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Agenda and schedule 2024
Industrial Energy Processes, KE2010 (7.5 ECTS points)
Version: 23 August

Welcome to the course Industrial Energy Processes!

Energy conversion systems are something that all people are dependent upon for transports, heating, household appliances, etc. The energy systems of the world are under a steady change and the major challenge today is how to combine sustainability with increased primary energy consumption globally. The special attention is on the close relationship between the use of primary energy and human-induced climate change.

In Sweden, the industrial sector uses more than one third of the energy (final use) and the industrial sector is the second emitter of fossil carbon dioxide after the transport sector. The supply and use of energy have become an increasingly strategic issue for energy intensive industrial companies due to volatile global energy prices and the perceived risk with unstable policy instruments intended to mitigate the use of fossil fuels (carbon taxes, energy taxes, etc.).

This course is covering advanced applied thermodynamics of importance for energy processes of industrial scale. During the course you will learn about technical, economic and, to some extent, environmental characteristics of real energy processes. The main part of the course is attributed to theory and problem solving within the field of technical thermodynamics.

Learning outcomes

After finished course, you should be able to:

- Analyse the technical performance of energy processes in industrial scale with the help of thermodynamic relationships.
- Calculate combustion reactions and heat yields for different fuels.
- Perform thermodynamic calculations on thermal power and combined heat and power cycles, e.g. steam cycles, combined cycles, and stationary motors.
- Estimate the potential for energy efficiency by utilizing process integration (pinch analysis) including heat exchanging, heat pumping, and waste heat recovery.
- Apply relevant system boundaries to energy-related problems.
- Analyse the performance of energy conversion systems in relation to ideal systems and with this as a starting point suggest improvements.
- Evaluate the economic consequences of different energy solutions.

Course content

The course consists of:

1) Lectures, exercises (tutorials), and calculation practices (räknestugor). During the lectures, different concepts and theories will be introduced by the teacher in a broader context (especially system aspects, energy recovery, economy, etc. that are insufficiently covered in the textbook). The exercises (tutorials) and calculation practices are mainly used for the individual training of energy calculations.
2) An assignment where the student evaluates an industrial system for combined heat and power (CHP) or heat only generation. During the assignment, the student will practise the application of energy and mass balances for a complete cycle as well as analysing the financial viability of the plant. The results from the assignment will be presented as part of the examination.

Assignment (beräkningsuppgift)

The assignment is normally carried out in a group of two or three. It is preferably solved by using Excel or Matlab. The final assignment report is linked to the final grade through the number of revisions of the report before it has passed.

Intermediate tests (kontrollskrivning)

Over the course, two intermediate tests that together could give up to 20 points are offered. If 12 or more points are achieved in these tests, full score will automatically be given on one specified problem at the exam; this problem should therefore not be solved. The benefits provided by passing the limit for the intermediate tests can be used for the exam and the following reexam in December 2024.

In addition to the bonus the intermediate tests may provide, they have proved to be very valuable training for the rest of the course. The results from the first intermediate test will also be used to form the assignment groups.

Voluntary practices for problem solving (räknestugor)

During the course there will be voluntary practices (räknestugor), where the student can practise problem solving together with the teachers. The students may ask the teachers for further explanations of problems and prepare themselves for the intermediate tests and the exam, as well as for the assignment work. We also try to answer questions through e-mail. Please schedule an appointment if you want to visit us.

Study visits

We hope to be able to arrange a full day field trip to Siemens Industrial Turbomachinery in Finspång and a half day field trip to the CHP plant at Värtaverket. The first is a factory where turbines have been produced continuously since 1913 and the CHP KVV8 at Värtaverket is the largest bio-fuelled CHP plant in Europe. Previous years, the field trips have been much appreciated among the students.

Course material

- Textbook: "Principles of Engineering Thermodynamics" (SI Version), by Moran & Shapiro (any edition). Earlier editions that also are called “Fundamentals of Engineering Thermodynamics” will work.
- Examples with solutions (available on Canvas)
- Previous tests and intermediate tests with solutions (available on Canvas)
- Tables and diagrams (T&D), “Tabeller och diagram för energitekniska beräkningar” together with hs-diagrams for water and air (circa SEK 240 by credit card at the Student’s Office at Teknikringen 28)

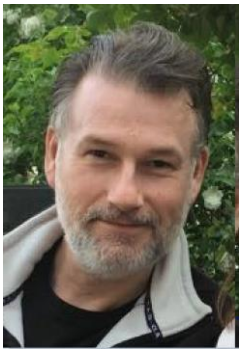
Examination

The exam (TEN1, 4.5 ECTS points) is due on 25 October (Tuesday), 08oo-13oo.
Intermediate tests: 9 September, 08oo-10oo, and 20 September, 08oo-10oo.

The assignment (BER1, 3ECTS points) includes a presentation, a final report, and an individual reflective report about your own contributions in relation to the project as a whole. The presentation is due on 7 October. The final report is linked to the final grade through the number of revisions of the report before it has passed. The final grade will be one step higher than the grade for the exam if the final report passes without revision and the final grade will be equal to the grade for the exam if the report passes after the first revision. The final grade will thereafter decrease with one step compared to the grade for the exam for each time the report is revised before it has passed.

You are allowed to retake the exam in an attempt to improve your grade even if you have passed the exam previously but only once. If the grade is lower in the second attempt, you will keep your first grade.

Teachers



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Week No	Date, time	Activity
35	Mon 26 Aug 1015-1200	Lecture 1: Introduction, energy and society, course description
	Mon 26 Aug 1315-1500	Exercise 1: Steam tables, steam diagram, air diagram
	Wed 28 Aug 1515-1700	Lecture 2: Fundamentals of engineering thermodynamics, energy efficiency, exergy efficiency
	Thurs 29 Aug 1315-1500	Exercise 2: Energy & exergy analysis
	Fri 30 Aug 1015-1200	Lecture 3: Combustion, flue gas condensation
36	Mon 2 Sept 1015-1200	Exercise 3: Combustion, flue gas condensation
	Tue 3 Sept 1515-1700	Lecture 4: Steam cycles
	Wed 4 Sept 0815-1000	Exercise 4: Cont. combustion, turbines
	Fri 6 Sept 0815-1000	Lecture 5: Gas turbine cycles, gas engines, combined cycles
	Fri 6 Sept 1015-1200	Exercise 5: Turbines, compressors
	Fri 6 Sept 1315-1600	Voluntary practice (räknestuga)
37	**Mon 9 Sept 0800-1000**	**INTERMEDIATE TEST 1** (Kontrollskrivning)
	Mon 9 Sept 1315-1500	Exercise 6: Steam cycles
	Tue 10 Sept 1515-1700	Lecture 6: Heat pumps, Cooling machines, steam compressors
	Fri 13 Sept 1015-1200	Exercise 7: Gas turbines & combined cycles, (heat pumps)
	Fri 13 Sept 1515-1700	Exercise 8: Heat pumps
38	Mon 16 Sept 1015-1200	Lecture 7: Pinch technology, process integration
	Mon 16 Sept 1315-1500	Exercise 9: Pinch technology
	Tue 17 Sept 0730-1800	If possible: study trip to Siemens in Finspång
	Fri 20 Sept 0800-1000	**INTERMEDIATE TEST 2** (Kontrollskrivning)
39	Mon 23 Sept 1015-1130 Mon 23 Oct 1130-1500	Lecture 8: Energy systems and economy Voluntary practice (räknestuga), assignment work (lunch break at 1200)
	Tue 24 Sept 1300-1500	Study trip to Värtaverket/Stockholm Exergi
	Fri 27 Sept 1015-1200	Voluntary practice (räknestuga), assignment work
	Fri 27 Sept 1515-1700	Voluntary practice (räknestuga), assignment work
40	Mon 30 Sept 1015-1200	Voluntary practice (räknestuga), assignment work
	Mon 30 Sept 1315-1500	Voluntary practice (räknestuga), assignment work
41	Mon 7 Oct 1015-1500	Presentation and discussion of assignment results
	Tue 8 Oct 1015-1200	Voluntary practice (räknestuga), assignment work
	Tue 8 Oct 1315-1500	Voluntary practice (räknestuga), assignment work
43	Fri 25 Oct 0800-1300	**FINAL EXAM**
51	Thurs 19 Dec 0800-1300	**RE-EXAM**

Study guide for **Moran, Shapiro, Boettner & Bailey**, "Principles of Engineering Thermodynamics" (7th, 8th, or global ed.), or **Moran & Shapiro**, "Fundamentals of Engineering Thermodynamics" (5th or 6th ed.) that is used during the course Industrial Energy Processes

Chapter	Remark	Week
1. Getting Started: Introductory Concepts and Definitions	Prerequisite from earlier courses	35
2. Energy and the First Law of Thermodynamics	Included	35
3. Evaluating Properties	Included	35
4. Control Volume Analysis Using Energy	Included 4.4 In edition 5 and 6 not included 4.12 In edition 7 and 8 not included	35
5. The Second Law of Thermodynamics	Included	35
6. Using Entropy	Included	35
7. Exergy Analysis	Included	35
8. Vapor Power Systems	Included	36
9. Gas Power Systems	9.1-9.11 Included 9.12-9.14 Not included	36
10. Refrigeration and Heat Pump Systems	Included	37
11. Thermodynamic Relations	Not included	--
12. Ideal Gas Mixtures and Psychrometrics Applications	Not included	--
13. Reacting Mixtures and Combustions	13.1-13.5 Included 13.6-13.9 Not included	35
14. Chemical and Phase Equilibrium	Not included	--