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ONE STEP AHEAD.

K1 MET
metallurgical competence center

7th K1-MET Research Conference

8 April 2026, voestalpine Stahl GmbH,
Guest House, Betriebsgebaeude BG (Building) 44, First Floor – Room 1,
voestalpine-Strasse 3, 4020 Linz, Austria

09:30 – 10:00	Get-together with coffee
10:00 – 10:10	Welcome and introduction

Session 1: Methodology

10:10 – 10:40	**Johannes Rieger (K1-MET)** Spectroscopic characterization of secondary ferrous materials using a moveable LIBS system
10:40 – 11:10	**Melanie Neubauer (MUL-CPS)** Methodology of AI-based scrap analysis: Optimizing deep learning models for real-time application in recycling
11:10 – 11:40	**Harald Ganster (JR)** Characterizing recyclable materials using hyperspectral sensor technology and AI-based evaluation, using steel scrap as an example
11:40 – 12:00	Coffee break
12:00 – 12:30	**Fanuel Mehari (SPECTRAL)** LIBS-based characterization of steel scrap: From lab to industry
12:30 – 13:00	**Andreas Haas (REDWAVE)** Advanced quality analysis of steel scrap using XRF and complementary technologies
13:00 – 14:00	Lunch break

Session 2: Implementation

14:00 – 14:30	**Birgit Palm (BFI)** Enabling reliable scrap use in steelmaking through advanced multi-sensor and model-based characterisation
14:30 – 15:00	**Alexander Leitner / Lucija Pustahija (RHIM)** From spectra to sorting decisions: Industrial implementation of LIBS and HSI for refractory recycling
15:00 – 15:20	Coffee break

Session 3: Impact

15:20 – 15:50	**Klemens Winkler (K1-MET)** Opportunities and obstacles in the use of post-consumer scrap in industrial production
15:50 – 16:20	**Melanie Leitner (K1-MET)** Validating multi-sensor systems for accurate tramp element analysis in post-consumer scrap

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7th K1-MET Simulation Conference

Abstracts

Spectroscopic characterization of secondary ferrous materials using a moveable LIBS system

Speaker: Johannes Rieger (K1-MET)

Coauthors: V. Merk, A. Michel, L. Pfeifer, P. Schneider, L. Streubel (LTB), W. Martinelli, Y. Radmann (SCHOLZ), S. Blume, J. Riedel (BAM)

Scrap and other iron-containing by-products serve as important secondary raw materials and a high recycling rate is of relevance to saving primary resources. Enhanced scrap recycling is of utmost importance for the steel sector and is often mentioned in different research roadmaps of the steel industry. An efficient and fast analysis of iron-containing materials using spark discharge-supported LIBS system is in the focus of a currently running project within the COMET programme. By using a moveable system, it is expected to use the obtained analysis to control the scrap mixture more efficiently according to the requested final steel qualities. The current contribution summarizes the development status, in which a LIBS system is equipped with a Galvo scanner for a fast and accurate certain laser beam deflection and control. For the application on scrap characterization, the focus is on copper detection in shredded scrap (E40 scrap class according to commonly used EU scrap specification).

Methodology of AI-based scrap analysis: Optimizing deep learning models for real-time application in recycling

Speaker: Melanie Neubauer (MUL-CPS)

Within the framework of the KIRAMET project, the Chair of Cyber-Physical Systems (Technical University of Leoben) develops computer vision methods for the automated characterization of steel scrap and contaminants. This presentation highlights the methodological pipeline from data acquisition to efficient inference. First, the creation of a specialized, annotated dataset for shredded steel and copper scrap is briefly addressed. Semi-autonomous annotation workflows were employed to efficiently capture the high variance and complexity of the scrap objects. The primary focus of the presentation lies on the optimization of segmentation algorithms for real-time application under resource constraints. The developed method "Instance-Based Importance Scores" (IBIS) is introduced. This pruning technique utilizes gradient information to selectively remove redundant model parameters, prioritizing relevance to object instances. Evaluations demonstrate that models can be compressed by up to 95% without significantly impairing segmentation quality. Finally, the presentation discusses how these "sparse models" not only reduce computational load but also exhibit promising properties regarding generalization (out-of-distribution) and robustness against industrial image noise.

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Characterizing recyclable materials using hyperspectral sensor technology and AI-based evaluation, using steel scrap as an example

Speaker: Harald Ganster (JR)

Extracting recyclable materials from a variety of sources is vital for achieving global climate targets and responding quickly and cost-effectively to production requests. To make the best possible use of recyclable materials in a circular manner, the materials must be analysed in detail to determine the properties of the raw materials. Hyperspectral cameras record data in multiple wavelengths, from the visible to the mid-infrared range, extending the concept of classic RGB color images to a wide range of spectral ranges, with up to 288 bands per camera. This data can be used to derive material properties, enabling the composition of material and product streams to be characterised and creating a unique fingerprint for each material. Scrap metal is a valuable secondary raw material in the iron and steel industry. However, a specific type of steel requires a specific scrap quality, which requires knowledge of its geometry and chemical composition. The InSpecScrap project used new hyperspectral imaging systems with AI-based analysis to demonstrate that the composition of scrap can be optimised by identifying foreign and interfering substances. This shows how digital technologies can support sustainability in the iron and steel industry.

LIBS-based characterization of steel scrap: From lab to industry

Speaker: Fanuel Mehari (SPECTRAL)

Laser Induced Breakdown Spectroscopy (LIBS) offers numerous advantages for chemical analysis, including high throughput, rapid results, remote sensing capabilities, and no sample preparation. One particularly promising application lies in the characterization of post-consumer scrap. Spectral Industries is actively contributing to two EU-funded projects focused on steel scrap characterization. The first is the DiGreeS project, which aims to digitalize steel production and make it more sustainable. To this end, a long-range telescopic LIBS system is developed to measure on steel scrap directly in the truck bed. The second is the PURESCRAP project, which seeks to increase the use of low-quality scrap grades by characterizing the shape and chemical composition through the combined power of multiple sensors. In this project, Spectral deploys LIBS above a conveyor belt to give input to the sorting process. This presentation will highlight Spectral's role in these projects, while also touching on applications beyond the steel industry.

Transitioning LIBS from a controlled laboratory setting to real-world production lines presents several challenges. The sensor must operate reliably under harsh and unpredictable conditions not found in the lab. In the presentation, we highlight advances in both instrumentation design (autofocus, belt protection, system health monitoring) and data analysis to address these challenges. An important aspect of the contribution to the DiGreeS project is experimentation with a diverse range of steel scrap samples, representing the variety of surface conditions and measurement scenarios encountered in practice. This includes samples with coatings, moisture and oxidation layers, as well as measurements taken at varying distances. We outline our approach to addressing these variables during the sensor calibration campaign, detailing our experiment design and sharing the resulting insights and modelling solutions.

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Advanced quality analysis of steel scrap using XRF and complementary technologies

Speaker: Andreas Haas (REDWAVE)

X-ray fluorescence (XRF) analysis is a widely established technique for determining the elemental composition of diverse materials. In the field of recycling XRF-analysis has been successfully used for years in sensor-based sorting technologies. Examples include the separation of non-ferrous metals, stainless steel scrap, incinerator bottom ash, ores, special glasses, and plastics. Within the EU-funded PURESCRAP project, together with the consortium partners, a novel approach was developed to assess the quality of shredded steel scrap. This was conducted utilizing XRF both as an independent technique and in conjunction with supplementary analytical methods, including RGB-imaging, laser-induced breakdown spectroscopy (LIBS), and 3D scanning. Following the evaluation of these methods at an industrial scale, it became evident that the combination of XRF with the additional approaches enables significantly improved material characterization. This opens the possibility for real-time, inline quality control and process monitoring, which can be established both at the output of scrap preparation plants and at the entry point to steel production – with the aim of significantly increasing the use of shredded scrap in steelmaking. In this presentation, an overview of the challenges, the technological concept, the experimental validation, as well as the implications for industrial application, and the potential for the use of scrap instead of primary raw materials will be given.

Enabling reliable scrap use in steelmaking through advanced multi-sensor and model-based characterisation

Speaker: Birgit Palm (BFI)

As both integrated and electric steelmaking plants move toward more sustainable and circular production pathways, the increasing relevance of steel scrap as a secondary raw material poses both opportunities and challenges. While integrated plants aim to increase scrap usage as part of their decarbonization efforts, EAF-based steelmakers face the parallel challenge of maintaining competitiveness in a future market where high quality scrap may become scarcer and more expensive. Thus, a detailed and reliable understanding of scrap properties like composition and shape, as well as their variability becomes essential. This contribution presents how sensing and modelling methods – ranging from optical and spectroscopic measurements to data driven analyses – can be used to better understand scrap properties and their impact on downstream processes. The presentation will address three complementary research areas. The first focuses on combining Laser Induced Breakdown Spectroscopy (LIBS) with visual camera data to enhance the robustness of scrap characterisation, enabling more reliable detection of surface and shape features, material composition, and object heterogeneity. The second research area highlights the potential of hyperspectral imaging (HSI) for scrap classification to support more effective and automated scrap sorting, thereby enabling higher-quality and more consistent secondary raw material input streams. The third topic explores a data driven scrap characterisation model that recently has been extended to incorporate slag related interactions, providing improved assessment and prediction of the impact of scrap use on EAF steelmaking processes. Across all three areas, key implementation challenges are additionally discussed to highlight the practical considerations for industrial deployment. Overall, the contribution demonstrates how spectral, visual, and process data can enhance the reliability of scrap assessment and support the effective use of scrap in modern steelmaking, thereby contributing to a more circular, resource-efficient and climate-friendly industry.

Acknowledgements
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The TRESOR project (funding reference 01IF23428N) is funded by the Federal Ministry for Economic Affairs and Climate Protection based on a resolution passed by the German Parliament.

From spectra to sorting decisions: Industrial implementation of LIBS and HSI for refractory recycling

Speakers: Alexander Leitner, Lucija Pustahija (RHIM)

The RAPTOR demonstrator, developed within the Horizon Europe project ReSoURCE, represents RHI Magnesita's first large-scale implementation of AI-enabled spectroscopic characterization for spent refractory materials. At its core, the system integrates two complementary sensing technologies: Laser-Induced Breakdown Spectroscopy (LIBS) for point-based elemental analysis, and Hyperspectral Imaging (HSI) for continuous surface mapping. Together with 3D particle recognition, these sensors provide the data basis for real-time material classification at industrial conveyor speeds. The talk presents how spectral information is transformed into robust sorting decisions. This includes calibration approaches, region-of-interest selection, normalization strategies, and the development of fast classification logic suitable for online operation. Key challenges such as variable feedstock conditions, particle geometry effects, and timing constraints between LIBS pulses, HSI acquisition, and ejection signals will be discussed. The experience from RAPTOR shows that combined LIBS/HSI sensing can reliably distinguish complex refractory chemistries and significantly increase the yield of circular raw materials. The presentation will also highlight lessons learned from bringing a laboratory-grade spectral workflow to TRL 6–7 industrial use.

Opportunities and obstacles in the use of post-consumer scrap in industrial production

Speaker: Klemens Winkler (K1-MET)

Coauthors: R. Rainer (SCCH), F. Strohmeier (SR), M. Kornexl (KEBA), M. Neubauer (MUL-CPS), G. Koinig, A. Tischberger-Aldrian (MUL-AVAW)

The steel industry is facing major challenges in the coming years with the transition towards sustainable, low-carbon production, rising energy prices, and declining iron ore grades. One promising approach to address these challenges is through the increased use of high-quality secondary raw materials. Within the Austrian flagship project KIRAMET, several innovative approaches to increase the use of secondary raw materials in the production of high-quality metal products were investigated. These approaches were demonstrated by three complementary use cases, SMART SORT, SMART WASTE and SMART TWIN. SMART SORT focuses on improving the quality of the E40 steel scrap fraction by using artificial intelligence to identify and remove impurities from the material stream. SMART WASTE investigates the use of product data to guide material streams during use and recycling phase of the product lifecycle and to enhance the recovery of valuable raw materials from end-of-life products. SMART TWIN develops a digital twin of the recycling process to optimize material flow, asset utilization as well as product quality and yield. This presentation provides an overview of how these approaches impact the use of scrap as a high-quality input material in Austrian metals production, supporting the industry on its path toward sustainability and resource efficiency.

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Validating multi-sensor systems for accurate tramp element analysis in post-consumer scrap

Speaker: Melanie Leitner (K1-MET)

Increasing crude steel demand and rising post-consumer scrap availability require precise knowledge of tramp elements to safely maximise scrap input. With an accurate chemical analysis of the scrap composition, tramp- or alloying elements become valuable resources rather than being considered impurities. The PURESCRAP project develops sensor solutions to analyse post-consumer scrap and to enable an increased use of low-quality scrap grades in steel production. The integrated sensor chain comprises a camera, LiDAR (Laser imaging, detection, and ranging), LIBS (laser-induced breakdown spectroscopy), and XRF (X-ray fluorescence). Through a comprehensive ICT network, the system accurately assesses the presence of tramp elements (e.g., Cu, Ni, Mo and Sn) and determines the material volume as well as the mass. The system is installed and tested at a Swedish scrap recycler. The intended working principle is that all scrap will be characterised and batch-sorted prior being shipped to steel-producing partners. At the steelworks, each batch is melted and samples are taken to determine the average chemical composition. This provides a reference analysis to evaluate and validate the sensor system's accuracy. To ensure that the scrap batches can be confidently used for new steel products, the material is cast in a vertical continuous caster and further processed into a wire. This demonstrates a reliable integration of characterised scrap batches into industrial production. PURESCRP is a CSP project funded by Horizon Europe, Grant Agreement nb. 101092168.

Affiliations

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LTB	LTB Lasertechnik Berlin GmbH
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MUL-CPS	Technical University of Leoben – Chair of Cyber-Physical Systems
REDWAVE	Competence Center REDWAVE, BT-Systems GmbH
RHIM	RHI Magnesita GmbH
SCCH	Software Competence Center Hagenberg GmbH
SCHOLZ	SCHOLZ Austria GmbH
SPECTRAL	SPECTRAL Industries
SR	Salzburg Research Forschungsgesellschaft mbH

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