

# Dissemination of European project focusing on Refractories

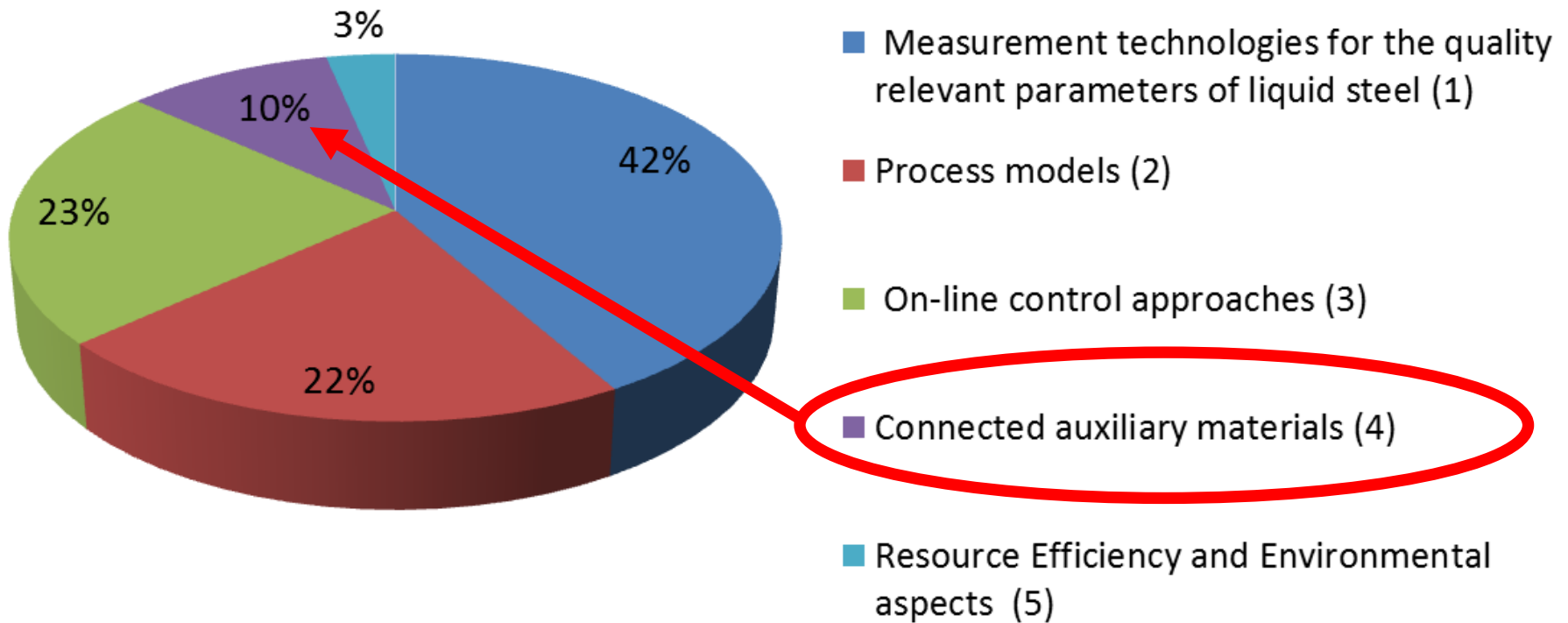
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# Identified topics for the dissemination

- Measurement technologies for the quality relevant parameters of liquid steel
- Process models
- On-line control approaches
- Connected auxiliary materials
- Resources efficiency and environmental aspects

# Identified topics for the dissemination

## Main relevant topics



# Sub-Topics of Connected auxiliary materials

- Sub-Topic 4.1 Refractories
- Sub-Topic 4.2 Stirring plugs
- Sub-Topic 4.3 Slag formers and slag control
- In total 6 projects were identified to address the topic Connected auxiliary materials
- Of this projects Sub-Topic 4.2 were addressed in three projects

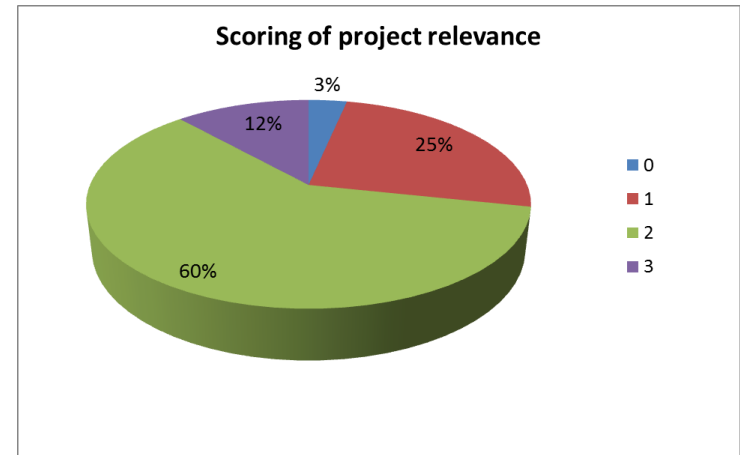
# Projects dealing with Sub-Topic 4.1

## Refractories

Report number	Title	Participants	End date	Relevant Processes
EUR 19485	Development of techniques to minimise ladle/slag interaction and prevent uncontrolled inclusion modification	IRSID, British Steel, SOLLAC	1999-06-30	LF
EUR 21335	Chromium-free alternative refractory for the lining of RH/DH vessels	Arcelor, Corus NL	2002-08-31	RH
EUR 21446	The Determination and elimination of the effect of Anti-Oxidants in Magnesia-Carbon bricks on steel composition and inclusion formation	Corus UK, CSM, DIFK, Saerstahl	2003-12-31	All

# Scoring

- The scoring of the projects has been based on the following four criteria:
  - **Zero:** if “the project idea does not work”
  - **One:** if “the project idea was in principle good, but industrial implementation was not possible at the time”
  - **Two:** if “the project idea is applied in at least one industrial plant”
  - **Three:** if “the project idea is state of the art and is applied in many plants”



- # of projects scored zero:
- 2 projects (3%)

# Projects dealing with Sub-Topic 4.1 Refractories

- The projects are all quite old
- Two projects deals mostly with reactions between refractories and steel
- One project deals with replacing chromium containing refractory materials in the RH process and also minimize the environmental effects from landfills of used refractories

# Dissemination

## **Development of techniques to minimise ladle/slag interaction and prevent uncontrolled inclusion modification**

- Contract No 7210/CC/302/303/809 7215-PP/027
- 1 July 1996 to 30 June 1999
- Project focus on
  - the carbon pick-up refractories in ULC steels
  - contamination of metal by glazed ladle lining
- Partner consortium
  - IRSID (now ArcelorMittal Maizières Research SA)
  - British Steel (now part of TATA)
  - SOLLAC (former French steelmaker now part of ArcelorMittal)



# Dissemination

## Development of techniques to minimise ladle/slag interaction and prevent uncontrolled inclusion modification

- Objectives of project
  - Identify detailed mechanisms of mass transfer from refractory lining of ladles towards steel in the two situations:
    - carbon pick-up by ultra-low carbon steels from C-bearing refractories at slag line.
    - contamination of metal by glazed ladle lining from previous casts
  - improve process practices in ladle to minimise both aspects
  - contribute to casting higher quality steels by better control of steel inclusion populations and of steel composition (carbon in ultra-low carbon steel) at ladle stage of the involved steelmakers

# Dissemination

## Development of techniques to minimise ladle/slag interaction and prevent uncontrolled inclusion modification

- Ways and means
  - Plant trials to investigate carbon pick-up during the production of ULC steels
  - Laboratory study of mechanisms of direct C transfer from MgO-C to ULC steels
  - Development of a low-C content Al-MgO-C refractory
  - Development of a combined fluid flow/thermodynamic model of the ladle filling process for Si-Mn steels, which includes the effect of ladle glaze on the formation and development
  - Pilot trials to investigate the formed ladle glaze

# Dissemination

## Development of techniques to minimise ladle/slag interaction and prevent uncontrolled inclusion modification

- Results
  - Plant trials showed that the new low-C content Al-MgO-C displayed good resistance to slag wear at plant.
  - The C pick-up results after deoxidation showed no significant difference with a standard brick
  - Validation of the fluid flow model was achieved by the mathematical modelling of a physical model of the filling process.

# Dissemination

## **Chromium-free alternative refractory for the lining of RH/DH vessels**

- Contract No 7210-PR/138
- 1 September 1999 to 31 August 2002
- Project focus on
  - Development and tests with new chromium-free lining
- Partner consortium
  - Arcelor (now ArcelorMittal)
  - Corus NL (now part of TATA)

# Dissemination

## **Chromium-free alternative refractory for the lining of RH/DH vessels**

- Objectives of project
  - Development and tests with new chromium-free lining
  - Recycling and treating magnesia-chrome wastes

# Dissemination

## Chromium-free alternative refractory for the lining of RH/DH vessels

- Ways and means
  - Clarify environmental issues regarding magnesia-chrome bricks
  - Investigate how the environmental issues worked against the Dutch and French legislation
  - Investigate treatments of chromium VI formed from used magnesia-chrome bricks by leaching tests
  - Required properties for RH refractories and evaluation methods
  - Recycling the magnesia-chrome wastes
  - Developing chromium-free refractories for RH and test them during industrial trials

# Dissemination

## Chromium-free alternative refractory for the lining of RH/DH vessels

- Results
  - The new refractory materials magnesia-hercynite material and magnesia bonded by  $\text{TiO}_2$  were identified as possible candidate to replace magnesia-chrome material
  - However, the materials need further improvements before it can resist the most severe conditions prevailing in located parts of the RH, such as the throat

# Dissemination

## **The Determination and elimination of the effect of Anti-Oxidants in Magnesia-Carbon bricks on steel composition and inclusion formation**

- Contract No 7210-PR/206
- 1 July 2000 to 31 December 2003
- Project focus on
  - Investigation on the effects of anti-oxidant materials in MgO-C bricks, used in the steel ladle, on steel cleanness and ladle life.
- Partner consortium
  - Corus UK (now part of TATA)
  - CSM
  - DIFK
  - Saarstahl



# Dissemination

## **The Determination and elimination of the effect of Anti-Oxidants in Magnesia-Carbon bricks on steel composition and inclusion formation**

- Ways and means, Laboratory scale
  - Laboratory experiments to develop and validate thermodynamic and kinetic models of a kinetic model of the transfer of species from refractory to metal and the modification of the metal composition and cleanness.
  - Laboratory tests to examining the interaction between refractory, slag and metal and their results suggest an alternative mechanism for the transport of MgO from refractory to steel.

# Dissemination

## **The Determination and elimination of the effect of Anti-Oxidants in Magnesia-Carbon bricks on steel composition and inclusion formation**

- Results, Laboratory scale
  - It was shown that breakdown of the large MgO grains into smaller crystallites, either by melting of the native gangue material, or by infiltration of slag into the internal grain boundaries of the MgO.
  - The results also showed the importance of sulphur, contained in the binding material of the brick, in the process of detachment of slag droplets and inclusions from the slag/metal interface.
  - Corus UK also carried out thermodynamic calculations to show the formation of species during refractory pre-heat and by interaction with slag.

# Dissemination

## **The Determination and elimination of the effect of Anti-Oxidants in Magnesia-Carbon bricks on steel composition and inclusion formation**

- Results, Laboratory scale
  - Both sets of experimental results and the kinetic and thermodynamic calculations show the production of potentially harmful inclusion species by reaction of anti-oxidant species in the refractory.

# Dissemination

## **The Determination and elimination of the effect of Anti-Oxidants in Magnesia-Carbon bricks on steel composition and inclusion formation**

- Ways and means, Small pilot scale
  - Corrosion tests in a 20 kg induction furnace and thermodynamic calculation.

# Dissemination

## **The Determination and elimination of the effect of Anti-Oxidants in Magnesia-Carbon bricks on steel composition and inclusion formation**

- Results Small pilot scale
  - Thermodynamic calculations showed the potential formation of harmful species when using Al or Si metal as anti-oxidants and the corrosion tests showed no advantages in their use, from a wear point of view.
  - MgO-C refractories with carbon contents varying from 5% to 24% were tested and the results showed best performance with MgO-5%C.
  - Material with MgO-5%C was recommended for plant trials in a ladle at Saarstahl.

# Dissemination

## **The Determination and elimination of the effect of Anti-Oxidants in Magnesia-Carbon bricks on steel composition and inclusion formation**

- Ways and means, plant trials
  - An initial trial examined the performance of a "high purity" magnesite lining, using MgO-12%C in the slag zone and MgO-5%C in the lower wall and bottom of the ladle. The test ladle was compared with a standard lining.
  - Further trial were completed with varying refractory composition
  - Rapid Analysis of Trace Elements, was carried out by Corus UK. The work concentrated on the development of a LIBS (Laser Induced Breakdown Spectroscopy) method for rapid mapping of surfaces, both conducting and non-conducting.

# Dissemination

## **The Determination and elimination of the effect of Anti-Oxidants in Magnesia-Carbon bricks on steel composition and inclusion formation**

- Results, plant trials
  - Longer life was achieved by the "High Purity" material, 57 heats compared with 35 for a standard lining
  - The plant trials showed contamination of MgO-C with unwanted anti-oxidant species, Al and Si metal. This is not believed to be accidental contamination by the supplier, rather it is thought to be contamination of one of the raw materials, probably the carbon.
  - The results show that internal grain structure, purity of raw materials and sulphur content of the binder are important factors which influence refractory performance and steel cleanness.

# Dissemination

## **The Determination and elimination of the effect of Anti-Oxidants in Magnesia-Carbon bricks on steel composition and inclusion formation**

- Results, plant trials
  - The results from the LIBS investigation shown that it can be a powerful investigation tool capable of analysing soluble concentrations, inclusion composition, position and size.



# Dissemination

## **The Determination and elimination of the effect of Anti-Oxidants in Magnesia-Carbon bricks on steel composition and inclusion formation**

- Results, overall
  - The overall conclusions from this work are that no advantages in terms of refractory life were seen for the use of anti-oxidants in MgO-C ladle bricks.
  - The generation of potentially harmful inclusions, such as spinel and corundum, was shown by the thermodynamic and kinetic models.
  - The presence of those species was confirmed by laboratory experiments and in plant samples.

# Dissemination

## **The Determination and elimination of the effect of Anti-Oxidants in Magnesia-Carbon bricks on steel composition and inclusion formation**

- Results, overall
  - Variable performance of MgO-C bricks was shown to be influenced by MgO and C quality issues, particularly the size of internal MgO crystallites and the contamination by unwanted anti-oxidant species.
  - Sulphur in the binding material was has shown to influence detachment of slag drops and inclusions from the slag/metal interface.

**Thank you for your attention!**



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