SE2127 Packaging Materials, 7,5 credits

Study period 3, spring semester 2011

The course is given by the Department of Solid Mechanics, KTH Engineering Sciences in collaboration with the Department of Fibre and Polymer Technology, KTH, Chemical Science and Engineering and Packaging Solutions at Innventia.

Learning objectives

After the course, the student should be able to

- describe the components of the packaging system performing in supply and demand chains, and demonstrate how these influences the design of packages,
- discuss important applications in packaging technology using correct terminology from physics, mechanics and chemistry,
- select suitable material and technology for manufacturing of a particular type of packages,
- explain the properties of a packaging material based on the structure and chemistry of the material,
- relate the results from mechanical testing of packaging materials to relevant fundamental solid mechanics parameters, and
- demonstrate the value of modelling and numerical calculations for design of packages.

Course content:

- Packaging logistics – the packaging value chain
- Functions of sustainable packaging systems
- Manufacturing of packaging
- Polymer based packaging materials
- Paper and board packaging materials
- Barriers
- Optical, printing and closing properties
- Solid mechanics for paper and paperboard
- Converting properties for manufacturing of wood fibre based packages
- The finite element method for packaging design
- Metal and glass packaging

Credits: 7.5 hp

Level: Advanced

Grades: A-F

Language: English

Course structure

Lectures 38 h, laboratory 12 h, design project

Examiner

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Course web pages

The forum KTH Social, https://www.kth.se/social/course/SE2127, will be the primary course web page. To access this page you need to login to your KTH account. This is the web page where lecture notes and other information will be posted. Here, you can also ask questions to the instructors as well as to other students in the course.

However, the department course web page, http://www.kth.se/sci/institutioner/hallf/gru/kurser/SE2127/VT11-1, will also be used as a back-up.

Prerequisites

A basic course in solid mechanics comparable to SE1010 Solid Mechanics gkMPT, SE1020 Solid Mechanics gkBD, SE1012 Solid Mechanics gkIPI or SE1055 Solid Mechanics gkF is desirable, but not formally required.

Laboratory

Laboratory 1: Packaging logistics analysis using the software CAPE PACK.

Laboratory 2: Preliminary study visit

Laboratory 3: Measurements of some mechanical properties of paper and board packaging materials and structures at Innventia. Test pieces will be prepared in advance in the laboratory of the Department of Solid Mechanics.

Participation in the laboratories is required, and the report on Laboratory 3 will contribute to the final grade in the course. More information on the laboratories will be handed out during the lectures and posted on the course web pages.

Design project

To gain experience for the quality measures of paperboard and plastics packages you should in groups of (2)3 students design a package made from a paperboard plastic composite materials. This design should include analysis of strength and stiffness, as well as artistic design, printing, manufacturing and cost considerations.

Your design should be reported in a "short paper", and presented orally during a seminar on Friday, March 12. The design project will be assessed regarding content, analysis, written and oral presentation, and will affect the final grade. Well ahead of the oral presentation, each group should give the examiner a short status report on the project work in order to clarify possible misunderstandings and to check details in the analysis.

Short paper A full text paper is not expected, but the "short paper" should be written as a complete report. You can write the short paper in English or Swedish at your own choice, but the presentation should be in English.

Presentation You should present your design using PowerPoint and demonstrators if available. A computer and projector will be available. Each group will only have approximately 15 minutes for their presentations.

The grade of the design project will be based on a combination of technical content (60 %), short paper (20 %) and oral presentation (20 %). The grade will be given as a score that will be added to the score on the written exam (if passed) and therefore it can affect the final grade on the course, see below.

More information on the design project will be given during Lecture 2 and posted on the course web page.

Examination

Written exam (TEN1, 4 credits), Home assignment and Laboratory (LAB1, 2 credits), Design project (ÖVN1, 1.5 credits)

The final grade on the course is given by a combination of TEN1, LAB1 and ÖVN1, where the score on the paper testing laboratory and the design project is added to the score on the written exam (when passed) to give the overall score that is used to give a grade on the course.

The maximum score on the written exam is 60 and a score of 30 is required to pass the exam. The laboratory report can give an additional score between -1 and 3, and the design project can give an additional score between -3 and 6. As a result they can change the final grade of the course both upwards and downwards (but not below E in case you have passed the written exam).

Literature

1. (PBoP) Pocket book of packaging
2. (FoPT) Walter Soroka, *Fundamentals of packaging technology,* 3rd Edition, Institute of packaging professionals, Naperville, Illinois, USA, 2002.
3. (BOA) *Paperboard Reference Manual*, Iggesund Paperboard AB (1993)
4. (CCC7) Twede, D. and Selke, S. E. M., *Cartons, Crates and Corrugated Board – Handbook of Paper and Wood Packaging Technology* (Chapter 7), DEStech Publications, Inc., Lancaster, Pennsylvania, USA, 2005.
5. (LJU) *Pulp and Paper Chemistry and Technology - Volume 4, Paper Products Physics and Technology,* Chapters 1, 2, 3, 4, 9, 10, 11, 12, 66.
6. (FRAC) Östlund, S. and Mäkelä, P., *Fracture properties*, KTH, 2011.
7. (HPT) R. E. Mark, C. C. Habeger, Jr., J. Borch and M. B. Lyne (Editors), *Handbook of Physical Testing of Paper* (Chapter 11), 2nd Edition, Marcel Dekker, New York, NY, USA, 2002.
8. (BPM) Barrier packaging materials, M. S. Hedenqvist, Chapter 26, 547-563, in *Environmental Degradation of Materials*, Ed. M. Kutz, William Andrew Publ., Norwich, NY (2005).
9. (LOG) Johansson, K., Olsmats, C., Tiliander, L. and Lorentzon-Karlsson, A., *Packaging Logistics*, Packforsk, Kista 1997, pages 9-15, 33-45.
10. (CDO) Chris Dominic
    Packaging Networks – A Study on Swedish Packaging Industry.
    Emergent structures in Supply/Demand Chain Management.
    Supply/Demand Chain Management
    Summary of published papers
11. (MET) *Metal Packaging*, Metal Packaging Manufacturers Association, www.mpma.org.uk (2006).
12. Magnusson, M. S. and Östlund, S., Problems with Solutions, KTH, 2011.

A folder containing 3-12 will be sold at in the student office of the Department of Solid Mechanics for SEK 150. Additional material will be handed out during the lectures for free.

The book, 2 (FoPT) Walter Soroka, *Fundamentals of packaging technology*, 3rd Edition, Institute of Packaging Professionals, Naperville, Illinois, USA, 2002, will be provided by the department during the course for SEK 500. If you want to keep the book after the course, the price is SEK 700; otherwise you will have to return the book in undamaged conditions and you will get your SEK 500 back.

Additional suggested reading

13. The Wiley Encyclopedia of Packaging Technology, 2nd Edition, A. L. Brody, K. S. Marsh, Wiley, New York, USA, 1995.

14. Savolainen, A. (ed.), "Paper and Paperboard Converting", Papermaking Science and Technology, Book 12, Finnish Paper Engineers' Association & Tappi, Fapet Oy, 1998.

15. R. E. Mark, C. C. Habeger, Jr., J. Borch and M. B. Lyne (Editors), "Handbook of Physical Testing of Paper" (Chapters 8 and 9), 2nd Edition, Marcel Dekker, New York, NY, USA, 2002.

16. Selke, S. E. M., Culter, J. D. and Hernandez, R. J., "Plastics Packaging: Properties, Processing, Applications and Regulations, Carl Hanser Verlag, USA, 2004.

17. Olsmats, C. and Dominic, C., Packaging Scorecard – A packaging performance evaluation method, Packaging Technology and Science **16**: 9-14 DOI: 10.1002/pts.604 (2003)

18. Dominic, C, Integrating Packaging Suppliers in to the Supply/Demand Chain, *Packaging Technology and Science* **18**: 151-160, 2005. DOI: 10.1002/pts.684.

19. Dominic, C., *Packaging Networks – a framework for integrating packaging suppliers in the demand chain*, Lund University, 2006.

Reading advice

A custom-made text book at a reasonable price is not available for this type of course. For that reason, the literature list is long in order to cover the contents of the course, and there is also some additional reading suggested above. This situation is not unrealistic from a practical point of view. In practice you are frequently facing the situation that several sources of information are needed to get knowledge you are looking for. It is, however, unrealistic to expect that the students should know all this literature in detail, thus, some kind of reading advice is required.

It is suggested that the lecture notes form the basis for individual studies. In the literature the concepts covered at the lectures are covered in more detail, sometimes at several locations, and by finding and using this information it should be possible to get a thorough understanding of the concept. Please, note that the assessment of the course content is focused on conceptual understanding rather than repeating facts, and knowledge of the underlying fundamentals is important.

Course evaluation

A web-based evaluation of the course will be made after the written examination.

Excerpts from last year's course evaluation

Below the suggestions for changes listed in last year's course evaluation are repeated. The items marked with yellow are in some way considered in this year's course.

Suggestions for changes

1. Students without previous university chemistry need an introductory lecture on polymer technology and plastics in order to improve learning of plastic packaging and barrier properties. This lecture could perhaps be given in parallel with the already existing lecture on fundamental solid mechanics for students with limited prior knowledge on solid mechanics.
2. The students should edit their reports and comment on the feed-back from the instructor on the report from the paper and board materials testing laboratory.
3. Develop and introduce a computational home assignment on laminate theory.
4. Add 2 hours of teaching time in order to increase flexibility in the course planning.
5. Take away at least two items in the literature list and concentrate on the parts of the literature that is appreciated and use lecture notes for other parts. ONLY SUCCEEDED WITH ONE.

Detailed program

Lecture #	Day, time, location	Instructor	Topics	Literature in addition to Lecture Notes
1	Tuesday 18/1, 13-15, E34	SÖ	Course introduction. Overview of packaging materials and applications. Packaging industry, value chain, primary, secondary and tertiary packaging, trends.	FoPT Ch. 1 and 2 LJU Ch. 10 PboP, (pp. 4-43)
2	Thursday 20/1, 10-12, D35	SÖ	Paper and paperboard based packaging, overview of different types of materials.	BOA (pp. 11-36, 51-57) LJU Ch. 10 HPT (pp. 564-576)
3	Friday 21/1, 8-10, D35	CD	Packaging logistics, functional demands, transport testing.	LOG, CDO
4	Tuesday 25/1, 13-15 D33	CD	Packaging logistics, functional demands, transport testing. Introduction to **CAPE PACK**.	LOG, CDO
5	Wednesday 26/1, 8-10, E32	SÖ	Paper physics, fundamentals of solid mechanics for paper materials.	LJU Ch. 1 and 2 BOA (p. 84-112)
6	Friday 28/1, 8-10, E34	SÖ	Paper physics, laminate theory	LJU Ch. 2, 11
7	Monday 31/1, 15-17, D33	MM	Tutorial 1 Paper stress-strain curve Laminate theory program **HOME ASSIGMENT**	Examples: 1.1.1, 1.1.8 1.2.1, 1.1.2, 1.2.13 **1.2.3, 1.2.4 & 1.1.3**
	Tuesday 1/2, 13-17, Solid Mechanics Student Computer Room	CD	**Laboratory 1**	CAPE PACK
8	Thursday 3/2, 8-10, D33	SÖ	Manufacturing of paperboard and corrugated board, quality parameters.	FoPT Ch. 5 and 15 BOA (p. 31-44) CCC Ch 7 HPT (pp. 564-576)
9	Monday 7/2, 8-10, E33	SÖ	Manufacturing of paperboard and corrugated board packaging, converting operations: printing, creasing, folding, gluing Intro to **DESIGN PROJECT.**	LJU Ch. 9, 10 BOA (p. 157-225) FoPT Ch. 4, 6, 15 and 18

	Tuesday 8/2, 8-17		**Laboratory 2**	Company visit
10	Friday 11/2, 8-10, E53	MH	Polymer based materials and packages, overview of different types of materials.	FoPT Ch. 9-11
11	Monday 14/2, 8-10, E33	MH	Barrier materials I	BPM, FoPT Ch. 14
	Tuesday, 15/2, 13-17, Innventia AB, Drottning Kristinas väg 61		**Laboratory 3**	Experimental determination of some mechanical properties of paper and board.
12	Thursday 17/2, 15-17, E34	MH	Barrier materials II	Handed out material BPM
13	Tuesday 22/2, 13-15, E33	MH	Plastic packaging – Other properties	FoPT Ch. 13-14
14	Thursday 24/2, 8-10, E34	SÖ	Design of paper and board packaging: stacking, analytical methods. Company software such as Billerud Box Design, Korsnäs Optipack and EUPS.	LJU Ch 10 BOA (pp. 119-128) FoPT Ch. 15, 17 HPT (pp. 576-652) Example: 1.3.3
15	Friday 25/2, 8-10, E33	SÖ	Design of paper and board packaging: dynamic loads and shocks, mechanosorptive creep	FoPT Ch. 17 LJU Ch. 4, p. 144
16	Monday 28/2, 15-17, E34	SÖ	Design of paper and board packaging, advanced concepts, FEM, fracture mechanics	HPT LJU Ch. 2, 11, 12 FRAC
17	Tuesday 1/3, 13-15, D35	MM	Tutorial 2	Examples: 1.1.9, 1.1.10, 1.1.11, 1.3.5
18	Tuesday 8/3, 13-15, E53	SÖ	Sackpaper. Glass and metal packaging. Environmental issues, life cycle analysis, packaging ergonomics. The future of paper and paperboard packaging.	FoPT Ch. 7, 8 & p. 505-509, MET FoPT Ch. 1 and 2 LJU Ch. 66
19	Thursday 10/3, 13-15, D41	SÖ, MH, CD	Presentation of **DESIGN PROJECTS**	
	Monday 14/3, 14-18, V35		Written examination	

Stockholm, January 13, 2011

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