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Project Deliverable Report

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VALorisation and dissemination of RFCS projects results and experience in steel surface quality issues: on as-cast CRACKs formation

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1. INTRODUCTION

The objective of the dissemination project is to revisit the most important European projects related to the formation of cracks in continuous casting carried out in the last two and a half decades. The basic idea is that an action of dissemination and valorisation of the most important results, based on an integrated critical analysis of a large number of projects, is useful to promote the exploitation of the results. This action is a necessary step for preparing and communicating a roadmap for future research activities and priorities.

Preliminary to these activities, classification of projects and literature classification is needed in order to identify the main topics on which the dissemination actions will be based.

To this scope, the present document shows the complete list of relevant reports and papers with some comments and statistics about them.

2. LIST OF RESEARCH TOPICS

Based on the existing projects (34 pertinent to the work issues) six main topics were identified.

They cover:

- the fundamentals of the crack formation occurrence, involving all the chemistry and physics of the change of state also related to the cooling pattern imposed by the operating conditions and the steel grade features,
- the modelling approach dealing with all the multi-physics items linked to casting and shell solidification, either focused on the caster zone the phenomena are examined (mould, secondary cooling zone) and on the expected microstructure formation,
- the process optimisation strategies including tailoring of operating practice and actions aimed to favour well-defined microstructure formation (e.g., inoculants addition to have equiaxed grains, etc.),
- the role of mould powders in regulating the heat transfer and consequently, the first solidification in the mould, responsible for the as-cast surface quality,
- the increasing use of dedicated instrumentation and control system tools to increase the margin of process improvement and allow sudden countermeasures to manage casting operations,
- the effort spent in the new casting technologies in order to achieve at the same time improved quality and increase of the overall productivity, especially via simplification of the casting and rolling route as occurs in the near-net shape casting.

In order to represent explicitly the different aspects pertaining to each topic, a series of sub-topics were also identified favouring classification. The synoptic of topics and related sub-topics is shown in Table 1. As described in Deliverable 2.1, in most cases, more than one

topic and/or sub-topic have been associated to each project, distinguishing between a 'main topic' and 'further topics', depending on their relevance.

Table 1: List of topics and sub-topics covered by 34 EU-Funded projects on cracks in continuous casting

Topic 1 - Basic knowledge	
T1.1 Chemistry	Understanding how steel chemistry effects the susceptibility of the product to cracking through solidification
T1.2 Microstructure	Understanding of how solidification, phase change and subsequent microstructure effect cracking in the final product
T1.3 Hot ductility	Understanding how segregation and grain boundary effects, including precipitation and micro alloying, influence hot ductility and tearing at the grain boundaries.
Topic 2 – Modelling	
T2.1 Mould modelling	Modelling of heat transfer from liquid steel through to cooling water within the mould and heat transfer and solidification in the steel strand
T2.2 Secondary cooling modelling	Modelling of the effect of online secondary water cooling
T2.3 Thermodynamic & microstructural modelling	Modelling phase stability and microstructure evolution during solidification and cooling
Topic 3 – Process Optimisation	
T3.1 Layout design	Modifications to the caster design to improve cracking performance
T3.2 Operating conditions	Definition of operating windows which reduce potential for cracking. Definition of rules for downgrading due to potential crack generation.
T3.3 Injection techniques	Identification of specific techniques for inoculant addition to liquid steel to modify solidification.
T3.4 Improved steel compositions	Definition of steel chemical compositions for improving castability, to reduce defect occurrence

Topic 4 - Mould powders	
T4.1 Mould powder properties	Study of the effect of mould powder properties such as heat transfer and lubrication relative to cracking performance. Study of the evolution of mould slag properties during casting, also by slag film characterisation. Development of new powders to facilitate increased casting speeds and improve quality.
T4.2 Mould powder feeding strategies	Control of rate, location and method of mould powder application to the mould
Topic 5 – Process control & sensing	
T5.1 Measuring systems	Instrumentation directly measuring casting parameters and other process features relevant to surface and internal quality. Online and off-line crack detection systems
T5.2 Online Control Systems	Online caster control systems used to improve caster and process stability and thus reduce cracking, including mould level, process parameter and secondary cooling control
Topic 6 - New Casting Technology/Demonstration projects	
T6.1 Near Net shape castings	Reduction of cracking in non-standard continuously cast sections such as thin slabs, beam blanks, etc.
T6.2 Magnetohydrodynamics	Use of Magnetohydrodynamics such as electromagnetic stirring and braking. Unconventional application of Magnetohydrodynamics

The aggregate in **Figure 1** shows how the 34 projects cover the five identified topics, including both the ‘main’ and the further’ topic associated to each project.

The two most covered topics are modelling on one side (40%) and process control and monitoring on the other (37%). The first topic of course supports the research activities in various aspects, so it is present in almost half of the projects – especially the less recent ones - as a relevant topic (even in a higher number of projects, if we consider ancillary activities), while the “popularity” of “Process control and monitoring” is due to the recent increasing need of controlling the casting operations and the quality achievement.

Basic knowledge and process optimisation topics are on the same share (28 and 23%), followed by the topic of mould powders (18%), whereas new casting technologies are of course the less referenced due to the fact that proposals in this field are very seldom submitted, since industry tends to develop new technologies under private projects.

Figure 1: Topic coverage by 34 EU-funded projects on cracks in continuous casting

