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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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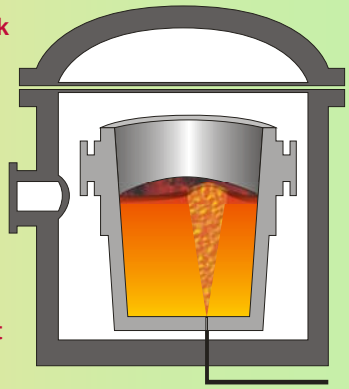
Technological background

- 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

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 treatment with reliable control of Argon bottom gas stirring intensity

  by joint application of thermal imaging based monitoring and improved dynamic process models

Methods / work plan

- Development and installation of a suitable thermo camera and data acquisition system for on-line recording of the melt surface during VD treatment
- Assessment of stirring intensity by an appropriate image analysis software, developed and optimised during extensive plant trials
- Performance of operational trials to investigate the interactions between stirring intensity and degassing reactions
- Application of dynamic process models for degassing of hydrogen and nitrogen. Incorporated of information provided by thermal image analysis as additional input for the model calculations
- 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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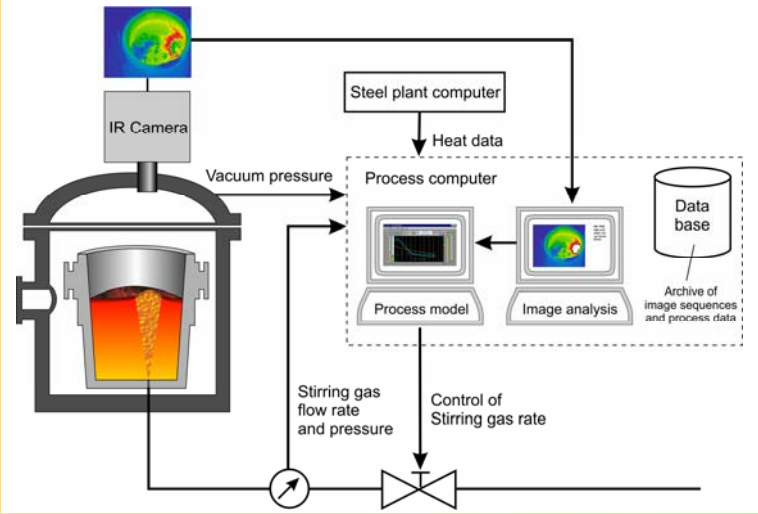
Current project status: Structure of the control system



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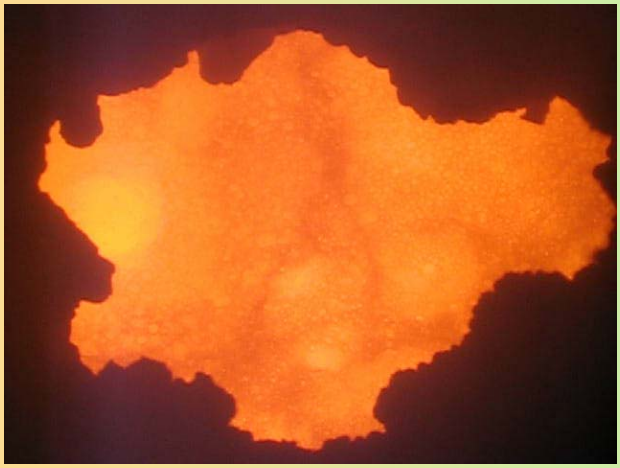
Current project status – Selection of a suitable thermal imaging device



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**

Experiences with SUSPRISE Joint call

- Application procedure and rules for project partnership clearly defined
- Structure of the proposal form well prepared
- 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)
- Added value of the joint call for the project partners:
  - Already existing transnational contacts were deepended
  - 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 a SME with wide experience in innovative technologies

Experiences with SUSPRISE Joint call

- **Concluding statement:**

  The SUSPRISE programme offered the chance to get a project funded in an unbureaucratic way, with 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 fulfil needs in ressource saving operational practice, and to solve problems as soon as they have been identified

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Introduction of the speaker

- Bernd Kleimt (1963) received a Dipl.-Ing. degree in electrical engineering from the University of Wuppertal, Germany in 1988.
- He joined VDEh-Betriebsforschungsinstitut (BFI) in 1989 and works in the field of modelling and control of steelmaking processes, especially for the electric arc furnace, converter and secondary steelmaking processes.
- In 1995 he received a Dr.-Ing. degree with a master thesis on modelling of decarburisation within the RH vacuum degassing process.
- Since 2001 he is head of the department "Process automation steelmaking" within the division “Iron and Steelmaking” of VDEh-Betriebsforschungsinstitut (BFI)