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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

Cracks in as-cast products still represent a matter deserving attention and research efforts, even after more than 20 years of research in the field of cracks in continuous casting and despite all improvements achieved. The main and final goal of the project is to draw a path for future research about cracks in continuous casting, from the review of the past work and from the discussion with the steel community about future needs and trends which took place during the 12 dissemination events organized within the project.

This deliverable presents a roadmap for future research needs in the field of cracks in continuous casting, which is the final goal of the VALCRA project.

2 Method

The roadmap has been obtained from the synthesis of the following elements:

- The analysis of the state-of-the-art literature on the subject, including not only the ECSC/RFCS final reports but also international research work (see deliverable D3.1, available at www.valcra.eu)
- The future developments envisaged by the past ECSC/RFCS projects
- The feedback from the audience of the technical dissemination events, collected during the Q&A sessions, also using online tools to interact with the participants
- The answers to the online survey submitted to all the participants after the dissemination events
- The answers to questions asked during an interactive webinar devoted to the definition of the roadmap, held on the 28th October 2020
- The requirements identified in a roundtable with the EU steel producers organized in the frame of this project on the 16th of November 2020
- Next challenges and research trends upon which the RFCS programme may focus in the coming years identified in the RFCS Monitoring and Assessment report 2011-2017 (see section below).
- Direct experience of the project participants.

The draft roadmap was discussed on the 2nd of December 2020 in a dedicated dissemination event reserved to European participants, to which attended also representatives of the EU commission and of EUROFER.

The final version of the roadmap was then presented in a webinar on the 16th of December, which was the final event of the project.

The videos of the events and the presentations are available on the project website www.valcra.eu.

2.1 RESEARCH CHALLENGES IN THE RFCS MONITORING AND ASSESSMENT REPORT 2011-2017

The key research topics to address future challenges recommended by the RFCS programme are:

- climate change (***emission reduction)***,
- resource efficiency,
- rational use of energy,
- new high-performance steels,

- steel and steel-based solutions for safe and improved applications,
- Industry 4.0 and digitalization,
- cost effectiveness,
- adaptation of working conditions, and
- workforce skills.

The VALCRA Roadmap is framed in the contest proposed by such challenges, as can be seen considering the various drives for future research identified during the VALCRA project and exposed in the next session.

3 VALCRA Roadmap for future research on cracks in continuous casting

The VALCRA roadmap is presented as a "wish list" of 11 points. For each of them a **drive** has been identified and a **suggestion** has been proposed.

3.1 NUMERICAL MODELLING

3.1.1 Drive

Numerical Modelling and other Digital platforms (e.g. Virtual Reality, Artificial Intelligence, Internet of Things, etc.) are key technologies that must be strongly backed up by real plant and experimental validation as well as adequate data inputs.

3.1.2 Suggestion

Actions prioritizing research on Digital twins, online metallurgical models, multivariate analysis for correlation with process conditions and Big Data analysis. This includes thermophysical and chemical properties, open-access databases and product **quality data accessible to all steelmakers**. Focus should be on:

- A database of mould powder properties
- Availability of plant data for validation
- Advanced and specific techniques for determination of thermomechanical properties

3.2 KNOWLEDGE TRANSFER FOR MODELLING

3.2.1 Drive

Numerical modelling techniques and knowledge need transferring across a broader platform other than stakeholders in RFCS projects. This includes Academia, Industrial Partners (not related to modelling) and decision makers (funding agencies, governments, industrial bodies, etc.) to enhance the understanding of modelling capabilities and limitations, as a mean to enable its wider application.

3.2.2 Suggestion

Actions that attempt breaching the barriers that prevent full exploitation of modelling, including e.g. complexity, software/hardware availability, licensing costs, skills gap and online implementation, dissemination actions and education.

3.3 RESIDUAL ELEMENTS

3.3.1 Drive

Emphasis on greener steelmaking including a move away from traditional integrated steel plants using the blast furnace route. There will be a higher use of scrap and more Direct Reduced Iron (DRI). Therefore, tramp/residual elements will have a greater role in secondary metallurgy, e.g.: Ca and S cause clogging, whereas Cu/CuS have influence on hot ductility.

3.3.2 Suggestion

Actions capable of addressing challenges arising from Carbon-free and Hydrogen steelmaking, as well as other new steelmaking techniques due to the increase of residual elements. Such actions should target an extension of actions to study the effect of alternative alloying elements for new generation steels from more economical and sustainable sources also in relation with process conditions.

3.4 ALTERNATIVE ELEMENTS

3.4.1 Drive

The use of alternative alloying elements which are cheaper or more readily/sustainably available can bring forward their own issues such as mould powder pick up, clogging and negative modification of flux properties.

3.4.2 Suggestion

Actions to study the effect of alternative alloying elements for new generation steels from more economical and sustainable sources. Such actions should target an extension of **metallurgical knowledge** also in relation with process conditions.

3.5 INTELLIGENT SENSORS

3.5.1 Drive

Measurement techniques able to produce tangible savings in yield or improved quality through automated monitoring and inspection of casting conditions/outputs and product quality.

3.5.2 Suggestion

Actions to develop sensors capable of process control and product monitoring and/or coupling to AI and other digital technologies to suggest corrective actions to cracking and process problems based on machine status and product quality.

3.6 MOULD POWDERS

3.6.1 Drive

As higher performance steels are created, there must be an associated development of casting powders and mould coatings to facilitate casting.

3.6.2 Suggestion

Research actions are needed to generate fundamental knowledge on the physiochemical properties of new combinations of flux materials and the interaction between these and new steels. Models which are used to predict these changes need to be further developed. Alternative techniques to allow standard powders to be used in more technically demanding applications.

3.7 METALLURGICAL KNOWLEDGE ADVANCE

3.7.1 Drive

Casting of advanced steel grades and the utilization of high productivity CC machines (high casting speed, increasing casting formats, etc.) give rise to new defects in as-cast semis and rolled products. These facts together with higher customer requirements decrease the production yield and raise the cost and environmental footprint of the whole steel production process.

3.7.2 Suggestion

Actions prioritizing research to increase basic metallurgical knowledge in order to assess the cause of defects in the as-cast/rolled product, and to find new casting technologies both to avoid defects and to increase yield.

3.8 NEAR-NET-SHAPE CASTING

3.8.1 Drive

Near-net-shape casting is very important in terms of yield and reduction of waste. However, if there are defects, there is a reduced window for rectification that could mean that more material is scrapped because it cannot be reclaimed or repaired.

3.8.2 Suggestion

Actions to improve quality to allow the near-net-shape savings to be realised by casting with no rectification and processing to final product with less waste, by improving quality of cast products with a knock-on effect on energy savings and sustainable production.

3.9 AGING PLANTS

3.9.1 Drive

There is much emphasis on new digital technologies and intelligent control systems, but these are only as good as the hardware that they control. Throughout Europe steel plants are aging.

3.9.2 Suggestion

Actions capable of addressing the aging of European Steelplants by:

1) extending the working life through improved efficiency
2) production of new grades and/or higher quality specifications with a higher value added on existing production units with none or limited investment.

3.10 THEORETICAL VS PRACTICAL VS TRL

3.10.1 Drive

Projects which address the gap between theoretical/fundamental knowledge and final implementation.

3.10.2 Suggestion

These solutions must be able to transfer technologies for the benefit of European industry enabling clear implementation routes for a wider number of stakeholders, or in the case that only one stakeholder is benefited, it should produce a significant step beyond state of art by application of breakthrough technologies or concepts with a clear path for development across several TRL steps.

3.11 DISSEMINATION

3.11.1 Drives

The pandemic event has impressed remarkable push for change to the ways of communication and the interest in on-line contents has increased and will continue to do so. We have experienced this during the VALCRA project and found out that webinars are excellent tools for dissemination. In fact, they offer the target audience:

- Significantly reduced investment in terms of time and travel compared to live events.
- Possibility to attend for a part of the day, without greatly impacting on the day to day operation, potentially allowing more attendees from a plant representing a greater spread of expertise and interest.

There has been a very positive response to the VALCRA on-line webinars reaching far beyond the numbers that we originally estimated.

We have found several attendees from universities, meaning that this is a means for providing a potential closer link between industry and academia (e.g. because students find it difficult to finance attendance of large-scale conferences).

3.11.2 Suggestions

EC could organise an annual on-line dissemination workshop to present all of that years' RFCS final reports linked with the publication of final project reports.

In a similar way to the VALCRA webinars, these events could also be recorded and kept as an online open access tool.

Provide an easily accessible, widely distributed forum which allows stakeholders to access up to date and emergent technologies funded by EU projects.