Innovation in Metallurgical Production

Introduction
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Teaching methods & final examination

- **Active Lectures (in English)**

  Monday: 8.30-10.00 - Room VM19
  Thursday: 12.30-14.00 - Room VM19

- **Active class at industrial plants**

- **Zoom meeting**: Summary of lectures / Forum / Questions (English/Italian)
  by appointment  
  ([https://unipd.zoom.us/j/4137633677](https://unipd.zoom.us/j/4137633677))

- **Examination** (in Italian or English as preferred)
  Oral sessions: Jan-Feb / Jun-July / Sept
Teaching methods & final examination

Innovation in Metallurgical Production

Video and audio registrations of lectures can be viewed at:

https://stem.elearning.unipd.it

Password: IMP2022
Programme of the course

Innovation in Metallurgical Production

1. Material, Design & Properties
   The optimization cycle, Material-Process-Design, The obsolescence of Materials and Technology

2. Criteria for material & process selection
   Materials, Processes and their attributes, Materials Properties Chart, Material Indices

3. Steel production & transformation
   From Blast Furnace to ULCOS Project, from traditional EAF to Siemens Innovations, twin-roll casting & horizontal continuous casting

Prof. G. Timelli: Introduction
Innovative Foundry Processes
Ablation technology, HQcast, SSR, SLC, RSF, MCcast, Squeeze casting, Counter pressure processes

Innovative Al foundry alloys
Ductile alloys for safety & structural components, impurities and trace elements, Rheinfelden, Hydro, Alcan alloys, The die life
<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mon 03-Oct</td>
<td>Introduction</td>
</tr>
<tr>
<td>Thur 06-Oct</td>
<td>Material, Design and Properties</td>
</tr>
<tr>
<td>Mon 10-Oct</td>
<td>Material, Design and Properties</td>
</tr>
<tr>
<td>Thur 13-Oct</td>
<td>The design process for material selection</td>
</tr>
<tr>
<td>Mon 17-Oct</td>
<td>The material index</td>
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<tr>
<td>Mon 24-Oct</td>
<td>The design process for process selection</td>
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<tr>
<td>Thur 27-Oct</td>
<td>Steel production and transformation</td>
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<tr>
<td>Thur 03-Nov</td>
<td>Direct reduction route for steel production</td>
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<tr>
<td>Mon 07-Nov</td>
<td>Primary steel route production</td>
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<tr>
<td>Thur 10-Nov</td>
<td>Primary steel route production</td>
</tr>
<tr>
<td>Mon 14-Nov</td>
<td>Secondary steel route production</td>
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<tr>
<td>Thur 17-Nov</td>
<td>Secondary steel route production</td>
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## Programme of the course

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
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<tbody>
<tr>
<td>Mon 21-Nov</td>
<td>Refining processes of steel</td>
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<tr>
<td>Thur 24-Nov</td>
<td>Casting operations of steel</td>
</tr>
<tr>
<td>Mon 28-Nov</td>
<td>Casting operations of steel</td>
</tr>
<tr>
<td>Thur 01-Dec</td>
<td>Innovative aluminium foundry alloys</td>
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<tr>
<td>Mon 05-Dec</td>
<td>Innovative aluminium foundry alloys</td>
</tr>
<tr>
<td>Mon 12-Dec</td>
<td>Conventional foundry processes</td>
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<tr>
<td>Thur 15-Dec</td>
<td>Innovative foundry processes</td>
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<td>Mon 19-Dec</td>
<td>Innovative foundry processes</td>
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<tr>
<td><strong>Tues 20-Dec</strong></td>
<td><strong>Visit at Siderforgerossi Group SpA</strong></td>
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<tr>
<td>Thur 22-Dec</td>
<td>Concluding remarks</td>
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Prof. G. Timelli: *Introduction*
Teaching methods & final examination

Visita aziendale: 20/12/2022
Durata visita: 14.30 – 18.00
Meeting point: v.le Stadio, Vicenza (fermata autobus) ore 13.00

Via Cartiera di Mezzo, 38
36011 Arsiero (VI)

www.siderforgerossi.com
Teaching methods & final examination

Innovation in Metallurgical Production

Via Cartiera di Mezzo, 38
36011 Arsiero (VI)

www.siderforgerossi.com
Reference books & websites

Reference Book

• G. Timelli
  Innovation in Metallurgical Production, Ed. AG-Servizi, Vicenza, 2019

Other Books/websites:

• M.F. Ashby
  Materials selection in mechanical design, Butterworth-Heinemann, 2005

• http://www.ulcos.org

• World Auto Steel, Advanced high strength steel (AHSS) - Application guidelines, ver. 4.1, Online at: www.worldautosteel.org

• E.J. Vinarcik
  High Integrity Die Casting Processes, John Wiley & Sons, 2003

• http://steeluniversity.org
Thesis & Stages

- Inside the projects with Italian or EU companies
- Inside Italian or EU projects
- Inside DTG laboratories
- Inside the projects with EU, US Universities
- Inside Erasmus projects
- Inside Erasmus +
- ...
1. Ottimizzazione del processo produttivo di leghe primarie d’alluminio (Azienda, Sunndalsøra - Norway)

2. Assessment the recyclability of complex aluminum scraps (Azienda/Università - Norway)

3. Correlazione tra processo fusorio e qualità in leghe leggere (Azienda, Essen - Germany)

4. Leghe innovative secondarie per sistemi frenanti (Azienda/Università, Sweden)

5. Sviluppo di trattamenti termochimici per dischi freno per applicazioni racing (Azienda/Università, Mapello - BG)

6. Sviluppo e ottimizzazione di leghe innovative per ruote in lega leggera per applicazioni racing (Azienda, Palosco - BG)

7. Minimizzazione di difetti da riempimento nella produzione di componenti automotive colati in LPPM (Azienda, Dello - BS)

8. Ottimizzazione dei trattamenti di inoculazione per ruote in lega leggera (Azienda, Dello - BS)
Introduction

Innovation in Metallurgical Production

Scenario

Market needs

Environment & Innovation

Planning

Product Design

Process Design

Marketing of products

Product innovation

Process innovation

Market needs

Planning

Product Design

Process Design

Marketing of products

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Innovation in Metallurgical Production

Scenario

Innovation in Metallurgical Production

Process
Design

Steelmaking & Foundry technologies

Metallic Materials
Scenario

Innovation in Metallurgical Production

Product & Process innovations

1. Education, information flow
2. Research and development

New technology

Market
Marketing
Industrial design
Engineering design
Production preparation
Manufacturing
Distribution (sales, service)

Management

planning
organising
motivating
control
The material development has been always brought by **innovative processes**.
Scenario: Aviation industry

A350 XWB puts the right material in the right place!

Wing
Empennage
Fuselage
Belly Fairing

Ti: Landing Gears, Pylons, Attachments
Al/Al-Li: Frames, Ribs, Floor beams, Gear bays,

A350-900 XWB Material Breakdown (%)
Including Landing Gear

- Composite: 52%
- Steel: 14%
- Al/Al-Li: 20%
- Titanium: 7%
- Misc.: 7%

Scenario: Aviation industry

GLARE: Glass Laminate Aluminium Reinforced Epoxy (composite-Al alloy)

Applications:
- Fuselage panels
- Leading edges
- Floor panels
Scenario: Aviation industry

Innovation in Metallurgical Production

FRAMES
STANDARD: 2024-T42 CLAD
MACHINED: 7175-T73XX

STRINGERS
2024-T42 CLAD
AND 7075-T73XX

UPPER SHELL
SKIN PANELS
2024-T3 CLAD

SEAT RAILS
7175-T6XX

FLOOR BEAMS
7175-T73XX

SUPPORT STRUTS
7175-T73XX

LOWER SHELL
SKIN PANELS
2024-T3 CLAD

particles Al₃(Sc, Zr)

subgrain diameter 0.5 μm

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Scenario: Aviation industry

Innovation in Metallurgical Production

**1970-1980**
- SPF Ti
- 7475 Al-alloys
- High strength Al-casting
- 7150 Al-alloy plate (wing)
- Split sleeve cold working
- New bonding techn. (A318)
- LBW (A318)

**1980-1990**
- Fairings
- Radome
- Rudder
- Spoilers
- Airbrakes
- Elevators
- VTP box
- Wet HTP box
- Ailerons
- Flaps
- Dry HTP box
- LG doors
- Engine cowlings
- Rear bulkhead
- Keel beam
- J-nose
- Center wing box
- Wing ribs
- Rear unpress. Fus.
- Cross beams

**1990-2000**
- Age forming
- High speed machining
- 2x24 Al-alloy

**2000-2010**
- LBW, EBW
- Al-Li alloys
- New Ti-alloys
- FSW
- Large die forging (7085)
- New Coatings
- Al-alloys: 2024HCT, 7055HF
- Premium Al-casting
- 7349 Al-alloy extrusions
- 7155 Al-alloy
- Split mandrel cold working

+ Lower Wing
+ Fuselage

A350 XWB

A380

A340-600

A300

A310

A320

A330 / A340

A400M
Scenario: Ship building

Innovation in Metallurgical Production

- Length: 46.2m
- Max width: 8.7m
- Speed: 18 knots

Weight central hull module 5.4m long

- With Aluminium 37% weight saving on hull
Scenario: Ship building

<table>
<thead>
<tr>
<th>Shipbuilding Material</th>
<th>$\gamma$ [daN/m$^3$]</th>
<th>$\sigma$ [N/mm$^2$]</th>
<th>$\sigma_y$ [N/mm$^2$]</th>
<th>E [N/mm$^2$]</th>
<th>$\sigma/E$ [mm$^4$]</th>
<th>$E/\gamma$ [mm$^4$]</th>
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<tbody>
<tr>
<td>Construction steel A,B,D,E</td>
<td>7800</td>
<td>450</td>
<td>235</td>
<td>206000</td>
<td>5.80</td>
<td>2641</td>
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<tr>
<td>High strength steel AH32, DH32, EH32, FH32</td>
<td>7800</td>
<td>570</td>
<td>315</td>
<td>206000</td>
<td>7.3</td>
<td>2641</td>
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<tr>
<td>AH36, DH36, EH36, FH36</td>
<td>7800</td>
<td>630</td>
<td>355</td>
<td>206000</td>
<td>8.07</td>
<td>2641</td>
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<tr>
<td>AH40, DH40, EH40, FH40</td>
<td>7800</td>
<td>660</td>
<td>390</td>
<td>206000</td>
<td>8.5</td>
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<tr>
<td>AlMg5083 H321</td>
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<td>310</td>
<td>215</td>
<td>70000</td>
<td>11.48</td>
<td>2593</td>
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<tr>
<td>AlMg5083 H321 welded</td>
<td>2700</td>
<td>280</td>
<td>168</td>
<td>70000</td>
<td>10.37</td>
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<td>AlMg5083 H111</td>
<td>2700</td>
<td>290</td>
<td>125</td>
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<td>10.74</td>
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<tr>
<td>AlSi6061 T5/T6</td>
<td>2700</td>
<td>260</td>
<td>240</td>
<td>70000</td>
<td>9.63</td>
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<td>AlSi6082 T5/T6</td>
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<td>70000</td>
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<td>GRP</td>
<td>1550</td>
<td>190</td>
<td>13000</td>
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<td>839</td>
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<tr>
<td>Wood</td>
<td>750</td>
<td>90</td>
<td>12500</td>
<td>12</td>
<td>1666</td>
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</tr>
</tbody>
</table>

- GRP mechanical properties are variable according to lamination combinations.
- Wood is still a valid alternative for boats (yachts) up to 20-22m long.
Scenario: Construction sector

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Prof. G. Timelli: *Introduction*

**Scenario: Automotive industry**

Innovation in Metallurgical Production
Objectives

Bachelor’s degree in Industrial Engineering

Chemistry & Metallic Materials
Basic knowledge: materials science and principal metal alloys

Degree in Industrial Engineering

Metallurgical Industrial Applications
Main metallurgical processes

Innovation in Metallurgical Production
Rule of *innovation* inside the *metallurgical industry*

Capability of Managing Production & Innovation into Engineering Industry
Contacts

Prof. Giulio TIMELLI

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Italian Association of Metallurgy

Prossimi eventi in programmazione

16/09/2019 Milano
Additive metallurgy

Materiali metallici e fabbricazione additiva

Corso ADDITIVE METALLURY MATERIALI METALLICI E FABBRICAZIONE ADDITIVA. Organizzato dai Centri di Studio AIM Metallurgia delle Polveri [..]

17/09/2019 Vicenza
Metallografia - Modulo Leghe Leggere

Eventi gratuiti previa registrazione (15€) www.metallurgia-italiana.net