“Valorisation and dissemination of technologies for measurement, modelling and control in secondary metallurgy”

DissTec

Measurement technologies in Secondary Metallurgy

Dissemination of results from European research projects

B. Kleimt, VDEh-Betriebsforschungsinstitut GmbH

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BFI Excellence in Applied Research | VDEh-Betriebsforschungsinstitut GmbH

MPI Materials Processing Institute – Excellence in Materials & Process Innovation

CRM GROUP

swerea | MEFOS

CSM Centro Sviluppo Materiali

Stahl

Objectives of the DissTec dissemination project

Main objective of **DissTec** is to revisit the most important European projects in the frame of ECSC and RFCS research programmes related to **Secondary Metallurgy technologies** carried out in the last 25 years, to valorise, distribute and promote the exploitation of the results.

- To identify merits and limitations of the various technological solutions, as well as the spread of their implementation in the European steel plants
- To evaluate the impact of the results on a technological level
- To promote the dissemination of gained knowledge and the introduced technological solutions in relevant projects on Secondary Metallurgy
- To identify future developments and trends in Secondary Metallurgy technology
- To supply guidelines for the next developments of Secondary Metallurgy technologies, to give indications on priorities for research subjects and activities
- To suggest a clear road map for the technological development in this field

Planned dissemination activities

- Set-up of a web site to allow the access to the results of the project analysis, the presentations of seminars and workshops and the road map for future developments
- Seminars on dedicated topics of secondary metallurgy technologies
- Webinars with demonstration of successful technological applications
- Workshops to provide the possibility for information exchange and open discussion, especially regarding the identification of future developments and the definition of a road map

Project partners

Project partners are the major steel research institutes in Europe:

- VDEh-Betriebsforschungsinstitut (BFI), Düsseldorf, Germany (Coordinator)
- Centro Sviluppo Materiali (CSM), Rome, Italy
- Centre de Recherches Metallurgiques (CRM), Liege, Belgium
- Swerea MEFOS, Lulea, Sweden
- Materials Processing Institute (MPI), Teesside, UK

Selection and assessment of research projects

Selection of ECSC and RFCS projects which were / are dealing with secondary metallurgy technology for evaluation and dissemination in DissTec:

- Time period: 1990 – Today
- 60 projects in total
- 35 ECSC projects (1990 – 2005)
- 25 RFCS projects (2006 – today)
- Project table with key data were provided on the project web site

Nr	Number of contract	Title	Acronym	Report number	Participants	Start date	End date	Abstract
1	7210-CB/107	Development of process technology and metallurgy for extremely low and strictly limited nitrogen contents	/	EUR 14483 DE	BFI	1989-01-01	1990-12-31	To satisfy requirements for steel with low nitrogen contents and steels with very precise nitrogen contents, fundamental data on denitrogenation in liquid steelmaking were applied to develop a thermodynamic and kinetic model.
2	7215-CA/107	On-line analysis of molten steel for automated steel production (1st phase)	/	EUR 15184	TK Nirosta, ARBED, KRUPP Elektronik, Krupp Forschung, Univ. Madrid	1989-04-01	1991-03-31	The objective of this pilot project was to build and test an on-line analysis system for monitoring and measuring the change in concentration of various elements in liquid steel by laser-induced spectroscopy. The measurement system was tested for monitoring the carbon content in an AOD converter.

Identification and categorisation of project results

- Dissemination of the research results is limited to the technologies which allow a relatively easy transfer to various plants throughout the European steel industry:
  - **Measurement technologies** for the quality relevant parameters of liquid steel (temperature, composition of steel and ladle slag, concentration and composition of non-metallic inclusions, ….)
  - **Process models** (analytical, thermodynamic, statistical, CFD-based, off-line simulation, on-line dynamic for monitoring and control, …)
  - **On-line control approaches** (manufacturing execution systems, set-point and alloy calculations, regulation and control, through-process control for the whole chain of secondary steelmaking, ….)
  - **Connected auxiliary materials** (refractories, stirring plugs, …)
  - **Environmental aspects** (reduction of emissions, re-use of by-products, …)
- Investigations which were purely focused on fundamental research or metallurgical quality issues were excluded from the dissemination activities, as the direct transferability of such results to industrial application will be limited.

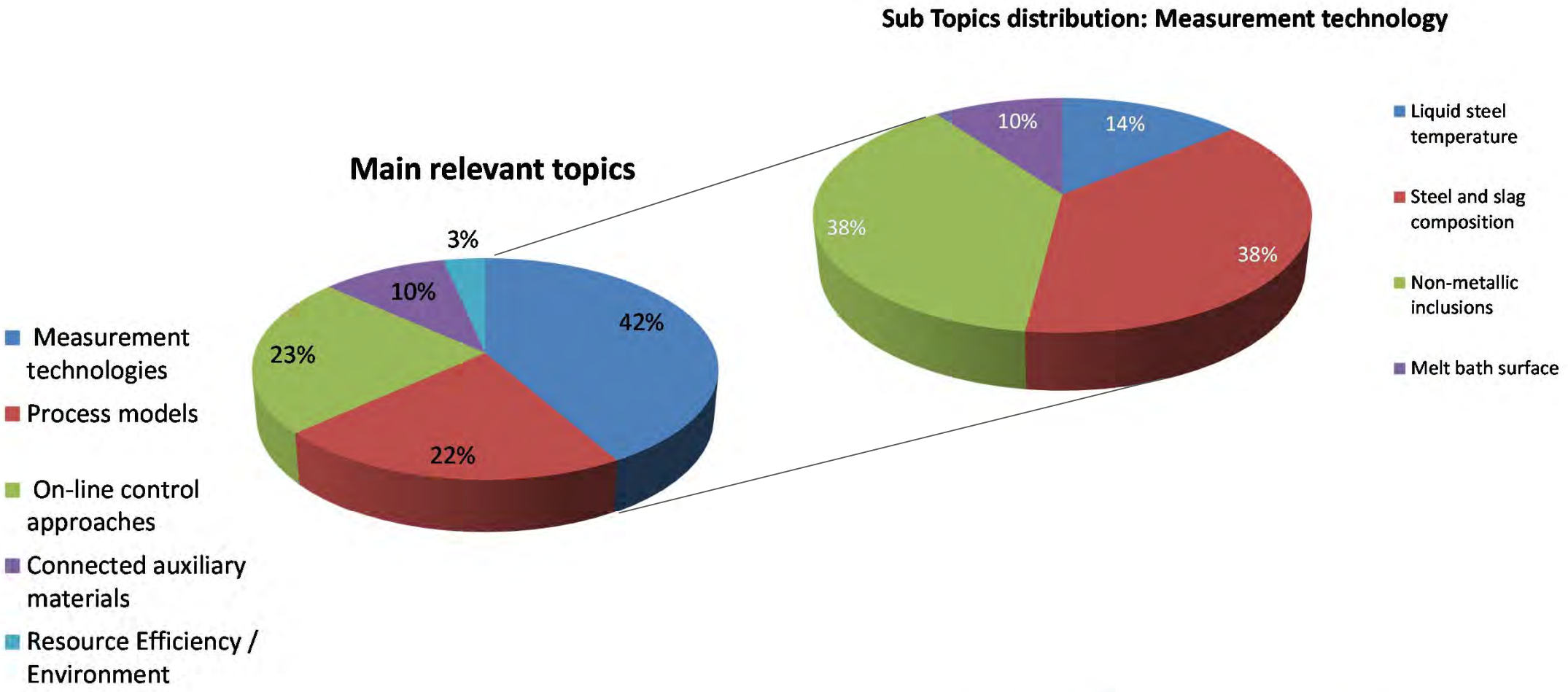
Main topics of project results with sub-topics (1)

1. Measurement technologies for the quality relevant parameters of liquid steel
    - 1.1. Temperature
    - 1.2. Composition of steel and ladle slag
    - 1.3. Concentration and composition of non-metallic inclusions
    - 1.4. Ratio of steel and slag at melt bath surface
2. Process models
    - 2.1. Analytical and thermodynamic models
    - 2.2. Statistical models
    - 2.3. CFD and physical modelling
    - 2.4. Off-line simulation
    - 2.5. On-line dynamic models for monitoring and control
3. On-line control approaches
    - 3.1. Manufacturing execution system
    - 3.2. Set-point and alloy calculation
    - 3.3. Regulation and control
    - 3.4. Through-process control for whole chain of secondary steelmaking
    - 3.5. Online monitoring of process conditions

Main topics of project results with sub-topics (2)

4. Connected auxiliary materials
   - 4.1. Refractories
   - 4.2. Stirring plugs
   - 4.3. Slag formers and slag control
5. Resources efficiency and environmental aspects
   - 5.1. Reduction of emissions
   - 5.2. Energy efficiency
   - 5.3. Resource efficiency and alloy yield improvement
   - 5.4. Re-use of by-products

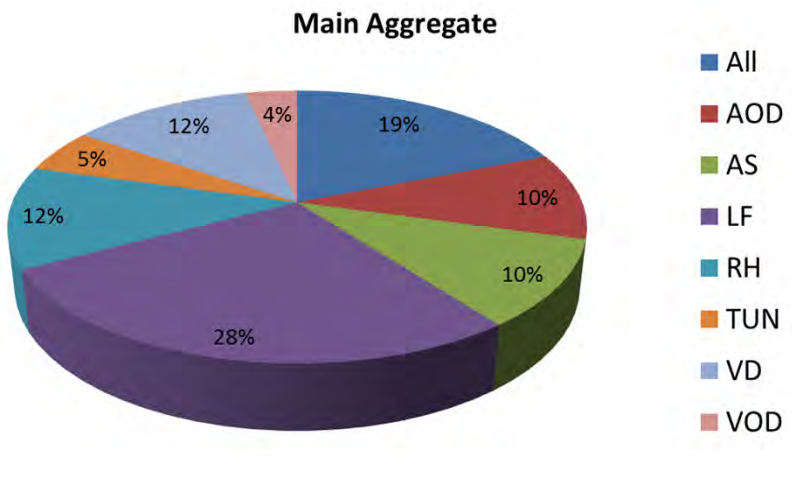
Distribution of projects to main topics and sub-topics

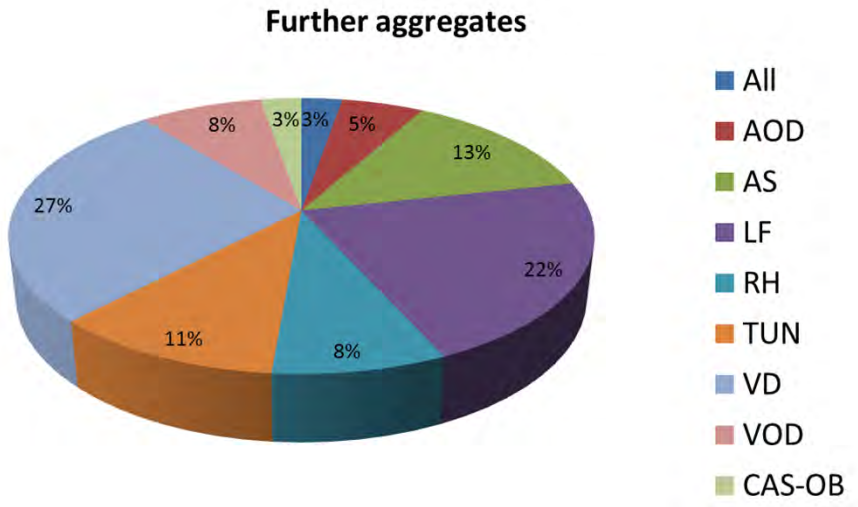


Categorisation according to Secondary Metallurgy aggregates

The projects were also classified regarding the involved aggregates of secondary metallurgy:

- Ladle furnace (LF)
- Ladle stirring station (AS)
- Vacuum tank degassing plant (VD)
- RH degassing plant (RH)
- CAS(-OB) plant (CAS)
- VOD plant (VOD)
- AOD converter (AOD)
- Tundish (TUN)

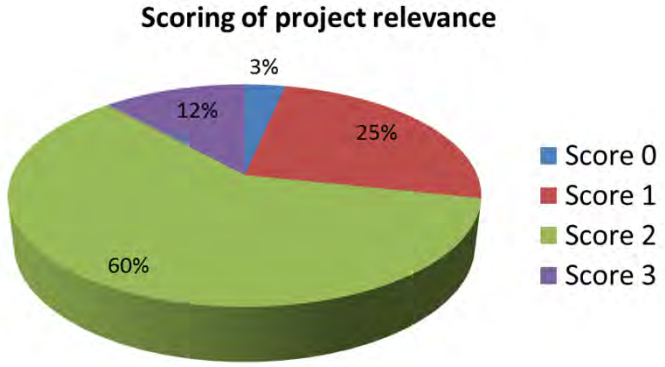


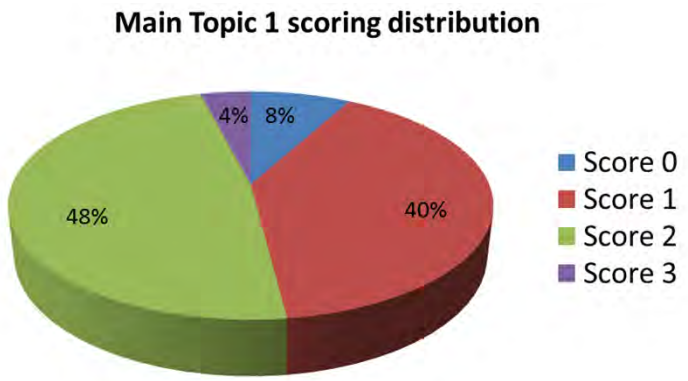


Analysis and evaluation of project results

Four criteria for scoring the relevance of the project results for industrial application were defined, for evaluating to what extent a project was successful:

- Score “zero”: the project idea did not work at all
- Score “one”: the project idea was in principle good, but industrial implementation was not possible at the time
- Score “two”: the project idea is applied in at least one industrial plant
- Score “three”: the project idea is state of the art and is applied in many plants





Documentation of project analysis results

- Extension of the project table with
  - main project results
  - Level of industrial and practical application
  - categorisation of relevant topics and aggregates
- Data base table with search functions for topics and aggregates accessible via web site

1) Searching only "Main relevant topic" : Use Pulldown menu and push button above
2) Searching only "Main aggregate" : Use Pulldown menu and push button above
3) Searching both "Main relevant topic" and "Main relevant topic : Use both Pulldown menus and push button "Activate both Filters"
2) See the whole table : Push button "Delete Filter"

Activate Filter Main relevant topic: 3_Online control

Activate Filter Main Aggregate: ALL

Activate both Filters

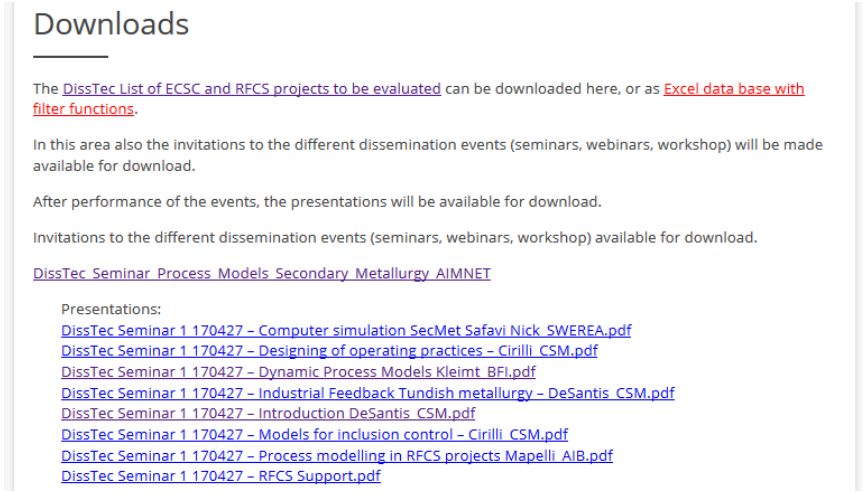
Delete Filter

Nr	Number of contract	Title	Acronym	Abstract	Main relevant topic	Further relevant topics	Relevant Sub-Topics	Main Aggregate	Further Aggregates	Main project results	Level of industrial / practical application	Report number
1	7210-CB/107	Development of process technology and metallurgy for extremely low and strictly limited nitrogen contents	/	To satisfy requirements for steel with low nitrogen contents and steels with very precise nitrogen contents, fundamental data on denitrogenation in liquid steelmaking were applied to develop a thermodynamic and kinetic model.	2		2.1, 2.4	AOD		General process indications were given on hot metal, plain carbon steel, high-alloy steels, vacuum treatment and a thermodynamic and kinetic model was developed to characterize the elimination or fixing of nitrogen.	Findings applied on benficiary plant.	EUR 14483 DE
2	7215-CA/107	On-line analysis of molten steel for automated steel production (1st phase)	AMSAS	The objective of this pilot project was to build and test an on-line analysis system for monitoring and measuring the change in concentration of various elements in liquid steel by laser-induced spectroscopy. The measurement system was tested for monitoring the carbon content in an AOD converter.	1		1.2, 3.5	AOD		The carbon content of liquid melt was measured online at an AOD converter using LIBS, but freezing of metal at the gas purged measurement bay ere in the converter bottom limited availability	After tesles at laboratory furnaces the measurement system was successfully applied for 6 month at an industrial AOD converter	EUR 15184
3	7210-CC/104	Development of a model for the vacuum circulating process	/	The objective of this project was to develop a detailed dynamic model for decarburisation in the RH process, which can be used for on-line monitoring of the process behaviour.	2	3	2.1, 2.5	RH		Dynamic process model for description of decarburisation behaviour during RH process	Process model was provided as simulation model with validation by industrial process data. On-line application was possible, but not foressen within the project.	EUR 16186 DE

DissTec web site

- Web site allows the access to the
  - results of the project analysis
  - schedule, dates and flyers of the seminars, webinars and workshops
  - download of presentations of seminars, webinars and workshops and to the road map for future developments
- English and German versions of the web site are hosted by BFI under

www.bfi.de/en/projects/disstec www.bfi.de/de/projekte/disstec



Dissemination activities

- Five seminars to be held at different sites in different countries with focus on various topics:
  - Measurement technologies for the quality relevant parameters of liquid steel (temperature, composition, cleanness, …)
  - Models for secondary metallurgy processes
  - Approaches for on-line monitoring and control
  - Connected auxiliary materials (refractories, stirring plugs, slag control, ..)
  - Optimisation of operating practices with focus on clean steel production
- Two webinars on:
  - Measurement technologies
  - Level 2 / Level 3 control systems
- Workshop for definition of a road map for Secondary Metallurgy technologies

Schedule for seminars, webinars and workshops

Event	When	Who	Where	Context	Topic
Seminar 1	27. April 2017	CSM	Brescia, Italy		Process Models for Secondary Metallurgy
Seminar 2	22. / 23. May 2017	MEFOS	Stockholm, Sweden		Connected auxiliary materials, gas stirring
Seminar 3	29. June 2017	BFI & CRM	Vienna, Austria	ESTAD 2017	Measurement technologies
Seminar 4	27. Sept 2017	MPI	London, UK IOM3 premises	IOM Seminar	Optimisation of Secondary Metallurgy practices -models, measurement and control technologies (focus on clean steel)
Seminar 5	14. / 15. November 2017	BFI	Duisburg, Germany FEhS Institute	VDEh expert group meeting "Electric Steelmaking"	On-line process control of Secondary Metallurgy plants (focus on EAF steelmaking)
Webinar 1	Sept 2017	CSM & BFI			Measurement technologies
Webinar 2	October 2017	MPI & BFI			Level 2/3 Control Systems
Workshop	10. Nov 2017	BFI	Düsseldorf, Germany	Steel 2017, Annual conference	Road map for future Secondary Metallurgy technology

Acknowledgements and contact

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Thank you very much for your attention !

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