UNIVERSITY of MISKOLC
Faculty of Materials Science and Engineering

Antal Kerpely Doctoral School of Materials Science & Technology

Cold Metalforming Processes

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COURSE DESCRIPTION

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Lecturer

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Recommendation

The lecture is propoesd for all students of the Kerpely doctral school, especially in the field of metalforming, physical metallurgy, heat treatment and casting.

Language

Hungarian or English.

Scope

The objective of the course is to teach the methods and equipments for crystallographic anisotropy examinations (X-ray diffraction texture measurements, EBSD, TEM orientation mapping), to help understand the main application options.
The objective of the course is to discuss the cold metalforming processes. A detailed description of each cold forming processes and technologies. Teaching of necessary knowledge of designing of technological processes in view of load, power consumption, costs and quality of production. Obtaining the empirical and theoretical background in order to the global survey of operation of the cold metalforming process.

Methodology

For larger student numbers, the course is held in contact lectures. The time of contact courses is based on agreements with the students. In case of 1-2 students, keywords are given of the corresponding block. Three blocks in total cover the whole course. Basic questions are also given for the blocks. 3 meetings are held during which answers for the basic questions, the students' questions and fundamentals are discussed.

Topics

1.Topic

Cold rolling technological processes

Steps of flat cold-rolling technology. Part of the preparation and finishing process steps. Machinery equipments for cold rolling mills. Rolling technology of special steel grades. Cold rolling of sheet steel. Velocity and stress conditions in the rolling gap. Rolling force, rolling power and torque requirements. Geometry of the rolling gap. Thermal conditions. The thickness of the rolled strip.

Basic questions:

1. *List the reasons and advantages of the cold-rolling and introduce the disadvantages against hot rolling. List the application fields of the cold-rolled products.*
2. *Highlight the process of the cold-rolling (tree of cold-forming process). Production and grouping of the raw material and end-product. Describe the process in term of the strip width.*
3. *Expound the process and purpose of the chemical pickling. Pickling material, time, equipment.*
4. *Expound the strip rolling process in term of the strip width and specific coil mass. The parts of the rolling mills. What is the principle of determining the rolling step number and the reductions for the rolling-steps?*
5. *Give the details of the technological process of the rolling of the table sheets. Quality requirements against special steel grades and so the conditions of its cold-rolling.*
6. *Velocity conditions, neutral plane. Stress conditions, pressure ont he contacting surfaces. Applied pulling stress on strips. The distribution of the friction shear-stress.*
7. *Explain the mechanical limit of the rolling process (sheet-capture condition, maximal reduction, limits of the pulling stress of strips). Effect of pulling stress on pressure on contacting surface.*
8. *Introduce and explain the thermal conditions in the strip and rolls. Thermal expansion of the rolls.*
9. *Give the details of the distortions of the geometry of the rolling-gap. Shape distortions of the sheets. Residual stress/swording. Introduce the shape correcting solutions.*
10. *Calculation of the rolling force and power and torque. The real value of the rolled height. Minimum of the strip height. Height-control systems.*

2.Topic

Drawing and extrusion

Process of cold extrusion and forging as well as wire and bar drawing technologies. Strain and strain flows. The force requirements of drawing and extrusion and cold forging processes. Thermal conditions. Raw materials, pre- and postprocessing of the workpiece. Lubrication. Forming equipments of the processes. Planning and optimalization of the wire drawing technology. Limitations of the technology planning in case of drawing and extrusion.

Basic questions:

1. *Highlight basic operations of cold extrusion. Additional operations.*
2. *Describe the types of the upsetting presses. Demonstrate the one step and multistep extrusion equipment and its operations.*
3. *Highlight the pre-processes of the cold forging/extrusion and its equipment.*
4. *Give the details of the kinematic and static analysis of upsetting.*
5. *Explain the ductility, shape and material limits of planning of the upsetting and heading. Demonstrate the optimum calculations with consideration of these limits. Introduce the technological possibility of the exceeding of limits.*
6. *Expound the forming equipment of wire and rod drawing. Determine the difference between the wire and rod (bar) drawing. Introduce the drawing dies and their parts.*
7. *Highlight the raw materials and pre-and post-processes of wire and bar drawing. Describe the types of lubrications in case of the wire material grades.*
8. *Give the details of the kinematic and static analysis of drawing with slab and upper-bound methods. Filament bending force.*

9. *Thermal conditions in the wire/rod and in lubricants and in the die. Explain the reasons and the processes of the die wear.*
10. *Explain the limits of technological planning of open die extrusion and wire drawing in term of shape, ductility, wire brake.*

3.Topic

Sheet metalforming process

Characteristic material properties influencing the sheet metalforming: flow curve, anisotropy, stabile deformation, ductility, shape. Strip straightening. Mechanical background of shearing. Shearing technologies. Mechanical background of bending. Sheet bending technologies. Mechanical background of deep drawing. Deep drawing technologies. Stretching.

Basic questions:

1. *Define the term of the sheet. Expound the anisotropy (Lankford, Hill). Earing.*
2. *Describe the instable deformation. Connection of the stabile deformation limit with Nadai flow curve. Lillet diagram.*
3. *Describe the ductility of sheets. Forming limit diagram. Introduce the measurements of FLD.*
4. *Explain the problems with Lüders band. How can it be eliminated? What problems does shape distortion cause? How can it be eliminated? Detailed Introduction.*
5. *Expound the types of the shearing processes. What is initial blank? Analyse the mechanics of the shearing (clearance, maximal force, force-displacement diagram).*
6. *Give the details of the quality of sheared surface. Ideal shearing surface. Introduce the faults of the shearing surface. Improving the surface quality with optimalizing of shearing and additional technological processes.*
7. *Give the details of the kinematic and static analysis of the sheet bending. Calculation of the stress and force requirements of bending. Calculation of springback.*
8. *Expound the process of the bending and its forming devices. Tube bending. Roll-forming.*
9. *Explain the principals of the deep drawing. Expound the static analysis in case of deep drawing of cylindrical blank (tension stress, equivalent strain). Consider the bending on the die and the Hertz contact friction.*
10. *Give the details the simplified static analysis in case of deep drawing of cylindrical blank (tension stress, equivalent strain). Define the conditions of force requirement of deep drawing. Approximation of the distribution of wall thickness of the drawn cup.*

References

1. Henry S. Valberg: Applied metal forming. Including FEM analysis. Cambridge University Press.2010.
2. John A. Schey: Introduction to Manufacturing Processes, McGraw Hill, Boston, 2000
3. Heinz Tschaetsch: Metal Forming Practise, Springer, New York, 2006
4. Kurt Lange , Handbook of metal forming, McGraw Hill, 1985
5. Schuler: Metal Forming Handbook, Springer, New York, 1998

Exam

Oral exam if basic questions are answered correctly.

Complex exam questions

1. Interpretation of cold rolling technology:
    a. advantages & disadvantages, process (pre-process and post-process included),equipment & rolling mills, raw materials & products (application fields),lubrication & cooling.
2. Interpretation of mechanical analysis of strip in the rolling gap. Thermal conditions in the rolls and in the flat product. Planning limits and objective functions for optimizing.
3. Interpretation of cold extrusion and forging technologies:
    a. types, advantages & disadvantages, process (pre-process and post-process included
    b. equipment & forming devices, dies, raw materials & products (application fields)
    c. lubrication & cooling, Principles of planning of technology
4. Interpretation of mechanical analysis of wire/bar in the drawing die in case of wire/bar drawing. Thermal condition in the wire and in the die. Planning limits and objective functions for optimizing.
5. Interpretation of sheet metalforming technologies (processes, operation principles, equipment, dies, lubrication, raw material). Sheet straightening, shearing, sheet bending, deep drawing, stretching.