Designing, Manning and Operating a World-Class Downstream Business

Dr Tom Farley
Managing Director
Innoval Technology Ltd
Summary of Presentation

- Innoval Technology
  - Background

- Designing an Efficient and Viable Downstream Plant
  - Market Analysis
  - Equipment Specification
  - Plant Design
  - Cost Modelling

- Developing the Right Skills

- Achieving World-Class Standards
Innoval Technology – Our Credentials

- Innoval Technology is an independent company providing a unique resource of expertise to the downstream aluminium industry
  - Formed in 2003 as a result of closure of one of Alcan’s Global R&D centres

- 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 20 years
  - Many have held Senior Management positions in global aluminium companies.
Innoval Technology – Strategic Support

- Innoval has undertaken the following types of strategic support work for potential investors in downstream fabrication businesses:
  
  ➢ Technical Due Diligence on existing plants
  
  ➢ Pre-Feasibility Studies and Greenfield plant design
  
  ➢ Plant investment and upgrade support
Designing an Efficient and Viable Downstream Plant
Methodical Approach

- Market Analysis

- Equipment Specification
  - Technical Configuration
  - Technology Choices

- Plant Design

- Cost Modelling
Market Analysis

- Review all potential products for the plant
  - Home market
  - Export market

- Gather data on product sales prices

- Important to have understanding of market price vs. production costs
  - Some products cost more to produce
  - High sales price does not necessarily mean high profit

- Analyse competition in home and export markets
  - Quality required to compete in chosen market

- Decide on which products to manufacture
Methodical Approach

- Market Analysis

- Equipment Specification
  - Technical Configuration
  - Technology Choices

- Plant Design

- Cost Modelling
Assess Technical Challenges for Chosen Products

- 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)
10,000 tonnes of aluminium per year (2 x 14 tonne coils per day)

Some may think this is a simple product
… BUT actually it is technically demanding
Can Body Stock - Thickness Reduction and Tighter Control

Coca-Cola’s First All Aluminium Can, 1967 (weight 21g)

Coca-Cola Aluminium Can, 2009 (weight 12g)
Can Body Stock - Thickness Reduction and Tighter Control

- Extremely tight specification for aluminium sheet thickness
  - Correct thickness tolerance can only be achieved with state of the art thickness control systems ...
  - ... AND the know-how to get the most from these systems
  - Unlikely to be achieved at start-up

- Failure to meet specification will lead to can plant jams and can strength issues

Profile (crown) ~ 0.5%

Strip width ~ 1.8 m

250 +/- 5 microns

Speed ~ 110 km/hr

Coil length ~ 10,000 m
Can Body Stock – The Challenge of “Earing”

- “Earing”
  - Anisotropic mechanical properties caused by crystallographic texture

- Sheet with “earing” that is out of specification will
  - Risk jamming and stoppage of the can plant line
  - Result in volume of can being too small

Ears

Can after re-draw and wall ironing with severe earing
Can Body Stock – The Challenge of “Earing”

- World-class earing can only be achieved when rolling DC ingot through a Hot Line that includes a Hot Tandem Mill.

Source: SMS
Summary of Sheet Rolling Process

1. Continuous caster
2. Continuous mill
3. Hot roller
4. Hot reversing mill
5. Hot tandem mill
6. Pre-heating
7. DC Caster
8. Furnaces
9. Filter
10. Scalper
11. Cold finishing mill
12. Cold mill
13. Inter-anneal
14. Final anneal
15. Cold roughing mill
16. Cold mill
17. Doubling mill (foil)
18. Cold mill
19. Coating
20. Hot coil
21. Hot coil
22. (Self-anneal)
## Rolling Technology Configurations for Various Products

### Hot Band Option

<table>
<thead>
<tr>
<th>Products</th>
<th>HRM + 4-stand HTM</th>
<th>coil-to-coil HRM</th>
<th>Belt Caster</th>
<th>Roll Caster</th>
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<tbody>
<tr>
<td>Typical Capacity (tonnes pa)</td>
<td>700k</td>
<td>150k</td>
<td>120k</td>
<td>20k</td>
</tr>
<tr>
<td>Can Body Stock (CBS)</td>
<td>✓ ✓ ✓</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
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<tr>
<td>Can End Stock (CES) &amp; Tab</td>
<td>✓ ✓ ✓</td>
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<td>✗</td>
<td>✗</td>
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<tr>
<td>Foilstock</td>
<td>✓ ✓ ✓</td>
<td>✓ ✓ ✓</td>
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<td>Standards - Low Mg</td>
<td>✓ ✓ ✓</td>
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<td>Surface Sensitive Products</td>
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<td>Thick Products</td>
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<td>Clad Products</td>
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<td>✓ ✓ ✓</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Others</td>
<td>✓ ✓ ✓</td>
<td>✓ ✓ ✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

✓ ✓ ✓ meets world class quality requirements
✓ can be made but does not meet all quality requirements
✗ cannot be made or fails to meet most quality standards.
Making the Appropriate Technology Choices

- Need to identify correct technology options to achieve current customer quality standards
  - E.g. on-line measurement technologies

- There are significant variations in performance and price of equipment

- Consider future proofing the equipment to meet evolving customer needs
  - Tightening of specifications
  - Increasing coil weights (width and length)
Methodical Approach

- Market Analysis
- Equipment Specification
  - Technical Configuration
  - Technology Choices
- Plant Design
- Cost Modelling
Plant Design – Capacity Calculations

- Correct sizing and multiples of equipment type
  - E.g. 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 losses at every stage (recoveries)
  - To sell 1000 tonnes of final product the rolling mill may need to roll 1200 tonnes

Example – Rolling Mill

The capacity of a rolling mill depends on the products being rolled

A rolling mill represents a significant component of Capex so must be specified very carefully
### Example – Rolling Mill Capacity Calculations

<table>
<thead>
<tr>
<th>Product</th>
<th>One</th>
<th>Two</th>
<th>Three</th>
<th>Four</th>
<th>Five</th>
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</thead>
<tbody>
<tr>
<td>Final gauge [mm]</td>
<td>0.1</td>
<td>0.22</td>
<td>0.5</td>
<td>0.8</td>
<td>2</td>
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<tr>
<td>Percent of production</td>
<td>33%</td>
<td>23%</td>
<td>22%</td>
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<td>13%</td>
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<tr>
<td>Rolling time [min]</td>
<td>54</td>
<td>18</td>
<td>10</td>
<td>6</td>
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<tr>
<td>Handling time [min]</td>
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<td>20</td>
<td>20</td>
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<td>10</td>
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<tr>
<td>Overall capacity [ktonne/yr]</td>
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#### Removal of heavy gauge product

<table>
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<th>Four</th>
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<tr>
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<td>0.1</td>
<td>0.22</td>
<td>0.5</td>
<td>0.8</td>
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</tr>
<tr>
<td>Percent of production</td>
<td>39%</td>
<td>28%</td>
<td>26%</td>
<td>7%</td>
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<tr>
<td>Rolling time [min]</td>
<td>54</td>
<td>18</td>
<td>10</td>
<td>6</td>
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<tr>
<td>Handling time [min]</td>
<td>30</td>
<td>20</td>
<td>20</td>
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<td>Overall capacity [ktonne/yr]</td>
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#### 10% increase in pass speeds

<table>
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<th>Four</th>
<th>Five</th>
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<td>Final gauge [mm]</td>
<td>0.1</td>
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<tr>
<td>Percent of production</td>
<td>39%</td>
<td>28%</td>
<td>26%</td>
<td>7%</td>
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<tr>
<td>Rolling time [min]</td>
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<td>15</td>
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<td>87</td>
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</table>
Plant Design – Optimising Layout of Equipment

- Based on knowledge of world-class operations
- Need to account for potential expansion
- Ensure efficient process flow
- Important safety considerations
- WIP Calculations (buffer sizes, WIP storage around plant)
  - “Discrete Event Simulation”, if necessary
Methodical Approach

- Market Analysis

- Equipment Specification
  - Technical Configuration
  - Technology Choices

- Plant Design

- Cost Modelling
Cost Modelling

- It is easy to build a simple Excel-based cost model ... BUT ...

- Need realistic model inputs based on experience and expert calculation
  - Product recovery vs year from startup
  - Efficient staff levels
  - R&D costs (~0.5% of turnover typical)

- Calculation of Capital Costs (CAPEX)
  - Inclusion of all key and ancillary equipment

- Calculation of Operating Costs (OPEX)
  - Requires a good understanding of the process
  - Computer models can be used to predict utility usage (electricity, gas, etc.)

- Useful to attribute costs correctly to different products

- More complex tools can be used to analyse the model (e.g. Monte Carlo)
Example of Cost Model Output
Pre-Feasibility Study – Flow Diagram

Market Analysis → products volumes → Equipment Specification → equipment → Plant Design → capex & opex → Cost Modelling → IRR, NPV, etc. → Viable? → no → Market Analysis → extra capacity → yes → Bankable Study → Sales prices
Developing the Right Skills
## Typical Staff Requirements for a Downstream Plant

- Typical 250,000 tonne rolled products plant operating in Western World

<table>
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<th>Day Staff</th>
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<td>60</td>
<td>60</td>
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Typical Skills Requirements for a Downstream Plant

- **Managerial**
  - Planning
  - Scheduling
  - Finance
  - HR

- **Sales**
  - Sales manager for each major product group
  - Technical Representatives at customer plants

- **Technical**
  - Metallurgists
  - Engineers
  - Chemists
  - Materials scientists

- **Plant and Maintenance**
  - Statistician
  - Engineers
  - Electrical
  - Mechanical

- **Other**
  - Craftsmen
  - Medical
  - Fire protection
  - Drivers
Recruitment Issues

- Graduates
  - Need a good supply of the correct disciplines
  - They will need further development and training

- Experienced Staff
  - Internal transfer from other group operations (if they exist)
  - Access to “early retirees” from world-class operations
  - Head-hunt from competitors

- Retention of Staff
  - Risk of competitors headhunting your good people
  - Threat to both existing and new companies
  - May come from a related industry, e.g., Steel and aluminium rolling need similar skills
  - Potential loss of knowledge
Approaches to Graduate Development

- University-based “Centres of Excellence”
  - Specialised focus (e.g. Aluminium, Rolling or Extrusion, Surface Science)
  - 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 Development of Staff
  - Use specialist training courses
  - Mentoring from experienced professionals
  - Can be provided by independent external organisations
# ALUMINIUM ROLLING TECHNOLOGY COURSE - Innoval Technology, Banbury 11-15th May 2009

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<td>Vibration</td>
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Managing Knowledge Assets

- Important to maximise the knowledge that exists in employees
  - Staff with valuable knowledge which is not being exploited
  - Share knowledge of manufacturing to improve product quality
  - Determine gaps in the knowledge base (R&D programme)
  - Loss of long-serving, knowledgeable employees
  - Standardise operations and develop “Best Practice”

Knowledge Management using K-Maps

- Team-based Workshop approach involving
  - Manufacturing
  - Technology
  - Sales
## K-Map of Aluminium Extrusion Operation

### Knowledge Map for Soft Alloy Extrusion

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Stages</th>
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<tbody>
<tr>
<td>Dimensional accuracy</td>
<td>Molten metal treatment</td>
</tr>
<tr>
<td>Bow &amp; twist</td>
<td>DC casting</td>
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<tr>
<td>Length per cavity</td>
<td>Homogenisation</td>
</tr>
<tr>
<td>Surface pick-up</td>
<td>Billet heating</td>
</tr>
<tr>
<td>Die lines</td>
<td>Billet shear / saw</td>
</tr>
<tr>
<td>Surface tearing</td>
<td>Die design</td>
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<tr>
<td>Tensile strength</td>
<td>Die preparation</td>
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<td>Die start-up problems</td>
<td>Die heating</td>
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<tr>
<td>Unplanned scrap</td>
<td>Die change practice</td>
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<tr>
<td>Scratches &amp; dents</td>
<td>Container heating</td>
</tr>
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<td>Downtime</td>
<td>Extrusion cycle</td>
</tr>
<tr>
<td>Tonnes per hour</td>
<td>Dead cycle</td>
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<tr>
<td></td>
<td>Puller</td>
</tr>
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<td></td>
<td>Hot saw</td>
</tr>
<tr>
<td></td>
<td>Forced air cooling</td>
</tr>
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<td>Cooling table</td>
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<tr>
<td></td>
<td>Stretching</td>
</tr>
<tr>
<td></td>
<td>Cold saw &amp; stack</td>
</tr>
<tr>
<td></td>
<td>Ageing</td>
</tr>
<tr>
<td></td>
<td>Packing</td>
</tr>
</tbody>
</table>

### How to Build a K-Map

- Assemble those with knowledge
- Define Product Attributes
- Define the Process Stages
- Define the strength of relationship
- Develop content via Intranet

### Legend

- **Strong**
- **Medium**
- **Weak**
- **Unknown**
- **Disputed**
- **No Relationship**
Effect of Forced air cooling on Tensile strength: Strong

What is happening?

During cooling from the extrusion press it is important to keep the Mg and Si in solid solution so that the section can achieve the required age hardening response without the need to carry out a separate solution heat treatment and quench.

In order to achieve this the section must be cooled to temperatures below about 250°C within a few minutes. If the cooling rate is not sufficient then coarse Mg2Si particles can form during cooling, resulting in low strength after ageing.

The steps within Cooling which affect Strength are highlighted under 'List Steps'

How are these controlled?

- Ensure that the air hood is correctly positioned
- Ensure there are no blockages in the air jets
- Switch on the air jets and fans
- Adjust the airflow to the required percentage for the profile weight as given on the works order.

Note: the water quench should not be used on 6063

Created: 14 Jun 2006 4:21pm by Guest
Last Updated: 20 Jan 2009 1:44pm by guest
Achieving World-Class Standards

...value through Innovation
State-of-the-Art Equipment is Not Sufficient

- Realisation that investment in world class equipment does not on its own give world class products.
- Many examples in aluminium rolling mills and extrusion plants.
  - Return on investments taking longer than planned
  - Cannot match quality of world-class products
  - Need expertise that equipment suppliers do not usually possess

Equipment manufacturers looking to partner with product specialists to deliver a complete package
Benchmarking & Technical Audits

- World-class companies frequently use their internal resources to benchmark their operations against their own “Best Practice”.
  - Team assembled for several days to review and observe operations
    - Experienced operators
    - Technical experts
    - Host plant
    - Experienced facilitator

- Output is a “gap analysis” of areas to be improved.
  - Action plan established
  - Progress then reviewed at regular intervals
  - Repeat visits to provide additional support, as required

- For single-site companies the same function can be carried out by external consultants
  - Can also be of benefit to large multi-nationals to get a “fresh view”
Typical Check-list for Technical Auditing & Due Diligence

- Environment, Health & Safety
  - Accident recording and rates

- Equipment Operation
  - Standard Operating Practices
  - Use of Statistic Process Control
  - Maintenance schedules and strategies
  - Investment plans

- Operational Efficiency
  - Machine utilisation
  - Recoveries

- Product Quality
  - Test procedures
  - Reject Rates

- Technology System
  - Approach to problem solving
  - Product and Process improvement methods
Summary

- An efficient and viable downstream plant can be designed using Innoval’s methodical approach based on >20 years working in the industry
  - Market Analysis
  - Equipment Specification
  - Plant Design
  - Cost Modelling

- A key stage is matching equipment specification to the optimum product mix in order to maximise the financial returns from the plant

- We have emphasised the need for a broad range of technical skills and routes to develop this important resource locally

- Achieving the anticipated financial returns requires more than just state of the art equipment and technology – but also input from world-class expertise and know-how
Thank you for your attention ...
Innoval Technology

An independent company providing expertise to the aluminium industry

www.innovaltecc.com