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Resource-saving and sustainable production of high-quality steel by enhanced on-line control of stirring efficiency in vacuum degassing

STEELVDCON

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Project partners

- **VDEh-Betriebsforschungsinstitut GmbH Düsseldorf, Germany**
  Private Research Organisation with focus on steel production
- **Böhler Edelstahl GmbH & Co KG Kapfenberg, Austria**
  Large Industrial Company, Producer of high quality steel
- **InfraTec GmbH Dresden, Germany**
  SME, Supplier of contactless infrared measurement devices

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Technological background

- To produce steel grades with highest quality and cleanness demands, often a vacuum tank degassing (VD) plant is used
- A ladle with the liquid steel melt is placed in a vacuum tank, and is treated under a low pressure of about 1 mbar
- Due to the equilibrium conditions under vacuum, undesired elements dissolved in liquid steel like hydrogen, nitrogen and sulphur can be removed
- A bottom stirring gas (normally Argon) is injected to promote the refining reactions and to ensure a good mixing of the steel melt
- The VD process at Böhler Edelstahl is characterised by a ladle diameter of 2 m, a heat weight of 50 t, and melt temperatures between 1600 and 1700 °C.

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Problem definition

- Production of high quality steel is connected with an extensive consumption of raw materials, expensive alloy materials, energy and other resources
- Performance of metallurgical operations within vacuum degassing is significantly influenced by intensity of Argon gas bottom stirring
- Rating of actual stirring intensity is normally left to subjective and error-prone judgement of the operator
- Failed adjustment of required stirring intensity
  - ↳ Aims of the metallurgical operations, especially adjustment of low target values for hydrogen, nitrogen and sulphur are not achieved
  - ↳ Vacuum treatment has to be prolonged or completely repeated
  - ↳ Costly heat treatment of the casted steel has to be performed
  - ↳ Significant losses in energy, raw materials and productivity

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Objectives

- To overcome the problems caused by an undefined stirring intensity during vacuum degassing treatment of liquid steel
- To ensure the reliable achievement of the target values of hydrogen, nitrogen, and sulphur, and the improvement of steel cleanness
  - ⇒ Development and implementation of an enhanced on-line monitoring and control system for vacuum degassing with reliable control of Argon bottom gas stirring intensity
  - ⇒ Joint application of thermal imaging based monitoring and improved dynamic process models

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Methods / work plan

- Development and installation of a suitable thermo camera for on-line monitoring of the melt surface during vacuum treatment
- Assessment of stirring intensity by an appropriate image analysis software
- Performance of operational trials to investigate the interactions between stirring intensity and degassing reactions
- Application of dynamic process models for on-line monitoring of hydrogen and nitrogen removal to optimise the degassing duration
- Development of a closed-loop control of the stirring gas rate during vacuum degassing, to ensure reproducible stirring intensity
- Test, validation and optimisation of the control system and its performance in long-term operational trials at the VD plant of Böhler Edelstahl in Kapfenberg, Austria.

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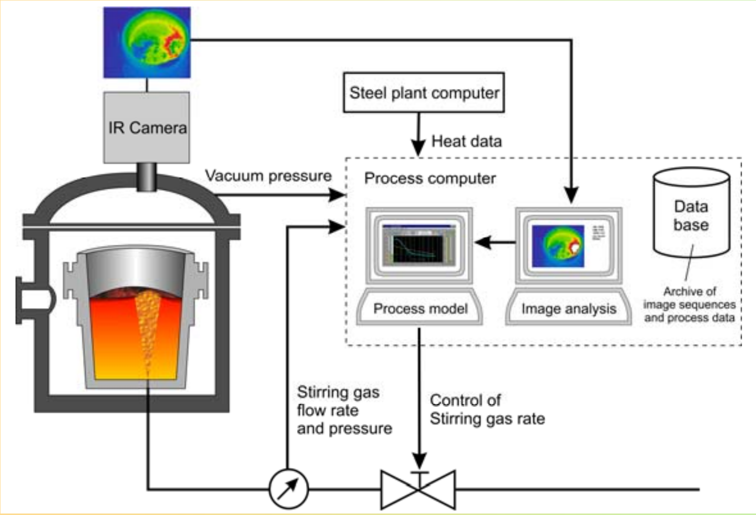
Structure of the control system



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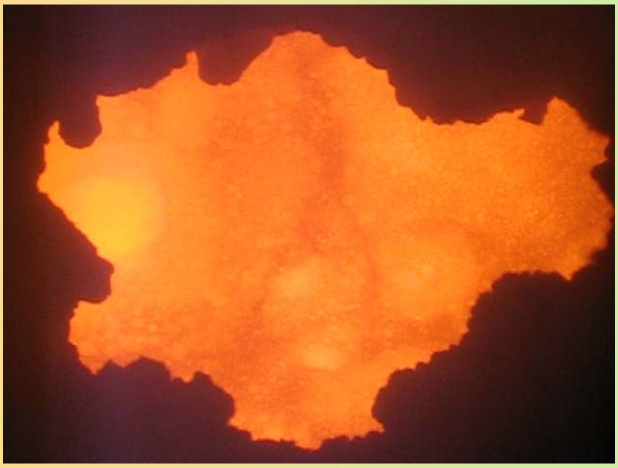
Current project status – Selection of a suitable thermal imaging device



View on the melt surface during vacuum treatment through the inspection window of the tank degassing plant of Böhler Edelstahl

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Current project status - Installation of the imaging device at the VD plant

Vacuum tank degassing plant
at Böhler Edelstahl

Inspection window and housing
for the thermal imaging device

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Expected results

- **Improved quality and cleanness of liquid steel**
- **Reliable achievement of the target values of hydrogen and nitrogen**
  ↳ by reproducible stirring intensity and model-based control
- **Significant savings of**
  - **Raw materials (alloys, slag formers, refractories)**
  - **Resources (e.g. argon stirring gas, steam for vacuum generation)**
  - **Energy (electrical and chemical),**

  achieved by
  - **reduced treatment times and less failure heats**
  - **Reduced necessity of heat treatment of casted steel in case the aim value for hydrogen has not been achieved.**
  - **Increased productivity of the complete steelmaking process**

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Experiences with SUSPRISE Joint call

- **Application procedure and rules for project partnership clearly defined**
- **Good support by national funding agencies in setting up the proposal and answering specific questions**
  - **regarding the structure of the consortium**
  - **the funding level available for the different partner types (SME, Industry, R&D)**
- **Submission of the proposal straight forward and very unbureaucratic**
- **Contract negotiations easy due to advices from the national funding agencies**
- **Compared to other transnational and national research programs:**
  - **very short time between decision of funding and project start (only 4 months)**
  - **Small consortium possible (compared to FP 7)**
- **Added value of the transnational joint call for the project partners:**
  - **Already existing transnational contacts were deepened**
  - **Possibility to perform the project with a competent industrial research partner from Austria with extensive expertise in R&D for high-end steel products**
  - **Effective support by an SME with wide experience in innovative technologies**

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Experiences with SUSPRISE Joint call

- **Concluding statement:**

  The SUSPRISE programme offered the chance to get a project funded in an unbureaucratic way, with a small transnational consortium and a very short time between submission of the proposal and start of the project.

  This is very important for the industrial partners in such a project, as they ask for a fast response to fulfill needs in resource saving operational practice, and to solve problems as soon as they have been identified

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