

UNIVERSITY OF CHEMICAL TECHNOLOGY AND METALLURGY

CENTRE OF MATERIALS SCIENCE

Approved:

Assoc. Prof. Ivan Gruev

Master Course MATERIALS SCIENCE AND ENGINEERING

PROGRAMME

PROPERTIES, SELECTION AND TESTING OF MATERIALS

Specialty: Materials Science

Degree of Qualification: Master of Materials Science and Engineering

Presented by:

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Compulsory Discipline: PROPERTIES, SELECTION AND TESTING OF MATERIALS**Total number of hours: 80****Structure of Discipline: Lectures - 40 hours; Exercises as Seminars and Laboratory - 40 hours****Control: Credits - 6**

TEACHING FORMS	SEMESTRE	HOURS	
		WEEKLY	TOTAL
Lectures :	2	4	40
Exercises:	2	4	40
<i>Laboratory</i>			
<i>Seminars</i>			
Project on Exercises	<ul style="list-style-type: none"> • Lecture course examination • Project presentation 		
Control:	<ul style="list-style-type: none"> • Mark or/and Credits take into account the active participation in the lecture course and seminars 		

OVERVIEW:

This discipline introduces the range of materials used in engineering applications along with some basic selection rules for determining the appropriate materials for a given application. The discipline also introduces development of fundamental-science knowledge that determines the properties of materials, such as bonding types and atomic/molecular structures of ideal and real type. The key mechanical and physical properties of materials as well as materials testing will be covered in the lectures and in core laboratory exercises.

CORE SYLLABUS DETAILS:

- Classification of materials into key groups
- Identification of key mechanical and physical properties affecting materials selection. Corrosion and hydrogen effects. Surface engineering aspects
- Concept of materials selection charts



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- Specifics of fundamental science: bonding between atoms; structure of engineering materials (packing in metals and ceramics, defects in alloys; molecular chains in polymers); relation between bonding type and real structure to mechanical properties
- Definition and measurement of key physical and chemical properties
- Definition and measurement of key mechanical properties, testing: Young's modulus; Strength; Hardness; Toughness; Fatigue limit
- Definition and measurement of whole life issues: Corrosion (including galvanic corrosion); Fracture and Fatigue and Environmental influence; Cost / availability; Recycling
- Appreciation that the microstructure affects the properties of metals using steel as an example
- Selection of materials for a given, simple application.

PROGRAMME

PROPERTIES, SELECTION AND TESTING OF MATERIALS

HOURS

LECTURES

40

1 **Materials Science and Engineering**

2

Metals and Materials: Science, Processes, Applications

2 **Principals of materials selection**

4

Identification of key mechanical and physical properties affecting materials selection. Corrosion and hydrogen effects. Concept of materials selection charts. Cost/availability. Recycling

3 **Atomic arrangement in materials**

4

The concept of ordering. Crystal lattices and structures. Selected crystal structures (*pure metals, diamond and graphite, coordination in ionic crystals, AB-type compounds, silica, alumina, complex oxides, silicates*), Inorganic glasses (*network structures in glasses, classification of constituent oxides*), Polymeric structures (*thermoplastics, elastomers, thermosets, crystallinity in polymers*)

4. **Defects in solid materials**

4

Some specifics of point, line, planar and volume defects in metals, alloys and non-metallic materials. Irradiation of solids. Hydrogenising of metallic materials. Defect



behaviour in some real materials *{dislocations and stacking faults in fcc, cph, bcc, ordered structures and ceramics, Defects in crystalline polymers and glasses}* Stability of defects *{dislocation loops, voids, nuclear irradiation and hydrogen effects}*

- 5. Physical properties** **8**
- Density, thermal properties; diffusion; internal friction; ordering in alloys; electrical properties; magnetic properties; dielectric materials, optical properties, materials colour and metallic shine. Specific aspects of physical properties (superconductivity, supermagnetics, specifics of materials colour, double refraction). Measurement of physical properties, selection, application
- 6. Chemical properties** **2**
- Engineering importance of surfaces. Corrosion. Surface engineering. Measurement procedures
- 7. Mechanical behaviour of materials** **10**
- Mechanical testing procedures *{tensile tests, indentation hardness testing, impact testing, creep testing, fatigue static and dynamic testing, long-crack—short-crack— inclusions ODA—superlong and giga fatigue testing, testing of ceramics, polymers and composites}*
- Deformation, fracture and fatigue: elastic deformation *{of metals and ceramics}* and plastic deformation *{slip and twinning, relation of slip to crystal structure, multiple slip, relation between work-hardening and slip}*, dislocation behaviour during plastic deformation *{dislocation mobility, variation of yield stress with temperature and strain rate, dislocation sources, discontinuous yielding, yield point and crystal structure, discontinuous yielding in ordered alloys, solute-dislocation interaction, dislocation locking and temperature, kinetics of strain-ageing, influence of strain boundaries on plasticity, superplasticity}*, mechanical twinning *{crystallography, nucleation and growth of twins, effect of impurities and prestrain on twinning, dislocation mechanism of twinning, twinning and fracture}*, strengthening and hardening mechanisms *{point-defect hardening, work-hardening, development of preferred orientation}*, metallic creep *{transient and steady-state creep, grain boundary contribution, tertiary creep and fracture, creep resistant alloy design}*, metallic fatigue *{nature, engineering aspects, structural changes accompanying fatigue, crack formation and fatigue failure, approaches of fatigue crack growth and total life, fatigue at inclusions and ODA approach, effect of surface roughness, hydrogen effects, ultralong and giga fatigue}*, fatigue of Ti and Al alloys, fatigue at elevated temperatures, environmental influence on fatigue
- 8. Strengthening and toughening** **2**
- Strengthening of non-ferrous alloys by heat treatment, strengthening of steels by heat treatment, fracture and toughness *{Griffith micro-crack criterion, fracture toughness,*

cleavage and the ductile-brittle transition, factors affecting brittleness of steels,

hydrogen embrittlement and other effects on steels, intergranular fracture, ductile failure, rapture, voiding and fracture at elevated temperatures)

9. Advanced Materials. Modern alloy developments. Nanomaterials.

Smart and multifunctional materials. Commercial steels, superalloys, Ti and Al alloys, structural intermetallic compounds, cast iron. Nanomaterials. Properties, application and testing

EXERCISES

40

- | | |
|---|-----------|
| 1. Measurement of key physical and chemical properties | 5 |
| 2. Measurement of key mechanical properties, testing: Young's modulus; Strength; Hardness; Toughness; Fatigue limit | 10 |
| 3. Measurement of whole life issues: Corrosion; Fracture and Fatigue in connection with environmental influence; Appreciation that the micro structure affects the properties of materials using steel as an example | 20 |
| 4. Selection of materials for a given, simple application | |

PROJECT: On properties, selection and testing for a given, simple application

Prerequisites: Physics, Physical Chemistry, General knowledge of Materials science; General background in Mechanics, Mechanics of Materials and Physics of defects

Personal work requirements: about 20 hours

Location of Discipline's Lectures and Exersices: UCTM, Laboratories - Central Research Laboratory of UCTM (Build. B), Laboratory of Metals and Alloys Testing at the Department of Physical Metallurgy and Heat Equipment (Builds. A and V), Laboratory for Advanced Materials Research (Build. V), Laboratory for Polymer Research (Build. V)

REFERENCES

1. R. E. SMALLMAN, BISHOP R. J., *Modern Physical Metallurgy and Materials Engineering*, Butterworth-Heinemann, Oxford, UK, 1999