Roll Cooling in Novelis Aluminum Hot and Cold Rolling Mills

PRESENTED BY ANDREW HOBBS

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Overview

Objectives of Roll Cooling
Roll Cooling Systems and Spray Nozzles
Coolant Types
Roll cooling measurements
‘Footprint’ Roll Cooling Design Model
Design guidelines
Objectives of Roll Cooling

- Reduce friction and wear
  - Roll force, Surface quality, Refusals
- Remove excess heat
  - Avoid damage to roll
- Control thermal crown on roll
  - Strip thickness profile and flatness
- Wash away wear debris
Roll Cooling Systems

- Several rows of spray nozzles, spaced 1-3 inches apart across the width of the roll
- Valves switch nozzles individually or in zones to selectively cool the roll
Spray Nozzles

- Nozzles deliver spray with a defined flow rate and geometry
- Two main types are used
  - Flat spray – narrow elliptical pattern
  - Full cone – circular pattern

Flat spray nozzle
(Pictures: Spraying Systems Company)

Full cone nozzle
(Pictures: Lechler)
Valves and Cooling Control

- Control the level and distribution of cooling on roll
- Pulse or Level control strategies

Mill coolant valves
(Picture: Primetals Technologies)
Aluminum Rolling Coolants

- Hot rolling emulsion
  - Naphthenic or paraffinic mineral oils
  - Emulsifiers (metal and amine soaps and/or nonionic surfactants)
  - Load-bearing additives (fatty acid, alcohol, ester)
  - Other additives (anti-oxidant, anti-corrosion, biocide,...)
  - Water

- Cold rolling oil
  - Base oil (hydrodynamic lubrication)
  - Additives

- Novelis patented technology for water-based roll cooling

<table>
<thead>
<tr>
<th>Process</th>
<th>Metal temperature</th>
<th>Metal thickness</th>
<th>Coolant</th>
<th>Lubricant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot rolling</td>
<td>300-500°C</td>
<td>2-500mm</td>
<td>Emulsion</td>
<td></td>
</tr>
<tr>
<td>Cold rolling</td>
<td>20-200°C</td>
<td>&lt;0.1-4mm</td>
<td>Mineral oil</td>
<td>Water</td>
</tr>
</tbody>
</table>

Coolant Effectiveness

- Roll cooling sprays within a coolant containment box (CCB) at exit side; Coolant drainage inside the CCB and CCB is under vacuum
Coolant Effectiveness

- Relative measurement of cooling performance of different Cold Mill Lubricants
  - Heated aluminum block, instrumented with thermocouples, was cooled in a standard test using sprays of various lubricant oils
  - Measured up to 25% reduction in htc compared to normal paraffin
Cooling Measurements

- Measurement of cooling effect of spray
- Heated rotating roll rig
  - Central section with cartridge heaters, instrumented with thermocouples, cooled by spray
- Measured the effects of flow rate, pressure, nozzle type, spray geometry, roll speed, coolant type
- More significant factors are extent of spray coverage area, flow rate and roll speed
- Correlations developed for design of cooling systems

Rotating roll rig for roll cooling measurements
Cooling Distribution

- Measurement of cooling distribution by liquid crystal technique
  - An aluminum sheet, with the back surface painted black and with a film of liquid crystal coating, was initially cooled to uniform ambient temperature
  - Hot water sprays were impinged on the front surface. Lines of color change were video recorded then analysed to yield contour maps of htc value
Spray Footprint Measurements

- Spray footprints measured with Fujifilm pressure-sensitive film
  - Film attached to an arc of mill roll circumference, where sprays impinge, and covered with ‘water-proof’ plastic sheet
  - Sprays are operated for 10 seconds and film color changes to red, depending on the pressure
  - Films can be scanned with Fuji analyser to determine the impingement pressure distribution
  - Measurement reveals blocked, misaligned or damaged nozzles etc

![Mill roll wrapped with Fujifilm pressure sensitive film](image)

![Analysis of Fujifilm pressure footprints](image)
Roll Cooling Design

- Design model incorporates knowledge from roll cooling measurements
- Model input parameters:
  - Roll and spray bars
  - Nozzle types and flow characteristics
  - Valve characteristics
  - Coolant type
  - Strip and rolling

Interface for Footprint roll cooling design model
- **Design guidelines**
  - Large spray coverage on rolls and space spray bars around circumference
  - Cool exit side unless carryover is an issue
  - Position spray bars not too close to roll and aim near perpendicular to roll (sensitivity to roll diameter)
  - Target 10-50% spray overlap for full range of roll diameters
SUMMARY

- Multiple functions of roll coolant
- Zoned application and controlled level of cooling
- Different coolant types
- Measurements for roll cooling design and process development
Thank you

Questions ?