must prepare according to instructions ahead of the lab exercises.
- It is not compulsory to hand in lab reports.
- The laboratories will be examined as part of the exam.

Language

The language of instruction is English.

[2] Note: grade E and higher means "passed". A grade FX can be raised to a grade E after successful completion of an additional task defined by the examiner. Grade F means "failed".
[3] Bonus points: bonus points can be obtained from for successfully passed weekly self-assessment tests. The bonus points will only be taken into account if the exam itself is passed (i.e. at least 50% correct).

Webtools

Two KTH webtools are used in this course as are **Bilda** and **KTH Social**. Bilda is accessible at http://bilda.kth.se. The course event is called "MJ2241 (2012) Jet Propulsion Engines - General Course". If a student does not have access to the event in Bilda, it most probably indicates that he/she is not registered to the course properly. In such case, please contact the course assistant. KTH Social is among others accessible from the KTH main website www.kth.se.

The use of these two tools is organized in the following manner:

Bilda

- Course documents (administrative, lecture notes)
- Administrative actions (confirmation of participation, enlisting for exam)
- Podcasts of lectures (through podcast channel)
- Discussion forum (discussion of technical questions by peers and faculty)
- Online tests (weekly self-assessment tests, exams)
- FAQs
- Submission of lab reports
- Course evaluation

Social

- General course description
- Course schedule containing the information of lecture contents
- Other information of interest

Confirmation of Participation

All students must confirm their participation in the course during the first week of the course. The confirmation is done online (rather than on a list in class) using the course webtool (Bilda), section "Contents". When confirming the enlisting, the students will be asked to give additional information, which is needed for administrative purposes.

Course Literature

Main course literature:

> Vogt, D.M., 2012, "Turbomachinery Lecture Notes", KTH Heat and Power Technology (Interactive e-book containing among other recorded learning units made available through Bilda)

Additional reading:

> Dixon, S.L., Hall, C.A., 2010, "Fluid Mechanics and Thermodynamics of Turbomachinery", 6th edition, Butterworth-Heinemann, ISBN13 9781856177931 (this book is recommended to students who would like having additional reading in addition to the lecture notes.)
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> Rolls-Royce, 2010, "Rolls Royce: The Jet Engine book", http://shop.keypublishing.com/acatalog/Rolls_Royce__The_Jet_Engine.html

In Case of Missing Lectures

It happens that students miss lectures. In the present course the lectures are recorded (notes on whiteboard, audio) and therefore can be followed afterwards. The recorded lectures are made available through Bilda by means of a podcast channel. Students can subscribe to the podcast using iTunes and follow these on a computer/iPad/etc. Also, the whiteboard notes are stored and made available in Bilda (Document section). Despite these features, students are encouraged to follow the lectures in class.

Course Schedule

Please refer to the course schedule published on KTH Social.

In Case of Questions

If you are uncertain about something, your first checkpoint should be the "FAQ" section in Bilda. If you do not find an answer to your question, please send an email to the course assistant.