SPIRE-05-2019 Project

REVaMP

Grant Agreement No: 869882

Transforming the metal making industry: Showcases for retrofitting and circularity

Joint Dissemination event

26.09.2023

Retrofitting Equipment for Efficient Use of Variable Feedstock in Metal Making Processes

Characterisation and intelligent use of metal scrap

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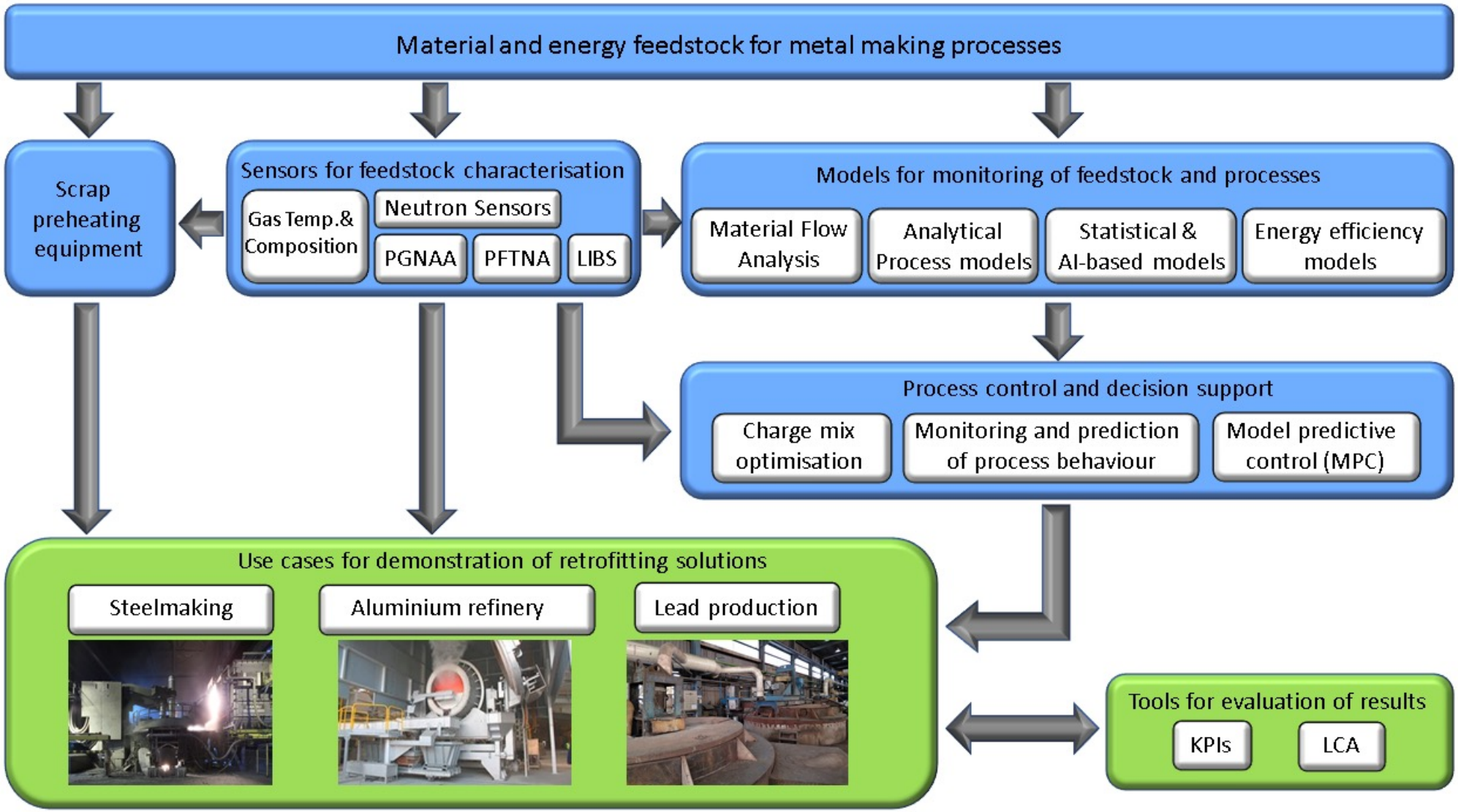
REVaMP – Objectives, Methods, Demonstration Cases, Expected results

VDEh-Betriebsforschungsinstitut GmbH

Main Challenges	Objectives	Methods	Demonstration Cases	Results
Cope with variable material feedstock	• Characterisation of materials • Charge mix optimisation	New Sensors New Equipment Enhanced Models Multi-Criterial Optimization Decision Support Systems Process Monitoring and Control	Steelmaking  Aluminium production  Lead production 	• Improved resource efficiency • Improved energy efficiency • Increased productivity • Improved quality • Constant quality
Use various / alternative energy sources	• Scrap preheating by alternative fuels • Optimisation of energy mix • Furnace operation optimisation			
Operate plants with maximum efficiency	• Off-line simulation and optimisation • On-line process control			

REVaMP – Interaction of Retrofitting solutions for application at Use cases



Project partners and roles in the project

LIBS Sensor

Steelmaking

Al scrap preheating

Lead production

Fraunhofer ILT

LSA

SIDENOR

AZTERLAN

REFIAL

GHI Hornos

CARTIF

EXIDE

AM Bremen

BFI

RWTH

NCBJ

SYSKON

POLON

EURECAT

GRUPAL Art

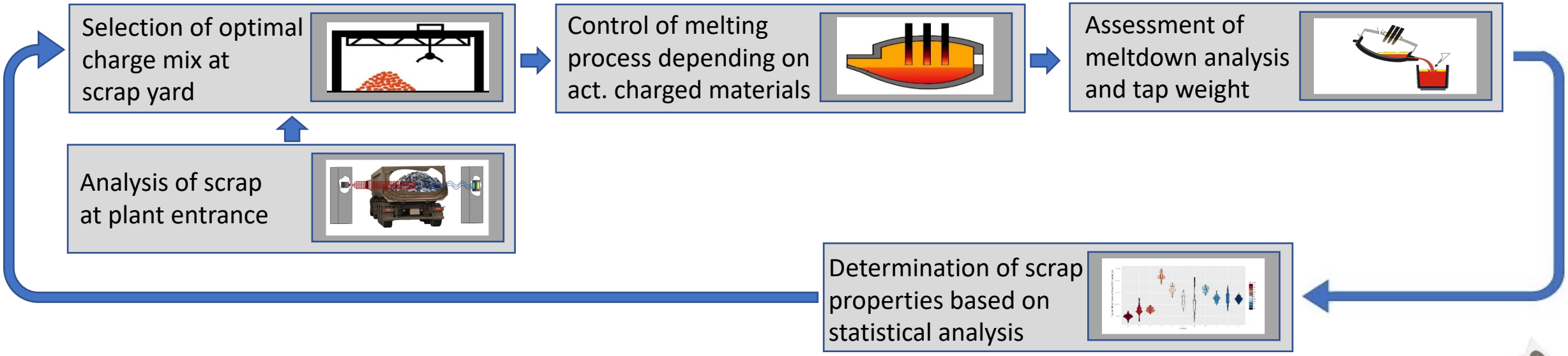
Steelmaking

Neutron Sensor

Aluminium refining

Scrap-based metal making: Background and REVaMP approach

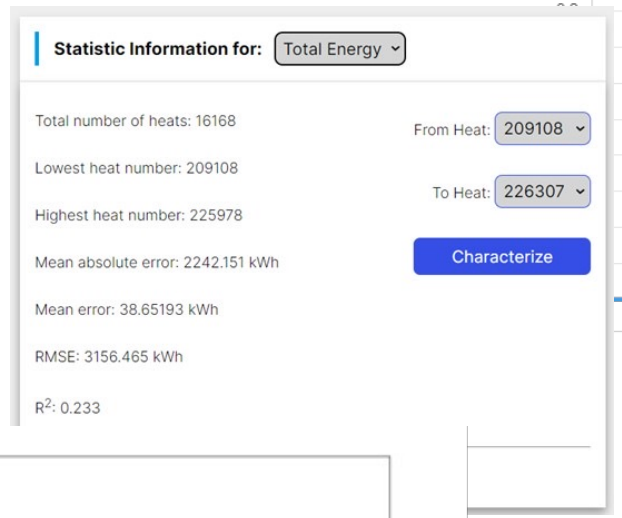
- Properties of charge materials for metal making play an important role for process performance and for achievement of target quality
- Optimal charge mix for the melting furnace has to be determined for each produced quality, considering composition, metallic yield and cost of the different scrap types
- Appropriate in-line sensors and statistical calculations have to be applied to track the scrap properties
- Process control of the melting furnace has to be adapted to the properties of the actually charged scrap types, for an energy and resource efficient process performance with an optimal environmental footprint

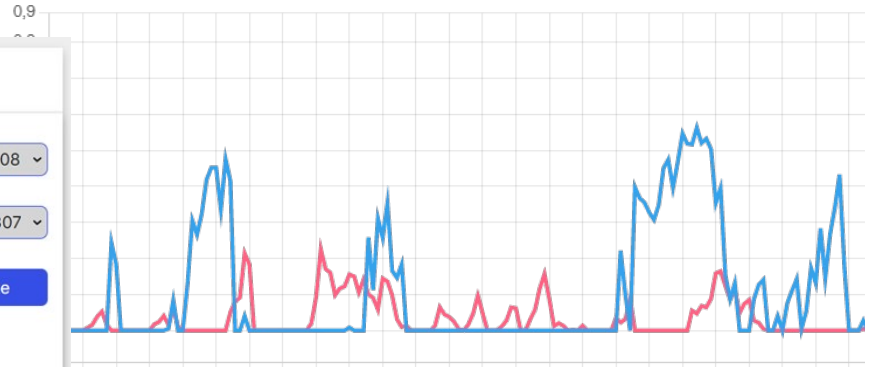


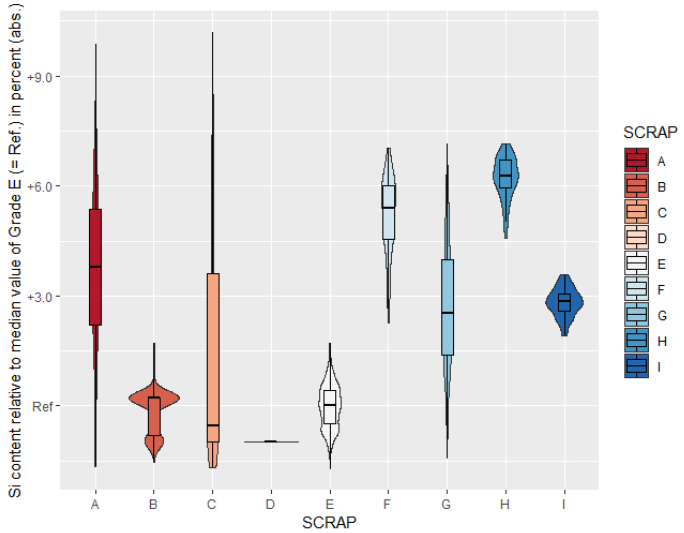
Determination of metal scrap properties based on statistical analysis

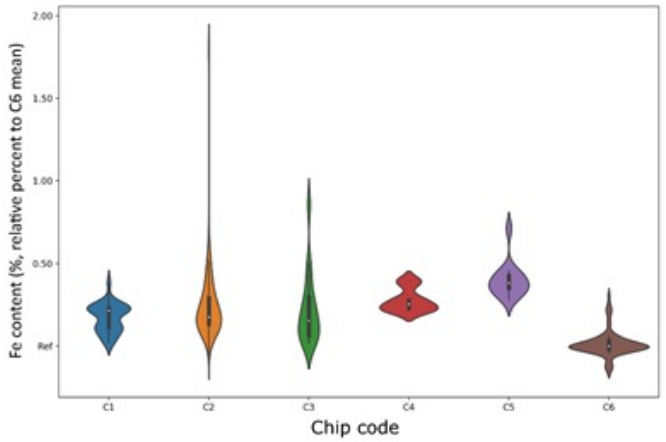
- Relevant properties of metal scrap are metallic yield, chemical composition and required energy input for meltdown of solid scrap for production of a liquid metal melt

- Input data for a statistical analysis are the charged scrap types and the achieved liquid metal weight and analysis for a larger amount of heats.
- For steelmaking, a web-based software tool was developed to provide comprehensive results regarding the scrap properties.



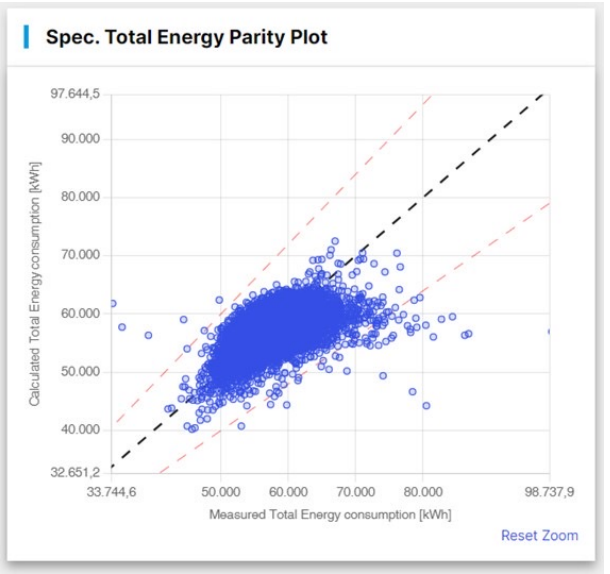






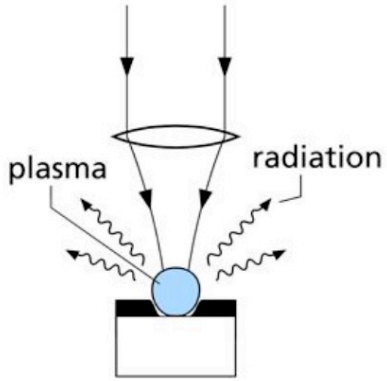
Si and Fe content of different Al scrap types

Web-based tool for analysis of steel scrap properties (e.g. Cu content and meltdown energy require-ment)

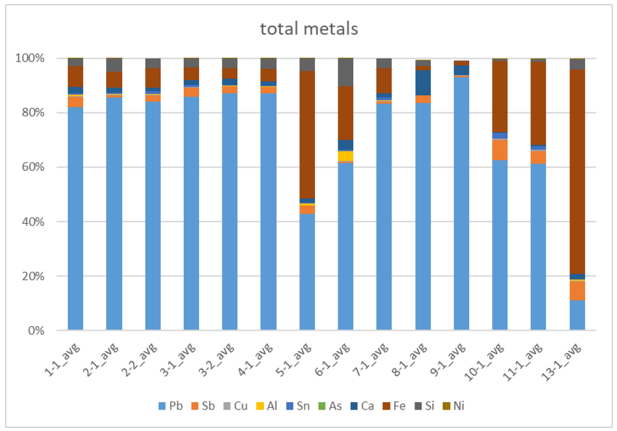


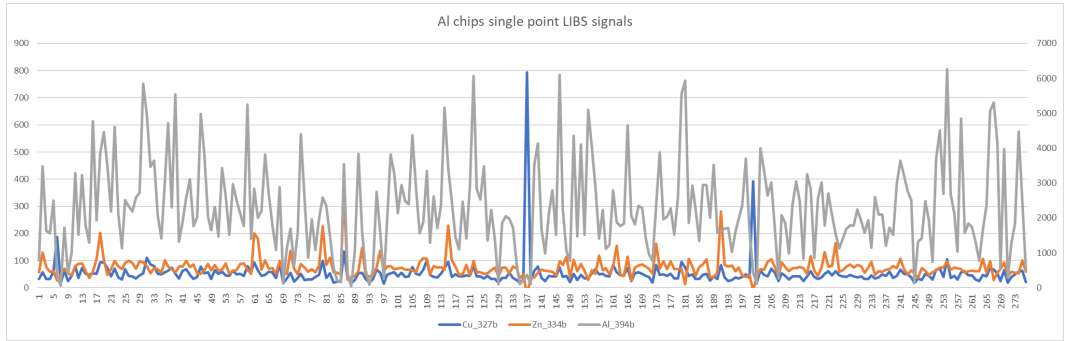
Surface analysis of metal scrap by means of LIBS technology

- Analysis of metal scrap composition at the surface by means of laser-induced breakdown spectroscopy (LIBS)
- Short laser beam pulses evaporate and excite a small amount of material at the surface. Spectral lines in optical emissions are collected and analysed to determine the elemental composition od the metal scrap.



- Analysis of aluminium chips and lead containing metal scrap on a conveyor belt

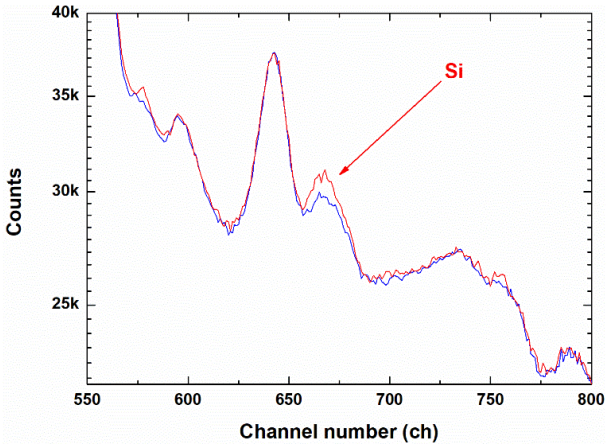


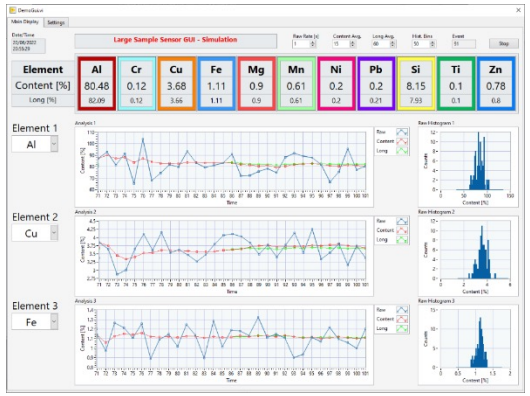


- Analysis of steel scrap with the LIBS system mounted on a gantry to scan the scrap surface of a truck loading at the entrance of the scrap yard.

Bulk analysis of metal scrap by means of Neutron sensors

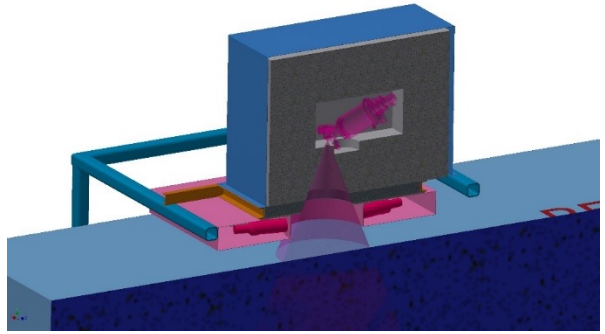
- Analysis of bulk metal scrap composition by means of a neutron activation analysis (PGNAA) sensor.
- Neutrons emitted from a source (isotopic or a generator) interact with the tested material, exciting its nuclei. These nuclei emit characteristic gamma radiation, which is recorded by means of scintillation detectors and converted into the energy spectrum. The analysis of changes in the energy spectrum by means of machine learning methods allows the determination of the material composition.





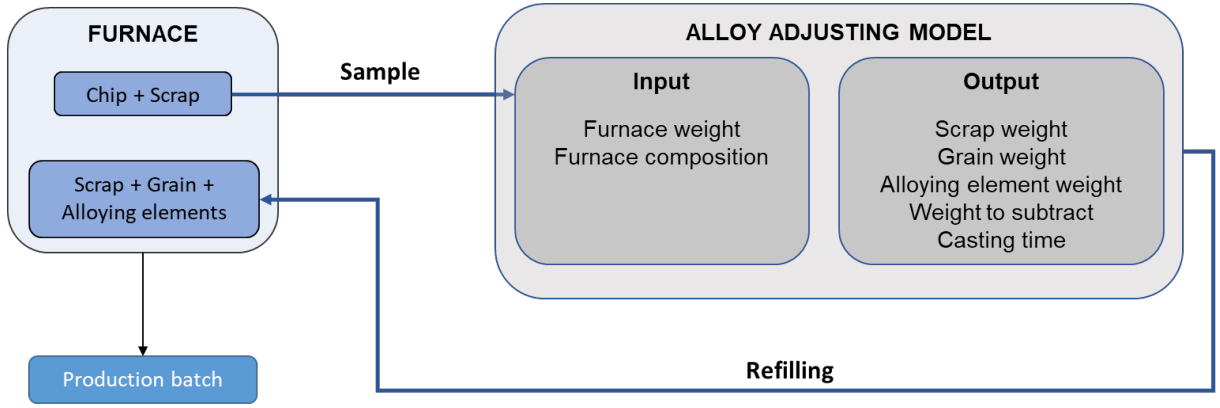
Analysis of aluminium chips at a continuous feeding system used for Al chips drying

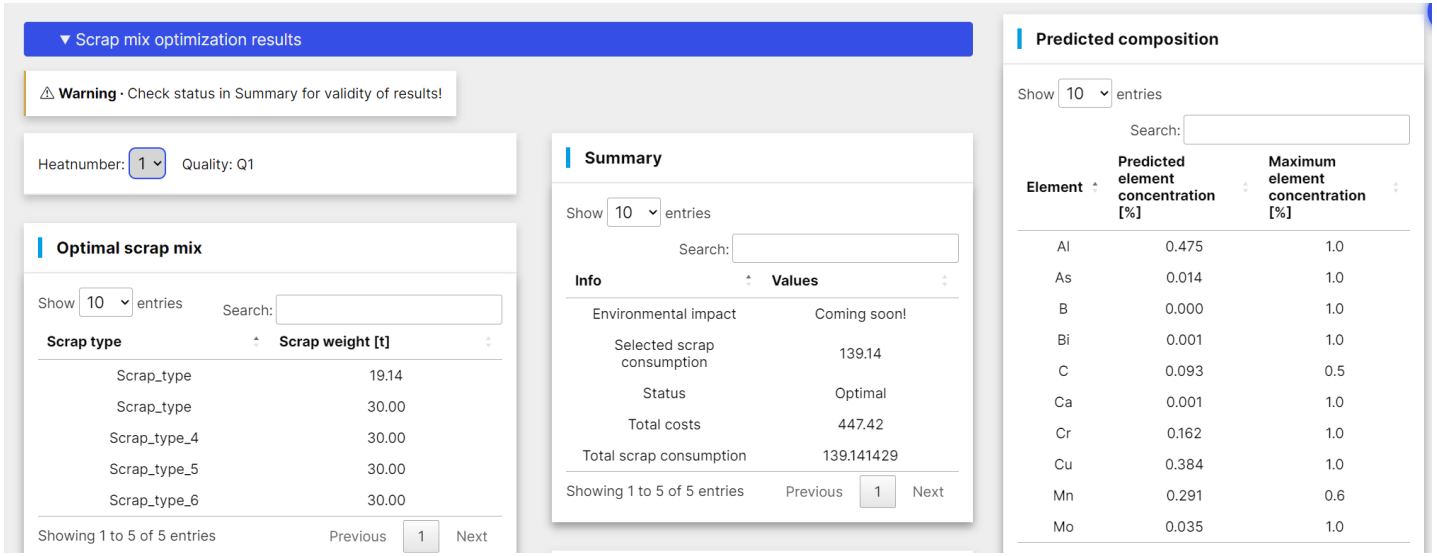
Analysis of steel scrap with the Neutron Generator mounted on a gantry to scan the scrap surface of a truck loading at the entrance of the scrap yard



Charge mix optimisation based on actual scrap characteristics

- The scrap characteristics are determined by statistical methods in combination with measurement data from the LIBS surface analysis and the Neutron sensor bulk analysis systems.
- Based on the information on chemical composition and metallic yield, a scrap mix optimisation software determines the cost and quality optimal scrap mix for production of a certain metal alloy quality.
- Besides the scrap purchase costs also the processing costs are considered, to account for higher specific meltdown energy requirements of low quality scraps.



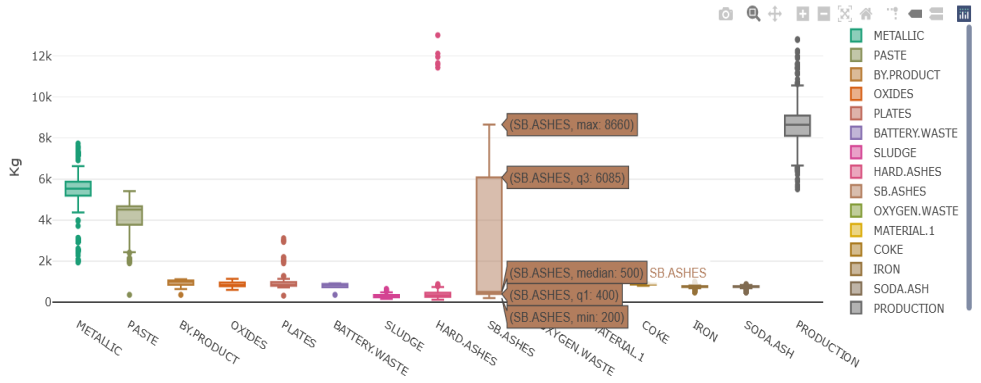


- For aluminium making the main task of the optimisation tool is to determine the the amounts of further scraps and alloy materials to be added after an analysis of a sample taken after meltdown of the first charge of chips and scrap material is available.

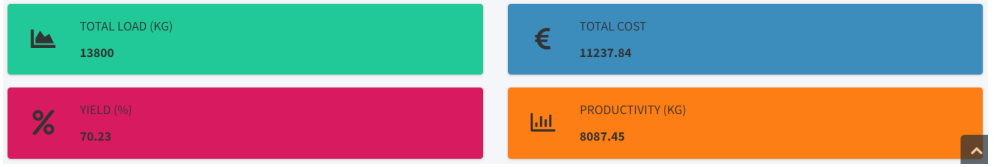
Monitoring and control tools for optimization of lead melting process

Design and implementation of a Smart Visualization Tool:

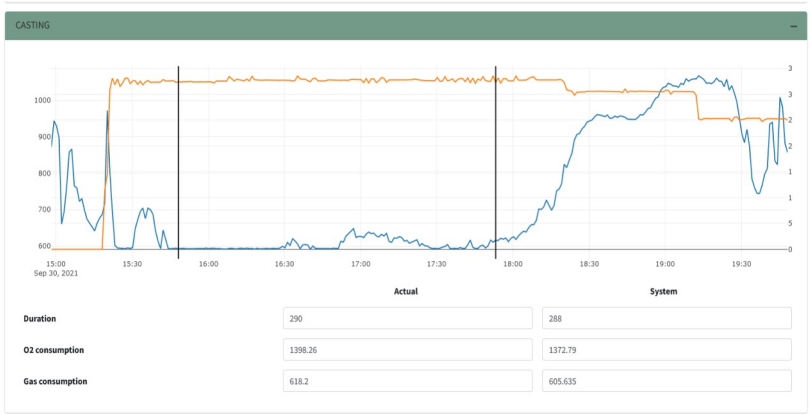
- **Monitoring Module for the charge material composition:**
  - Historical and statistical production data of the lead scrap smelting process
  - Laboratory analysis data of lead bullion composition



- **Furnace Charging Module**:
  - Optimal selection of raw materials and fluxes to be charged to the furnace for lead production.
  - Estimation of the cost of raw materials per lead cast.

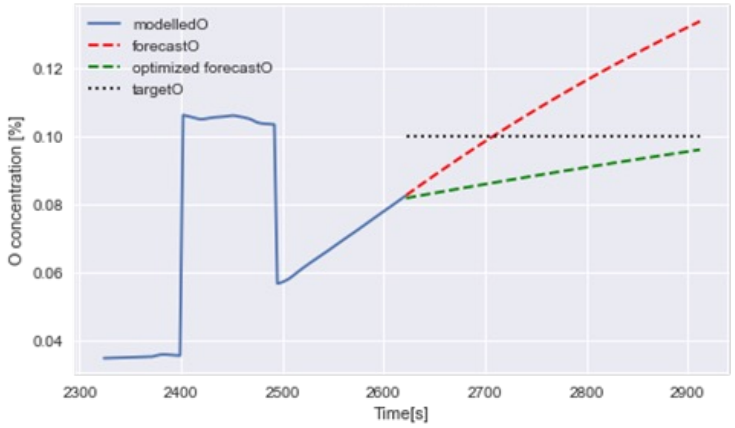


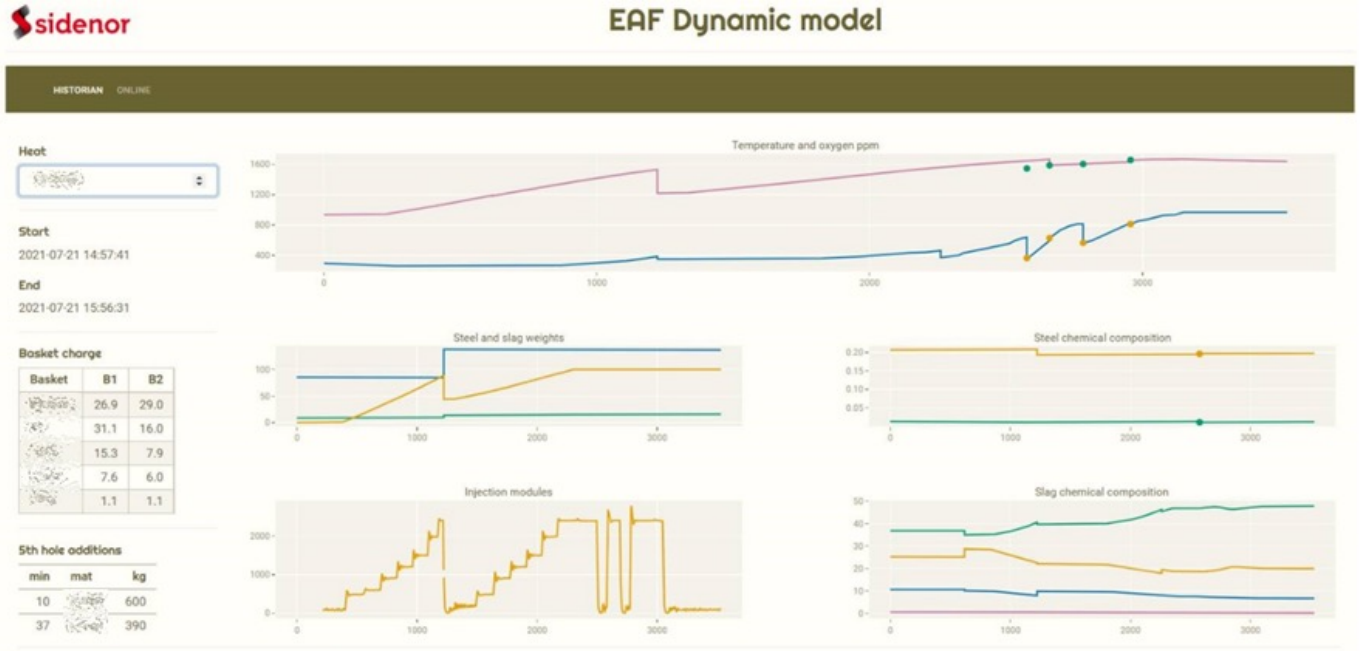
- **Temperature Control Module for the melting process:**
  - Detection of failures occurring in the different produced in the stages of the melting process, like organic burning, fusion, reduction and tapping.
  - Serving as decision support tool to establish set points and timing for the oxygen and gas controllers.

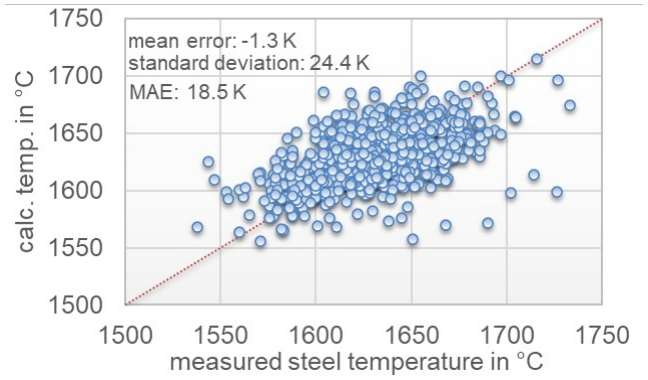


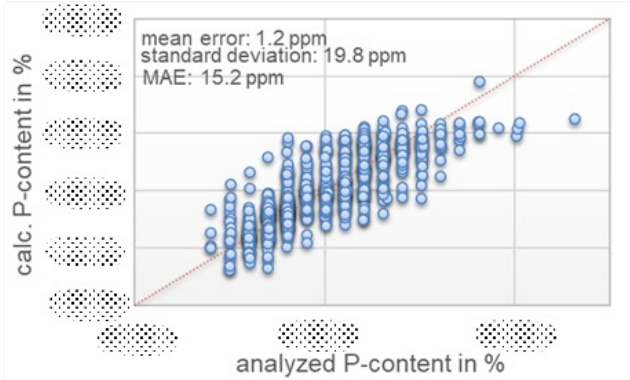
Model-based steel scrap melting process control for the EAF

- The profiles for energy input have to be adapted to the actually charged scrap mix
- A dynamic process model allows for on-line monitoring and prediction of the actual process behaviour
- Control actions including end-point control to effectively achieve the process targets are determined by a model predictive control approach.









Prediction accuracy for Temp. and P content

Expected benefits for the process industry and transferability of results

Benefits:

- Statistical models and in-line measurement techniques for **scrap characterisation,** combined with a **charge mix optimization tool,** allow to enhance the utilization of metal scrap as secondary raw material. This in turn drastically reduces the CO_2 emissions which are connected with the reduction of primary raw materials like iron ore and aluminium oxide.
- The on-line implementation of **Dynamic process** allows an **accurate monitoring of the melting process behaviour.** Embedded within a **model predictive control concept**, the model can provide useful advices to the operator to adjust the relevant **set-points for energy and resource efficient process control**.

Transferability:

- Statistical methods for charge mix characterisation can be transferred to all other process industries where a mix of different secondary raw materials is used, e.g. copper or glass production.
- The in-line sensors can be used also for other raw materials like other metals or minerals
- The application of dynamic process models makes sense for monitoring of all high-temperature processes with a complex energy and mass balance, as melting of other metals or glass.

SPIRE-05-2019 Project

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Thank you very much for your attention !

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For more information please visit our free hybrid workshop on 19.10.2023

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