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Syllabus for

P25 – Surface Engineering

Credits	7.5 credits
Examiner	Shrikant Joshi, University West
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Target group	The course is designed for (a) doctoral students to make them aware of the growing portfolio of surface modification and coating technologies that are becoming increasingly relevant to the modern-day industry, (b) researchers interested in contributing to this multi-disciplinary field and (c) technical support / design engineers seeking to enhance durability & performance of engineering components.
Fee for industrial members	-
Prerequisites	The desired level of pre-knowledge is that expected from a candidate admitted to a post-graduate (Master's or PhD) program in Mechanical/Production/Metallurgical Engineering/Engineering Physics or similar. Adequate

industrial experience in the above areas in lieu of formal academic education in the field will also be appropriate.

Aim

To provide comprehensive knowledge regarding surface engineering & coatings, including understanding of processes, awareness of characterization & performance assessment tools, and familiarity with realizable benefits through case studies

Teachers / tutors

Shrikant Joshi is a Professor in the Department of Engineering Science at University West, with over 25 years of experience in the fields of Surface Engineering and Laser Materials Processing. His research in Surface Engineering has spanned varied coating technologies, namely conventional atmospheric & solution precursor plasma spraying, detonation spraying, cold gas dynamic spraying, electron beam physical vapour deposition and cathodic arc PVD. His research in the field of laser materials processing has included heat treatment and alloying/cladding. His work has led to many industrial applications, over a dozen patent applications and more than 120 publications in peer-reviewed journals.

Fredrik Eriksson is a university lecturer in the Thin Film Physics division at Linköping university. His research is focused on understanding the physics and materials science behind the formation of new thin materials with unique properties in the form of nanometer sized layers. In addition to his research, Fredrik Eriksson is also teaching the theory and practical use of physical measurements and advanced analytical instruments used for materials analysis, in particular X-ray scattering for thin film characterization.

Hans Kristoffersen is a senior researcher and project manager at the Process development department at Swerea IVF with almost 30 years of experience in heat treatment of steel. His research has been focused on e.g. induction hardening, quenching, distortions and quality. Modelling and FEM simulations of different heat treatment processes are also core competences.

Eva Troell is a project manager and senior researcher at the Process development department at Swerea IVF with almost 25 years of experience in heat treatment of steel. Her research has focused on quenching, nitriding processes and environmental issues. She is one of three editors of “Steel and Its Heat Treatment – A Handbook” published by Swerea IVF. ISSN 0349-0653. 2012.

Learning outcomes

Upon completion of the course, the students should be able to:

- Identify a suitable surface modification technique for a specified application
- Apply the technique to modify/improve properties

- Evaluate the basic properties of the modified surface…

Contents

Surface engineering is today a vast interdisciplinary field of increasing relevance to virtually all engineering industries. The course content is designed to impart both theoretical and practical knowledge to the participants, such that it will not only familiarize them with the immense capabilities of the surface engineering approach but also make them competent to utilize it for their research/production needs. The course will provide an overview of techniques for surface modification or deposition of protective coatings, discuss the rationale behind employing them and also describe associated processes and tools available for characterization and performance assessment of engineered surfaces. Some case studies will also be presented to highlight the utility of surface engineering.

The participants will be encouraged to have e-mail and phone communication with the course leader two/three weeks before the course to share their specific interest in and expectation from the course to enable fine-tuning of the content if possible.

Detailed contents:

- Introduction to surface engineering
  - Typical failure of engineering components; surface degradation modes
  - Definition & scope of surface engineering
  - Classification & general principles
  - Incorporating surface engineering in component design
  - Broad comparison of various techniques
- Surface Coatings
  - Diffusion vs. overlay Coatings
  - Pack cementation (aluminizing, boriding etc.)
  - Weld Overlay
  - PTA Cladding
  - Electrodeposition
- Heat Treatment – Introduction
- Surface Treatments Without Compositional Change
  - Induction hardening
- Surface Thermochemical Treatments
  - Carburizing
  - Nitriding
- Related Processes
  - Carburizing
  - Nitriding
- Thermal Spray Processes
  - Fundamentals of thermal spray: sequence of events, structure, defects
  - Thermal spray variants
  - Flame, Arc

    - Plasma & related techniques
    - Detonation
    - HVOF & HVAF
- Laborations (Surface preparation, coatings by powder spraying using Plasma and HVAF, roughness & thickness measurement, optical microscopy)
- Cold Spray
    - Feedstock for thermal spraying
    - Introduction to solution-based spraying
    - Case studies
- Laborations (Coatings by suspension spraying using plasma)
- Vapour deposition techniques
    - Physical Vapour Deposition
    - Chemical Vapour Deposition
- Laborations
    - Thin film deposition (using PVD/CVD)
- Thin film characterization techniques
    - X-ray Diffraction Techniques
    - Scanning Electron Microscopy + Energy Dispersive X-ray Analysis
    - Nanotribology
- Laborations
    - SEM+EDX (Imaging of surface & cross-section, elemental analysis)
    - Nanotribology (hardness, elastic modulus, and friction of thin films)
- Possible company visit (Impact Coatings AB)
- Characterization of coatings and surfaces (Introductory)
    - Roughness, thickness, adhesion etc.
    - Surface Hardness & Hardness Profiles
    - Phase Constitution
    - Residual Stress
    - Microstructure & Image Analysis
- Laborations
    - Coating characterization
- Performance Assessment of Engineered Surfaces (introductory)
    - Wear (Abrasion, Erosion & Sliding)
    - Corrosion (Polarization, Salt Spray)
    - Oxidation (Isothermal, Cyclic)
    - Thermal Cycling
- Advanced surface engineering practices
    - Surface engineering by energy beams (Electron-Beam, Laser)
    - Sol-gel Techniques
    - Hybrid processing

Organisation The course comprises four modules at different locations, each module having approximately 10-12 h teaching during two days.

Literature

Apart from Scientific papers that will be additionally recommended, the following literature can be useful as reading material.

Reference literature

- K.G. Budinski, Surface Engineering for Wear Resistances, Prentice Hall, Englewood Cliffs, 1988.
- J.R.Davis & Associates, Surface Engineering for Corrosion & Wear Resistance, ASM Intl., 2001.
- P. Martin, Introduction to Surface Engineering & Functionally Engineered Materials, Wiley, 2011.
- M. Ohring, The Materials Science of Thin Films, Academic Press Inc, 2005.
- A.W.Batchelor, N.L. Loh & M.Chandrasekaran, Materials Degradation & Its Control by Surface Engineering, Imperial College Press, 2011.
- P.H. Morton, Surface Engineering & Heat Treatment, Brookefield, 1991.
- Metals Handbook Ninth Edition, Vol.5, Surface Cleaning, Finishing & Coating, ASM, Metals Park Ohio, 1982.
- M.G. Fontana, Corrosion Engineering, McGraw Hill, NY, 1987.
- B.G. Mellor (ed.), Surface Coatings for Protection against Wear, Woodhead Publishing, 2006.
- G.W. Stachowiak, Engineering Tribology, 3rd edition, Elsevier / Butterworth-Heinemann, 2005.
- T. Burakowski & T. Wierzchon, Surface Engineering of Metals: Principles, Equipment, Technologies, CRC Press, 1998.

Examination

The assessment of participants' performance will involve both written and oral examination as well as assigned project work.

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