GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2024-2025

Microstructure-Property Control of Metals (E066230)

Course size *(nominal values; actual values may depend on programme)*

Credits 6.0 **Study time 180 h**

Course offerings and teaching methods in academic year 2024-2025

A (semester 2)	English	Gent	lecture	
			practical	
B (semester 2)	Dutch	Gent	practical	0.0h

Lecturers in academic year 2024-2025

Kestens, Leo	TW08	lecturer-in-charge
Claessens, Serge	TW08	co-lecturer

Offered in the following programmes in 2024-2025	**crdts**	**offering**
Bridging Programme Master of Science in Sustainable Materials Engineering	6	A
Master of Science in Materials Engineering	6	B
Master of Science in Sustainable Materials Engineering	6	A

Teaching languages

English, Dutch

Keywords

Microstructure, property, metal, aluminium, stainless steel, Ni-super alloy, shape memory alloy, amorphous metal.

Position of the course

The course aims to give the student an insight in the relation between microstructure and the properties of classical (steel, non-ferrous alloys) and modern (advanced high strength steel, superalloys, shape memory alloys, metallic glasses) engineering metallic materials. Both theoretical principles and practical applications are given in an in-depth review together with details for microstructure –properties control through heat treatment and processing.

Contents

The course treats the relation between microstructure and properties of metals. It contains 15 chapters.

1 Introductory lecture. Methods for microstructure control of the properties. Influence of alloying elements on steel structures and properties. Steels for general constructional application. Alloying strategies, strengthening mechanisms, heat treatment, microstructure, properties.
2 Tool steels. Alloying strategies, strengthening mechanisms, heat treatment, microstructure, properties, application, defects.
3 Bearing steels, spring steels and wires. Requirements. Alloying strategies, strengthening mechanisms, heat treatment, microstructure, properties, application, defects.
4 Maraging steels. Alloying strategies, strengthening mechanisms, heat treatment, microstructure, properties, application, defects.
5 Steels with excellent formability. Deep drawing Quality and (DDQ)steels and EDDQ steels, difference in processing between ELC and IF route, texture and precipitation control, in-use properties.
6 Rail steels –requirements. Alloying strategies, strengthening mechanisms, heat treatment, microstructure, properties, application, defects. Case studies-

Characterisation of specific damage in rail steels (head-checks and squats, formation of white and brown etching layers).

7 High strength low alloyed (HSLA) steels, solute drag, precipitation control, heavy gauge production, influence of processing parameters, toughness, weldability, specific case of line pipe, Bauschinger effect. Link towards bainitic steels and bainitic ferrite.

8 Advanced high strength steels for automotive application. Dual-Phase (DP), Transformation induced plasticity (TRIP)-assisted , Quenching and Partitioning (Q&P) steels and other multi-phase grades, processing, microstructure, in-use properties, applications.

9 Cu and Cu based alloys. Pure Cu-properties production, application. Brasses and bronzes. Alloying strategies, strengthening mechanisms, heat treatment, microstructure, properties, application, defects.

10 Light metals. Al-alloys Mg alloys and Ti alloys. Classification, strengthening mechanisms, heat treatment (GP zones), microstructure, properties.

11 Alloys for applications at special conditions: Cryogenic FeNi, and other cryogenic alloys like brass or TiAlSn, INVAR. Background on weathering steels.

12 Heat resistant steels, types of alloys (from 2.25 Cr to 14 Cr and further) precipitation control, creep resistance, ODS. Steels for nuclear energy application.

13 Ni and Co based super alloys. Alloying strategies, strengthening mechanisms, heat treatment, microstructure, properties, application, defects. Increasing the operational temperature range of the super alloys with thermal barrier coatings.

14 Shape memory alloys. History and theoretical background. Thermo-elastics martensitic transformation. Compositions, microstructure, properties. Transformation characteristics. Measuring and control of operating temperatures. Applications.

15 Metallic glasses. Characterization of metallic glasses-degree of crystallisation (amorphisation), crystallisation temperature. Technologies for production of ribbons, powders and wires. Bulk metallic glasses. High entropy alloys.

Initial competences

E066020 Microstructure of Materials

Final competences

1 Understanding principles and methods for control of microstructure and properties of metals and alloys

2 Understanding the various types of treatments and their ability to change the properties of metals

3 Recognition of the microstructures of the alloys discussed in the course

4 Selection of appropriate composition and treatment to obtain the best combination of properties for specific applications

5 Scientific and practical approach to an appropriate microstructure-properties design and solving practical problems with steels, non-ferrous alloys, superalloys, shape memory alloys and metallic glasses.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Lecture, Practical

Extra information on the teaching methods

Lectures, practical classes,

Study material

None

References

- "Fundamentals of Steel Product Metallurgy" B. C. De Cooman, J. G. Speer, N. Yoshinaga, I. Y. Pychmintsev, -selected chapters
- “Physical Metallurgy” A.P. Gulyaev -selected chapres
- The Science and Engineering of Materials, D.R.

Askeland, PWS Publishing company, 1994.
- Shape Memory Materials, K. Otsuka, C.M Wayman, Cambridge University Press, 1998.
- Heat treatment, microstructure and properties of non-ferrous alloys, C.R. Brooks, Metals Park Ohio, 1982.
- Superalloys, Alloying and Performance, B. Geddes, H.Leon, X. Huang, ASM International, 2010.
- Fatigue of beta processed and beta heat-treated Titanium Alloys, R. Wanhill and S. Barter, SpringerBriefs in Applied Sciences and Technology, 2012.
- Physical metallurgy of steels, W. Leslie, Hempisphere Pub. Corp. , 1981

Course content-related study coaching

Assessment moments

end-of-term and continuous assessment

Examination methods in case of periodic assessment during the first examination period

Oral assessment

Examination methods in case of periodic assessment during the second examination period

Oral assessment

Examination methods in case of permanent assessment

Skills test

Possibilities of retake in case of permanent assessment

examination during the second examination period is possible in modified form

Extra information on the examination methods

During examination period: Oral exam after written closed book preparation.
Supporting materials for solution of the problems will be provided.
During semester: graded lab sessions.

Calculation of the examination mark

Exam: Oral exam after written **closed book** preparation. Supporting materials for solution of the problems will be provided during the exam. Final evaluation consists of 2 parts.
Formation of the final evaluation:
Part 1
During the semester
Results of the work during the semester (practicum), evaluated by assistants based on the work and the quality of the written report. The reports should be submitted to the assistants before the start of the examination period: **max: 4 points**.
During the exam
Part 2: Results from 2 or more theoretical questions (oral exam): **max: 16 points**
Total: **20 points**
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