Institute of Refractories Engineers

LADLE REFRACTORIES

Training Day 2010
Rotherham

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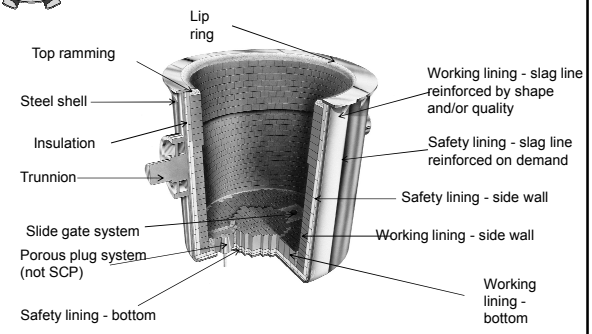
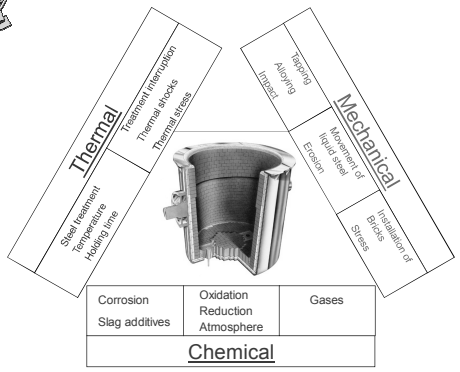
Secondary Steelmaking: Steel Ladles - Introduction

- Originally, ladles were used only to carry the steel from the primary steelmaking equipment to the casting bay.
- They were lined with cheap low quality materials such as fireclay brick or rammed sand.
- Currently the ladles are required to hold steel for long times at higher temperatures for continuous casting.
- They are now used as reaction vessels for a range of metallurgical processes such as stirring, degassing and arc heating.
- Due to the wide range of processes possible within the steel ladle, the refractories must withstand the wear mechanisms related to these processes.

Ladle construction: Main areas



Ladle Wear Mechanisms



Ladle Wear Mechanisms

Ladles:

- Mechanical:
  - Erosion by molten iron/steel e.g. during tapping, stirring
  - Erosion by slags and additions.
- Chemical:
  - Corrosion by slags; e.g. ladle slagline brick 'dissolving' in the process slags
  - Reactions occur faster at higher temperatures
- Thermal:
  - Thermal shock caused by rapid temperature change
  - Thermal stresses between materials
- (Carbon deposition reaction)

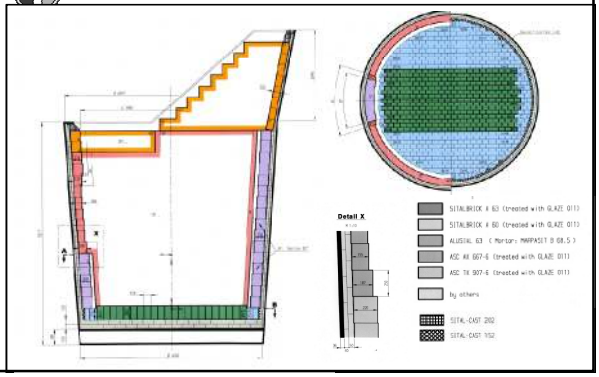
Charging (Iron) Ladles

Ladle Refractories: Brick application at Corus (1)

Main Wear Factors:
- Iron pour from torpedo ladles
- Iron and slag chemistry
- Long residence time
- Carbon monoxide
- Steel returns to vessel

- **Charging Ladle Lining Materials:**
  - Safety Linings - 60% Alumina brick (fired andalusite)
  - Intermediate Linings - 42% Alumina Firebrick
  - Working Linings:
    - Bottom – Resin bonded Andalusite
    - Sidewalls – ASC
    - Pour lip – fired Andalusite (Shotcrete at top)

Charging Ladle Design



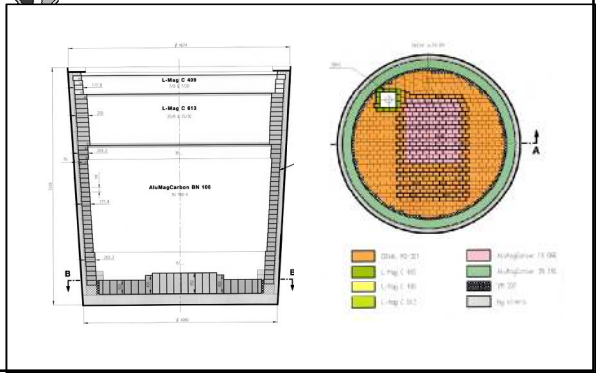
Conventional and LAF (Steel) Ladles

Ladle Refractories: Brick application at Corus (2)

- **Main Wear Factors:**
  - Steel tapped from vessel
  - Steel and slag chemistry

- **Conventional Ladle Lining Materials:**
  - Safety Linings - Magnesia Chrome brick
  - Intermediate Linings
    - 42% Alumina Firebrick (bottom)
    - DV 'backfill'
  - Working Linings:
    - Bottom – AMC brick (impact), Resin bonded Doloma
    - Sidewalls – AMC
    - Slagline – Magnesia Carbon

Conventional Ladle Design

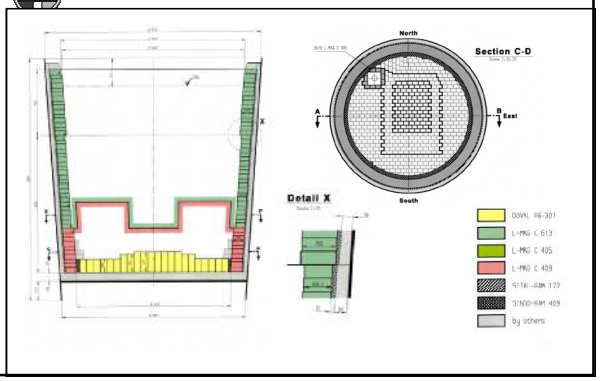


Ladle Refractories: Brick application at Corus (3)

Main Wear Factors:
- Steel tapped from vessel
- Steel and slag chemistry
- Long residence time
- Stirring, additions, degassing, ladle arc furnace

- **LAF (Steel) Ladle Lining Materials:**
  - Safety Linings
    - 60% Alumina (bottom, fired andalusite)
    - Magnesia Chrome (sidewalls and slagline)
  - Intermediate Linings
    - 42% Alumina Firebrick (bottom)
    - DV 'backfill' (sidewall)
  - Working Linings
    - Bottom – Resin bonded Doloma,
    - Sidewalls and Slagline – Magnesia Carbon

LAF Ladle Design



Ancillaries

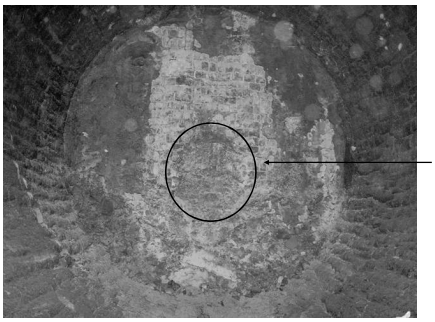
Micro-porous insulation tile. Installed behind the safety lining brickwork

Ladle wellblock

Tladle Performance

- Charging Ladle:
  - ASC Design – average 504 Heats (2010)
- Conventional Ladle:
  - Maximum life 100 Heats. Ladle utilisation at very low level so ladles generally terminated for non-refractory reasons
- LAF Ladle:
  - Bottom average (slagline replaced) 57 heats (2010)
  - Ladle full campaign average 99 Heats (2010)

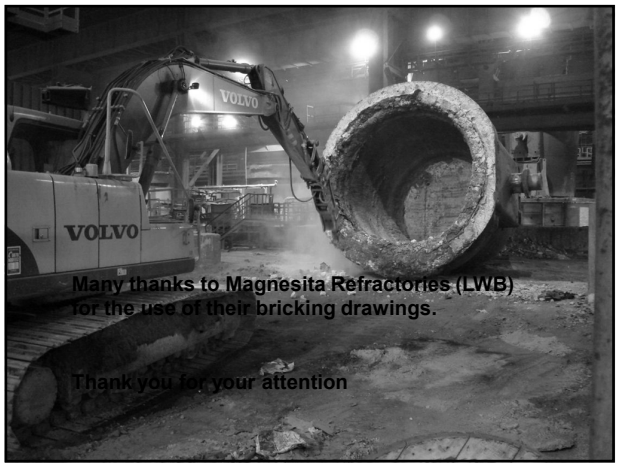
Refractory Campaign End



Refractory Campaign End

Ladle Refractories: Summary

- Ladles are one of the highest refractory cost areas.
- The ladle uses a diverse range of materials.
- Proper selection and installation are essential to realise safest, and best cost solutions
- Correct ladle usage is also essential:
  - Keep temp of refractories consistent
  - Control slag V ratio
  - Control of steel temp & treatment times
  - Steel residence time



Many thanks to Magnesita Refractories (LWB) for the use of their bricking drawings.

Thank you for your attention