Improving Rolling Plant Performance

Dr Tom Farley
Innoval Technology Ltd

Aluminum International Congress V
Sao Paulo 24-26 April 2012
Innoval Technology joins Danieli Aluminium Strip Division

Innoval Technology, a leading provider of independent technical expertise to the global downstream aluminium industry, joins forces with Danieli Fröhling and Danieli Wean United to form the Danieli Aluminium Strip Division. The Oxfordshire-based company brings unparalleled aluminium rolling expertise to the Danieli group of companies, which rank among the three largest suppliers of plant and equipment to the global metals industry.
A single source Supplier for the complete Aluminium strip production

provided by DANIELI
DANIELI

€ 3.2 Billion Turnover, ~9400 employees around the world (2011)

Total Focus on the Metals Industry
Outline of Presentation

- Innoval Technology

- Challenges Facing Aluminium Rolling Companies

- Improving Rolling Plant Performance
  - Expertise and Process Models
  - Developing and Training Staff
  - Designing new rolling operations for maximum returns
Outline of Presentation

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Innoval Technology – Our Background

- Innoval Technology provides a unique resource of independent expertise to the downstream aluminium industry
  - formed in 2003 as a result of closure of one of Alcan’s Global Technical Centres
  - in 2012 became part of Danieli Group

- We are a group of 26 aluminium experts – our strength is the breadth of our aluminium knowledge
  - rolling and extrusion process expertise
  - metallurgy product expertise
  - surfaces expertise

- Our engineers have an abundance of product and process experience
  - most have been supporting the industry for over 25 years
  - many have held Senior Management positions in global aluminium companies
Innoval Technology – Supporting Aluminium Businesses

- **Strategic Support**
  - technical Due Diligence on existing plants
  - pre-Feasibility Studies and Greenfield plant design
  - plant investment and upgrade support

- **Technical support**
  - process Improvement
  - product Development and Quality
  - energy Reduction

- **Training**

Everything we do is aimed at maximising returns for our clients
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Challenges Facing Aluminium Rolling Companies

Aluminium Industry Changes

- increased use of aluminium in high-growth emerging regions
- cost reduction in low-growth regions
- acquisitions, mergers, divestments and closures – break up of the supply chain
- reducing R&D in low-growth regions

Challenges

- more exacting customer requirements and specifications
- increase utilisation of capital assets
- reduce operating costs (reduce energy consumption)
- competition from other materials
- increasing focus on sustainability
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The use of Models to Improve Rolling Plant Performance

- To achieve world-class product quality and machine performance often requires the solution of difficult problems relating to …
  - metallurgy
  - surface
  - dimensions
  - residual stresses and strains
  - need to overcome machine productivity constraints

- To solve the most challenging rolling problems requires a deep technical understanding
  - need experienced industry experts (in-house or consultants)
  - *enhanced by the application of computer models for increased insight*
The use of Models to Improve Rolling Plant Performance

- Many of the processes are performed “out of sight”
  - where measurements of important process parameters are not possible

- Innoval develops and uses physics-based models as tools to improve rolling plant performance
  - to study a wider range of manufacturing parameters than is possible in normal production
  - to recreate a particular problem within the computer increases insight into the problem

- This approach can be used to supplement more traditional approaches to problem-solving such as 6-sigma

- Where appropriate models can also be implemented on-line
  - to maximise the value of the understanding contained within them
Improving Rolling Plant Performance using Ingot Heating Models

- Ingot pre-heating is an example of a rolling process stage where important parameters are hard to measure
  - in this case, the temperature deep inside the ingot

- It is important during pre-heating for all parts of the ingot to reach the target temperature for target time
  - but it is also important not to exceed the safe temperature in any part of the ingot

- A calibrated model can provide the “hidden” temperatures to allow faster and more efficient heating practices

- Ingot pre-heating is the most energy-intensive part of the aluminium rolling process
  - models can be used to devise heating schedules to minimise energy usage
  - also used to identify furnace issues
Example: Ingot Homogenisation and Preheating Models
Example: Ingot Homogenisation and Preheating Models

![Graph showing temperature and energy over time for ingot homogenisation and preheating models.](image)

- **Temperature [°C]**: Set Air Temperature, Ingot Lead Temperature, Ingot Lag Temperature.

**Time [hrs]**: 0, 5, 10, 15, 20.

**Temperature [°C]**: 0, 5, 10, 15, 20.

**Energy [GJ]**: 0, 5, 10, 15, 20.
Improving Rolling Plant Performance using Roll Gap Models

- A lot happens in the roll gap
  - thickness changes leading to dimensional quality
  - surface changes leading to surface quality
  - temperature changes leading to metallurgical quality

- A good understanding of roll gap physics is important
  - to optimise rolling mill schedules
  - to maximise returns from existing and new rolling mills

- A model of the roll gap provides invaluable information
  - rolling loads, torques and motor currents for different alloys
  - resulting strip and roll temperatures, flatness and profile.
Cold Mill Roll Gap - approximate Scale

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<tr>
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Volume of aluminium in roll gap ~10cm³ per m width
Example: Roll Gap Models
### Example: Roll Gap Models

#### (a) 5 pass schedule

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<th>Load (kN)</th>
<th>Amps including Losses</th>
<th>Forward Slip (%)</th>
<th>Net Torque (mm)</th>
<th>Qce (mm)</th>
<th>Qce (kW)</th>
<th>Power per Roll (kW)</th>
<th>Power including Mechanical Losses (kW)</th>
<th>Power To Motors (kW)</th>
<th>Efficiency (%)</th>
<th>Starting Pressure (bar)</th>
<th>Ending Pressure (bar)</th>
<th>Heat by Def (kW/m)</th>
<th>Total Heat (kW/m)</th>
<th>Stored Energy (kW/h)</th>
<th>Contact Time (s)</th>
<th>Entry Contact Angle (°)</th>
<th>Unwind Power (kW)</th>
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#### (b) 4 pass schedule

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The Importance of Cooling the Rolling Process

- There is a continual drive to improve the quality of rolled products
  - dimensional properties such as thickness, profile or flatness
  - surface quality

- Heat flows from the aluminium into the rolls
  - up to 500 kW per m width (hot rolling)

- The coolant used in a modern mill performs multiple functions (simultaneously):
  - remove heat from the rolls to control bulk roll temperature
  - lubricate the rolling process
  - wash away debris which might otherwise give surface quality problems
  - control local thermal expansion as profile and flatness control actuator
Improving Rolling Plant Performance using Roll Cooling Models

- A mill spray roll cooling configuration must remove sufficient heat from the rolling process to maintain appropriate target work roll temperatures
  - need correct roll coating for good aluminium surface control on hot mills
  - need sufficient temperature differential between the work roll and the applied coolant in cold rolling for control
  - need to avoid steep thermal gradients at the strip edge

- For good profile and flatness control the distribution of coolant across the roll width must be carefully designed

- Innoval’s experience shows that most roll cooling systems can be improved from the original supplier’s design
  - the Danieli Diamond Mill cooling systems are designed correctly from the start
Example: Roll Cooling Model

- Calculation of spray footprints, heat transfer coefficients, cooling effect and roll temperatures
Example: Roll Cooling Model

- Spray impact regions around the total surface area of one roll

Poorly designed cooling system

Optimised cooling system
Improving Plant Performance using Coil Heating/Cooling Models

- **Coil Annealing**
  - A greater understanding of the temperature-time history inside coils can lead to reduced annealing times and reduce energy consumption without compromise to quality
  - Increased productivity and annealing capacity

- **Forced Coil Cooling to reduce Work in Progress (WIP)**
  - Coil cooling models can be used to design forced media cooling systems for fast cooling of coils between rolling passes
  - Reduced WIP
Improving Rolling Plant Performance - Finishing Process Models

- The stresses and strains developed in aluminium sheet during finishing operations can be calculated to provide insight into each process
  - understanding leads to improved quality, recovery and productivity

- Coiling Models

- Levelling Models

- Slitting Models
Outline of Presentation

- Innova Technology

- Challenges Facing Aluminium Rolling Companies

- Improving Rolling Plant Performance
  - Expertise and Process Models
  - Developing and Training Staff
  - Designing new rolling operations for maximum returns
Development and Training Employees

- Need to retain experienced staff

- Need to develop a source of University graduates
  - correct disciplines
  - need further development and training

- Set up and foster University-based “Centres of Excellence”
  - specialised aluminium focus
  - sponsor students, projects and departments

- In-house R&D Centre
  - develop specific skills within R&D projects
  - transfer R&D people to plants in operational roles

- Ongoing training of all staff
  - use specialist technical companies for regular training and mentoring
# Training Example: Aluminium Rolling Technology Course

**ALUMINIUM ROLLING TECHNOLOGY COURSE - Innoval Technology, Banbury 14-18th May 2012**

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Designing New Rolling Operations for Maximum Returns

- World-class equipment does not on its own guarantee world class products
  - Need the correct technology options for the products to be made
  - Need support from product and process experts

- Many examples in aluminium rolling mill investments
  - ROI took longer than planned
  - difficulty achieving the quality requirements of world-class products

- Maximum returns require performance above the levels achieved during machine commissioning
  - the machine must be designed correctly for world-class performance
  - need technical expertise and know-how to maximise returns

- Danieli Diamond Mills are designed with Innoval expertise to succeed
Choosing the Right Technologies - Assess Product Challenges

- Products vary in their complexity and in their difficulty of manufacture

- The products determine what equipment is required in the plant
  - type of rolling or extrusion equipment
  - type of finishing operations

Example – Can Body Stock (CBS)

- A single can line manufactures 2,000 cans per minute (1 billion per year)
- Can line requires very high quality CBS
- CBS is technically demanding to produce
- Need a high Capex hot mill configuration to produce CBS
Choosing the Right Technologies - Capacity Calculations

- Correct sizing and multiples of equipment type
  - For example - what size of furnace and how many?

- Assessment of spare capacity within key assets
  - What other products could the plant make to fill any spare capacity?

- Awareness of the magnitude of process scrap at every stage (recoveries)
  - 1000 tonnes of cast slabs may only produce 700 tonnes of finished product
  - Product dependent

Example – Rolling Mill
- The capacity of a rolling mill depends on the design and the products being rolled
- A rolling mill represents a significant component of Capex so must be specified very carefully
Designing New Rolling Operations for Maximum Returns

- Market Analysis
  - products
  - volumes
- Capacity Models
- Equipment Specification
  - equipment
- Plant Design
  - capex & opex
- Cost Modelling
  - IRR, NPV, etc.
- Viable?
  - no
  - yes
- Bankable Study

Sales prices

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Summary

- Challenges Facing Aluminium Rolling Companies

- Importance of Experts and use of Process Models
  - Many key processes are conducted “out of sight”
  - Models are powerful tools to help in the optimisation of rolling processes so that maximum productivity is achieved without prejudicing product quality
  - Innoval staff have many years experience of both creating and applying these models to the benefit of the rolling and finishing processes

- Developing and Training Staff
  - Aluminium rolling technology course

- Designing new rolling operations for maximum returns
  - Iterative design process to maximise ROI
  - Need technical expertise and know-how to achieve world-class quality levels

Leads to improved rolling plant performance
Obrigado!
Innoval Technology

providing independent expertise to the aluminium industry

www.innovaltec.com