

*AI-Powered
Characterisation
and Modelling
for Green Steel
Technology*

WHAT IS AID4GREENEST?

AID4GREENEST is a three-year (September 1, 2023 – August 31, 2026) Horizon Europe project with a budget of more than 5 million EUR. It aims to develop a range of new Artificial Intelligence-based rapid characterisation methods and modelling tools for the steel sector.

IN THIS EDITION

- Project partner progress updates
- Latest project news
- New members
- Highlighted collaborations
- Upcoming events
- And more...

ADVANCING TRUSTED AI AND COLLABORATION FOR GREENER STEEL

Welcome to our fifth project newsletter!

This edition marks an important moment for AID4GREENEST, as our work continues to turn advanced steel research into practical tools, validated methods, and tangible industrial progress. Artificial intelligence, modelling, experimentation and standardisation are coming together in support of a smarter and more sustainable steel sector. What makes this progress especially valuable is the spirit of collaboration behind it. Through the shared commitment of all partners, we are moving steadily towards cleaner, more efficient and more reliable steel manufacturing. Thank you for following our journey and for being part of the AID4GREENEST community!

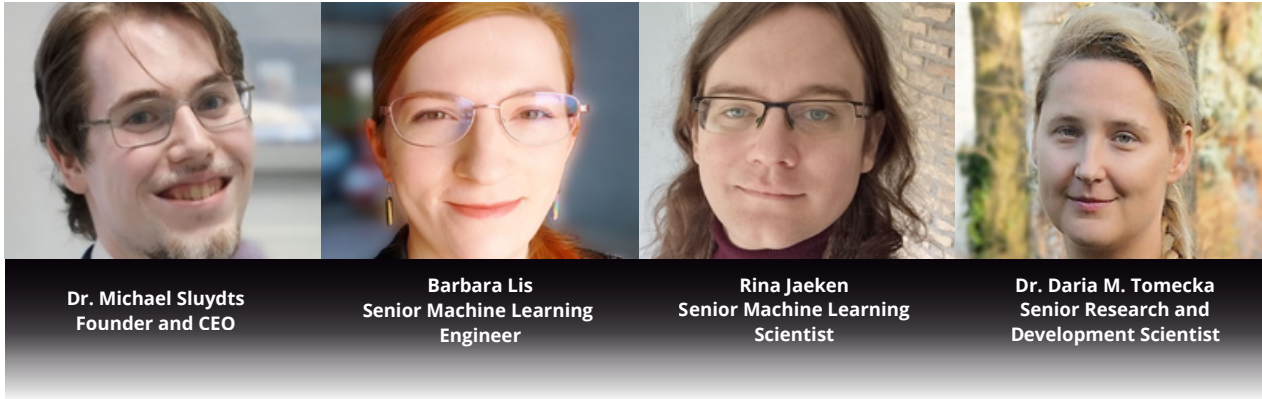
Dr. Ilchat Sabirov

AID4GREENEST Project Coordinator
IMDEA Materials Institute

Unlocking historical microstructural data with AI-powered tools

02

EDITION 5
MARCH
2026



ePotentia

Across research institutions and industrial partners, decades of microstructural characterisation have produced vast archives of optical microscopy (OM), scanning electron microscopy (SEM) and electron backscatter diffraction (EBSD) images. These archives represent an enormous investment in experimental effort, yet much of this data remains underutilised. Images are scattered across local drives, labelling is inconsistent or incomplete, and finding relevant prior work often relies on individual researchers' memory, rather than systematic search.

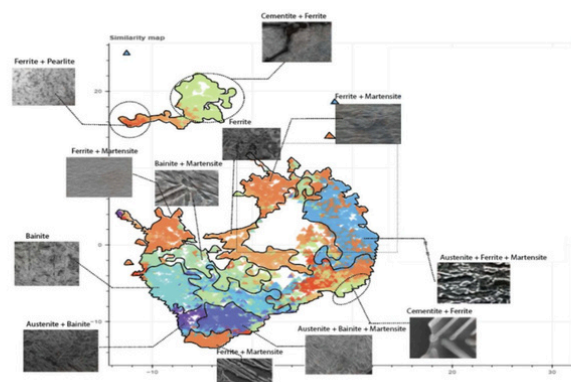
Within AID4GREENEST, **ePotentia** is developing MicrostructureDB, an open data platform that combines structured data management with integrated AI tools, making both the data and the intelligence built on top of it directly accessible through an intuitive web interface.

MicrostructureDB development is supported by **Ghent University**, which provides seed data, metallurgical expertise and model training, and **Fraunhofer IWM** for insights into standardisation of data and workflows and various other partners for contributions in data and user feedback.

From pixels to materials space

The core of MicrostructureDB's AI capability is a foundation model for steel microstructures: a deep learning system trained using self-supervised learning techniques that converts any microstructural image into a compact numerical representation, a "fingerprint", where similar microstructures are automatically grouped together. This mapping is learned entirely from visual structure, without manual labels, making it applicable to the messy, inconsistently labelled historical archives that are common in practice.

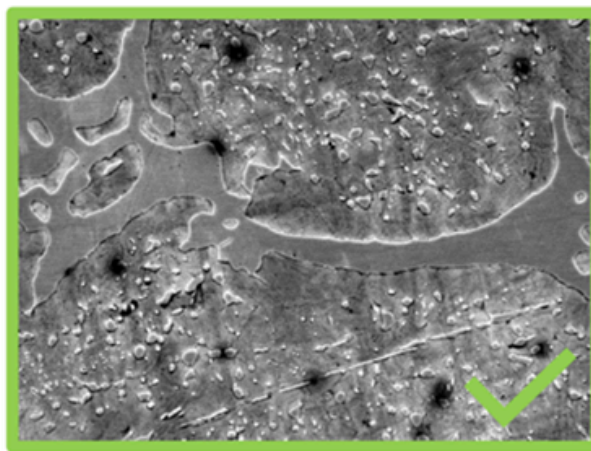
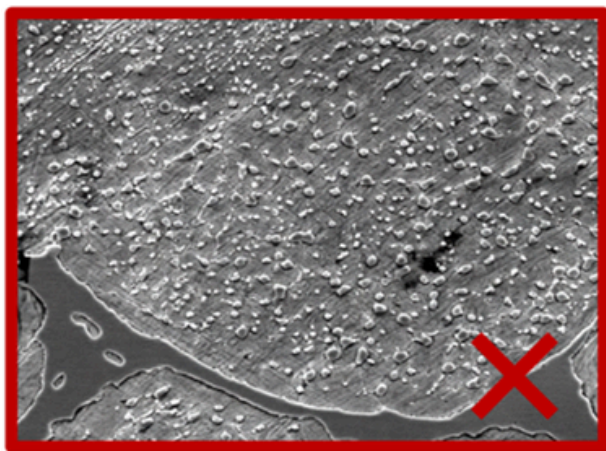
The result is a materials space where thousands of images are organised by visual and morphological similarity. In this space, related microstructures cluster naturally, different magnifications of the same steel family sit nearby, dual-phase microstructures appear between their constituent phases, and imaging artifacts stand out as outliers. Researchers can explore this space interactively, discovering relationships across datasets that would be invisible through manual inspection.



A map of microstructure space showing automatically created 'countries' representing different types of steel.

Overcoming data scarcity with synthetic microstructures

Even in large archives, data for certain steel types can be rare, either because the material is uncommon, or because the data is proprietary. To address this, generative AI models developed within the project produce synthetic microstructure images that expand the available data. These synthetic images are now virtually indistinguishable from real micrographs by visual inspection alone.



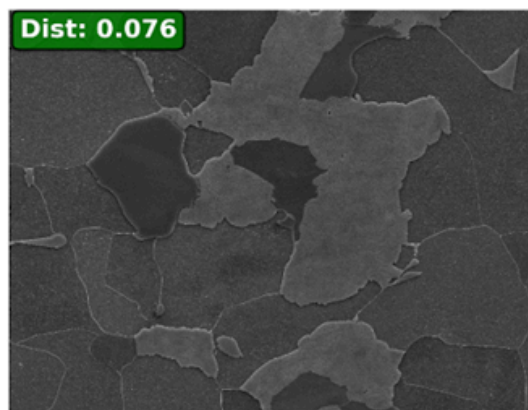
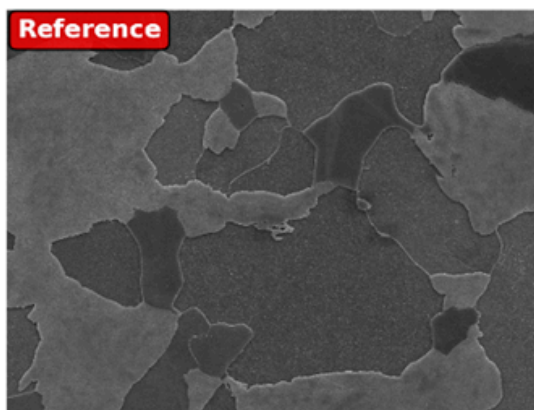
An example of two images showing a microstructure from the ultra-high carbon steel database (DOI: 10.1007/s40192-017-0097-0). (left) generated by AI (right) real.

The foundation model's embedding space serves as a quality check: synthetic images that land in plausible regions alongside real data confirm the generator's fidelity. In contrast, the model's ability to detect subtle differences ensures quality control.

From representation to practical tools

The foundation model powers several practical tools integrated directly into the platform:

- Image similarity search: uploading a new image immediately retrieves the most similar microstructures from the entire archive, helping researchers find relevant prior work across steel families and institutions.
- Anomaly detection: unusual images, whether due to mislabelling, imaging artifacts, or genuinely novel microstructures, are automatically flagged, supporting data quality management.
- Property and processing prediction: the learned representations serve as input features for models that predict mechanical properties, processing parameters, and phase classifications.
- Automated EBSD batch processing: raw EBSD data can be uploaded and automatically processed to generate orientation maps, phase maps, grain statistics, and other derived visualisations, all viewable live in the browser without requiring local analysis software.

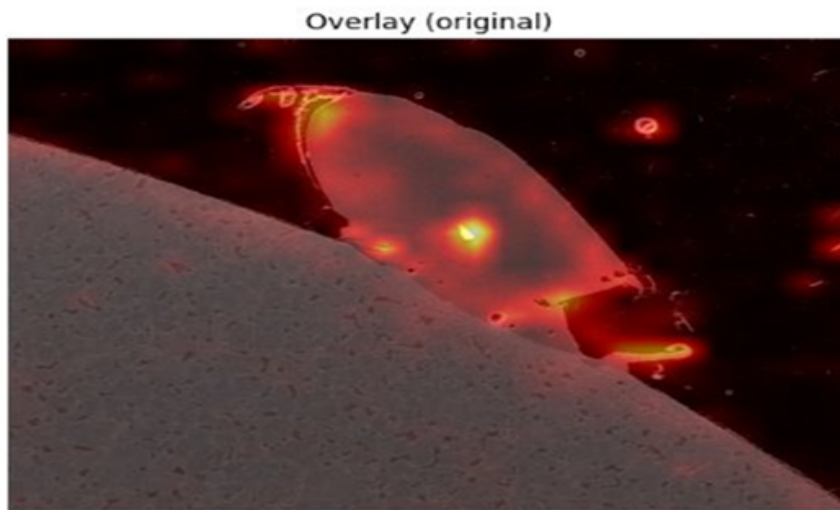


Example of image search, demonstrating how the foundation model is able to conceptually define similarity, rather than looking for exact matches.

The EBSD processing pipeline has received particularly positive feedback, as it removes one of the most time-consuming bottlenecks in the characterisation workflow, turning hours of manual post-processing into automated, reproducible analysis accessible from any computer.

Explainability and trust

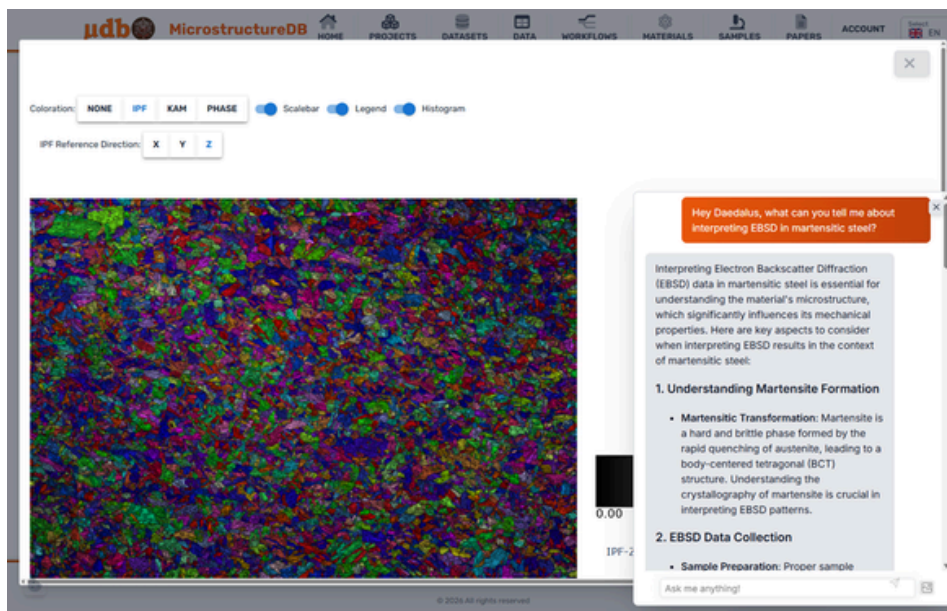
We recognise that AI tools are only useful if domain experts can understand and trust their outputs. Our foundation model provides inherent interpretability maps, spatial visualisations showing which regions of an image the model focuses on when making its assessment. These maps consistently highlight metallurgically relevant features such as grain boundaries, precipitate regions, and phase interfaces, providing researchers with intuitive explanations of the AI's reasoning.



Example of an anomalous image, overlaid with an interpretability map, showing exactly what the AI finds strange in the image.

Making AI accessible

A key challenge with AI in materials science is that powerful models often remain locked in Python notebooks, accessible only to those with programming expertise. MicrostructureDB addresses this through a web-based interface, where all AI functionality is available through point-and-click interactions. In addition, we are developing a chatbot interface that allows researchers to query the database and AI tools using natural language, asking questions like "show me similar microstructures to this sample" or "what processing conditions produced this type of bainite?"



Example of the EBSD analysis interface, showing an automatically generated EBSD map, with the chatbot window in the bottom right.

Current status and call for contributors

The AI pipeline is operational with the foundation model integrated into the platform. We are currently refining the automation of the embedding and prediction pipeline, developing novel explainable AI methods tailored to metallurgical interpretation, and preparing for cross-partner validation with data from consortium members.

During the current beta phase, the platform and AI tools can be requested for free by data contributors, reflecting the project's commitment to open data and collaborative development. MicrostructureDB supports multiple data ingestion pathways, browser upload, API access, and local synchronisation tools, to accommodate different institutional workflows.

Following the project, a credit-based system will sustain the AI services, with free monthly credits and additional credits for open data contributors, ensuring that sharing data is always rewarded.

We welcome consortium partners and external collaborators interested in contributing microstructural data or testing the platform. Contact: michael.sluydts@epotencia.com

ePotencia
Data • Science • Hosting

AID4GREENEST launches CEN workshop to develop European standard on accelerated creep testing



Javier López-Quiles
Project Manager

Fernando Utrilla Ortega
Head of R&D&I

[Spanish Association for Standardisation UNE](#)

Standardisation activities in AID4GREENEST

The AID4GREENEST consortium will create a CEN Workshop for the elaboration of a CWA (European standard) to standardise project results, in particular the methodology for Accelerated Creep Testing. A CWA is considered an effective way to

disseminate and communicate project results, as well as to facilitate their future implementation by the steel industry, steel consumers, characterisation communities, etc.

From a wider point of view, the CWA will increase the efficiency of steel manufacturing processes, and support the development of advanced materials, including high-strength steels, that are increasingly used in the EU's key strategic sectors such as renewables, space and defence, e-mobility, and energy.

At the same time, a contribution will also be made to the EU's green objectives to reduce carbon emissions and waste generation. The CEN Workshop, managed by **UNE**, will be a technical body under the umbrella of the European Standardisation Committee (CEN), and will count on the participation of several AID4GREENEST partners and other interested organisations.

It is expected that the CWA will serve as the foundation for further standardisation deliverables, including an EN European standard.

Successful thermal stability test confirms performance of AID4GREENEST's experimental shaft



Carlos Llovo Vidal
Metallurgy & Process Researcher

[Reinosa Forgings and Castings](#)

A significant AID4GREENEST project milestone was reached recently, as engineers from **Reinosa Forgings & Castings** (RFC) visited Siemens Energy's Brno facilities to review the results of the thermal stability test performed on the experimental shaft prototype developed within the project.

Positive Results Confirm Structural and Thermal Performance

The test campaign delivered highly positive results, confirming both the structural integrity and thermal performance of the large-scale

shaft. The findings validate RFC's capability to forge and heat treat energy shafts in line with the demanding requirements of high-temperature applications in steel turbines. This achievement represents the successful completion of the manufacturing and testing phase of the prototype, a major step forward for the project consortium.

The next phase will involve sectioning the shaft to examine its internal microstructure in detail. This analysis will generate high-value metallurgical data to support and refine the advanced simulation models currently under development by project partners. These models are central to AID4GREENEST's ambition to integrate AI-based tools for material process and structure modelling.

Collaboration at the Core

The AID4GREENEST consortium extends its sincere thanks to Siemens Energy for their close technical collaboration, access to its facilities, and the in-depth engineering discussions that followed the testing campaign.

Such industrial cooperation is essential to ensuring that research outcomes translate into real-world industrial impact. By combining advanced modelling with industrial validation, AID4GREENEST is contributing to more efficient production routes and lower-emission solutions for the energy and steel sectors. This successful validation of the experimental shaft marks another concrete step towards smarter, greener and more competitive European manufacturing.



AID4GREENEST researchers highlight impact of casting-induced segregation on microstructure evolution in large steel components

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[University of Oulu](#)

AID4GREENEST researchers from the **University of Oulu (UOulu)**, have published new research on the effect of solidification induced segregation on austenite formation and grain growth during reheating of a forged steel part.

The study, [highlighted in the IOP Conference Series: Materials Science and Engineering](#), presents new experimental and modelling results that shed light on how chemical segregation formed during casting influences microstructural evolution during the reheating of large, forged steel components.

Medium carbon steels alloyed with elements such as chromium, molybdenum, nickel and vanadium are widely used in demanding applications, including large shafts for power plants, where an optimal combination of strength, ductility and creep resistance is required.

Achieving these properties depends on controlling the prior austenite grain size during heat treatment. As austenite nucleates and grows during reheating, the size and distribution of these grains directly influence the subsequent phase transformations that occur upon cooling.

“Although the chemical composition of the steel favours uniformity of elemental distribution throughout the matrix, the solidification process during the casting of the ingot may actually result in extensive macrosegregation of the alloying elements,” explain the publication’s authors Prof. Mahesh Somani, Dr. Aarne Pohjonen, Oskari Seppälä and Rishabh Bharadwaj from UOulu.

“This is especially true in large castings meant for industrial production. Effectively, these castings are influenced by dendritic solidification which results in trapping of solute-rich liquid between the dendritic arms. These interdendritic regions later solidify into solute-rich regions, a phenomenon known as microsegregation”.

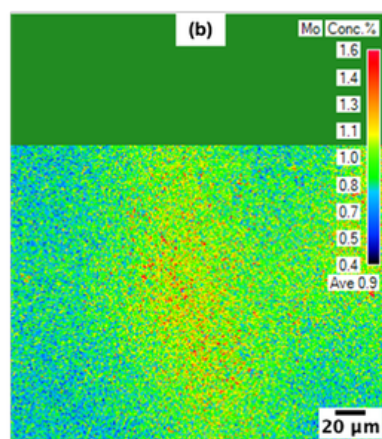
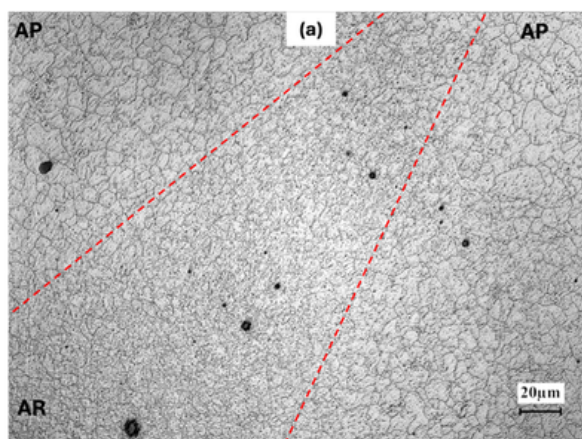


Figure 1: (a) Optical microstructure showing prior austenite after cooling the steel specimen at a cooling rate of 5 °C/s, observed using confocal laser scanning microscope, showing alloy-rich (AR) and alloy-poor (AP) regions, and (b) EPMA analysis showing the variation of molybdenum content in the alloy-rich (AR) and alloy-poor (AP) region (different location than a).

In the recent publication, clear variations in prior austenite grain structure (shown in figure 1) were observed in 30CrMoNiV5-11 type steel, and elemental analysis confirmed that these differences were directly associated with solidification-induced segregation.

To better understand and predict this behaviour, the researchers extended a previously developed cellular automata (CA) model describing austenite formation and grain growth during heating.

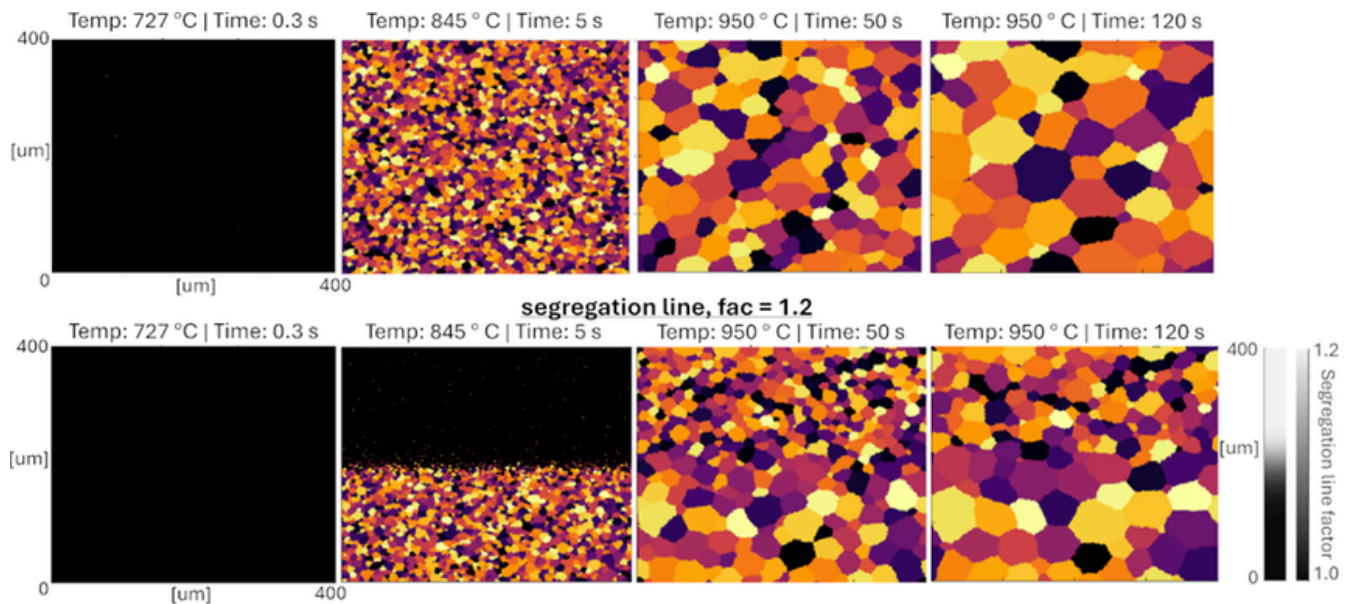


Figure 2: Effect of segregation region to the activation energy factor and equilibrium temperature on the austenitisation and grain growth phenomena in the implemented numerical model.

Segregation effects were introduced into the model by allowing position-dependent variation of nucleation and growth parameters to represent alloy-rich and alloy-poor regions. Through a numerical test case (shown in figure 2), the researchers demonstrated how these local variations can be included in the numerical simulations to simulate the observed spatially heterogeneous austenite grain structures.

The model allows for reproducing the type of grain size differences observed experimentally, underlining how the incorporation of segregation into the modelling framework is essential for realistically simulating reheating of large, forged components. In future studies, the model's parameters will be calibrated to correspond to the experimentally observed grain structure variations.

“In future studies, we will aim to fit the model using thermodynamic software and to experimentally observe austenite grain structure that will be obtained from interrupted heating tests, as well as grain growth studies,” the authors state.

References: Pohjonen, A., Seppälä, O., Bharadwaj, R., Somani, M. 2025 IOP Conf. Ser.: Mater. Sci. Eng. 1335 012028

Predicting the invisible: how digital twins are revolutionising green steel forging



One of the most critical, yet invisible, challenges in manufacturing high-performance forged components lies deep within the material itself, at the microscopic scale of individual grains. Achieving the right grain structure is everything: it determines strength, toughness, and fatigue life. But controlling it in complex, large-scale industrial forging processes has traditionally relied on costly trial-and-error.

Within the AID4GREENEST project, researchers at **Fraunhofer IWM** (Freiburg, Germany) have taken a decisive step towards changing this paradigm.

[Fraunhofer IWM](#)

The team has developed and validated a physics-based, mean-field microstructure simulation framework capable of predicting steel grain evolution throughout the entire thermomechanical processing chain, from initial reheating through to the final forging phase. The framework was tested against a demanding industrial benchmark: a large-scale turbine shaft made from high-performance low-alloy steel, forged by project partner **Reinosa Forgings & Castings**. The complex, multi-stage forging process creates extreme thermal and mechanical gradients that make microstructure control exceptionally challenging.

The results were exceptional. The model successfully predicted the grain structure evolution across the entire component, capturing both refined microstructures and the intricate spatial heterogeneity arising from complex thermomechanical histories. Validation through metallographic analysis of the actual forged component confirmed the model's ability to accurately represent real-world industrial forging physics.

This breakthrough delivers a transformative tool for the AID4GREENEST vision: enabling forging companies to de-risk the adoption of green steels by predicting how new, more variable materials will behave before they enter production. The capability to simulate material behaviour with confidence unlocks tremendous potential for energy savings, waste reduction, and quality assurance from first production. The next step: the rich output data, including predicted microstructure and thermomechanical fields, will serve as critical inputs for complementary full-field microstructure models currently being developed by the **University of Oulu**. This collaborative effort is bringing the project one step closer to delivering a complete process-microstructure-property simulation chain for sustainable steel components.

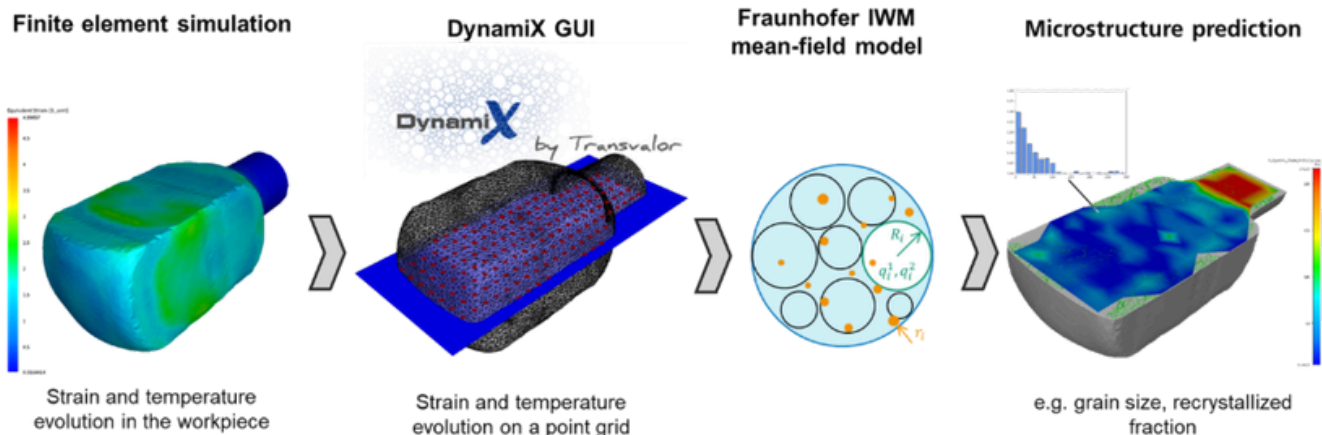


Figure 1: Microstructure simulation framework.

AID4GREENEST researchers present robust model calibration to enable greener steel manufacture



Dr. Christina Schenk
Staff Scientist

Prof. Ignacio Romero
Senior Researcher

[IMDEA Materials Institute](#)

AID4GREENEST researchers have presented new research that strengthens the scientific foundations behind reliable, uncertainty-aware modelling, a key pillar for AI-driven innovation in sustainable industry.

The research: “[A Framework for the Bayesian Calibration of Complex and Data-Scarce Models in Applied Sciences](#),” from Prof. Ignacio Romero and Dr. Christina Schenk at **IMDEA Materials Institute**, presents a

comprehensive review and practical implementation of Bayesian calibration based on the well-established [Kennedy-O’Hagan \(KOH\) framework](#).

This approach is widely recognised for its ability to combine simulation models and experimental data while rigorously quantifying uncertainty and accounting for model discrepancies. For AID4GREENEST, this topic is especially relevant given the project’s focus on developing AI-supported modelling and rapid characterisation tools for greener steel production and manufacturing processes, where simulations are often computationally expensive and experimental data are limited.

Under these conditions, robust calibration and transparent uncertainty estimation are essential to ensure that predictive models can be trusted in research and industrial decision-making.

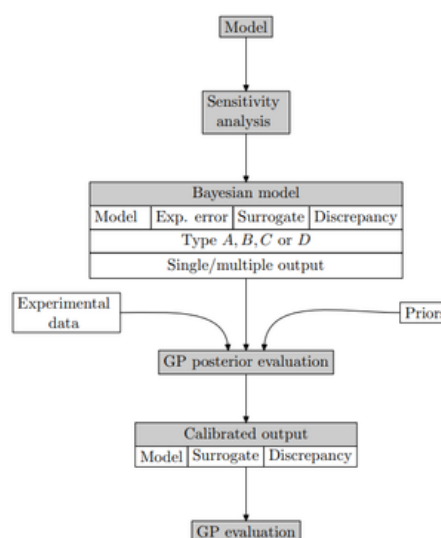
The publication also highlights the implementation and use of [ACBICI \(A Configurable Bayesian Calibration and Inference Package\)](#), an open-source Python library designed to translate the Bayesian calibration framework into a practical and extensible workflow.

The framework supports both single- and multi-output calibration, enabling simultaneous inference across several interrelated model outputs, a frequent requirement in complex materials and process simulations. It integrates advanced Bayesian inference algorithms, posterior approximation methods, Gaussian process-based prediction, and sensitivity analysis into a unified and largely automated pipeline.

This makes it possible to perform scalable, interpretable, and sample-efficient inference even in data-scarce scenarios.

A further contribution of the study is a consolidated set of practical recommendations for conducting reliable Bayesian calibration. These guidelines, derived from both theoretical insight and

implementation experience, help users apply rigorous methods without unnecessary complexity. This work from AID4GREENEST researchers Prof. Romero and Dr. Schenk lowers the barrier to adopting sophisticated calibration strategies. In doing so, it directly supports the project’s mission to combine AI, simulations, and experimental data in a scientifically robust way, accelerating the development of more sustainable materials and industrial technologies.



Structure of a Bayesian calibration procedure.

AID4GREENEST sustainability breakthrough: strategic insights for low-impact steel production

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[EurA AG](#)

Led by **EurA AG**, the AID4GREENEST sustainability team has conducted a comprehensive cradle-to-gate environmental assessment of the project's large steam turbine shaft, benchmarking its performance against leading industrial standards. The analysis spans the entire production chain, applying a two-tiered benchmarking framework: a product-level comparison aligned with European Environmental Product Declaration (EPD)

practices, and a process-level validation against key steel industry performance indicators.

Two distinct manufacturing scenarios were evaluated (integrated production versus an external processing configuration) to assess their environmental implications. The results reveal that even advance-stage production decisions can profoundly influence the product's overall environmental footprint, underscoring the strategic role of process integration in sustainable manufacturing.

These findings deliver actionable insights for optimising production strategies, directly supporting AID4GREENEST's mission to pioneer more efficient, lower-impact steel component manufacturing.



PROJECT NEWS



AID4GREENEST SHOWCASES CUTTING-EDGE RESEARCH AT EUROMAT 2025

AID4GREENEST had a strong presence at the FEMS EUROMAT 2025 Conference in Granada, Spain, organising the symposium "*Artificial Intelligence, Modelling and Data Science in Advanced Alloy and Process Design*". [Read more...](#)



AID4GREENEST CELEBRATES 4TH ANNUAL CONSORTIUM MEETING

In September, AID4GREENEST celebrated its 4th annual consortium meeting following a full week of project-related activities in Granada, Spain. [Read more...](#)



[AID4GREENEST WELL REPRESENTED AT AI MSE 2025](#)

Representatives from AID4GREENEST project partners **ePotentia**, **Ghent University** and **Fraunhofer IWM** were on hand to present project results at the 2nd annual *Artificial Intelligence in Materials Science and Engineering conference (AI MSE 2025)*, organised by the German Society for Materials Science in November. [Find out more...](#)



[BREAKTHROUGH IN PREDICTIVE METALLURGY HIGHLIGHTED AT IFC 2025](#)

AID4GREENEST and **Fraunhofer IWM** researcher, Dr. Maxim Zapara, showcased a breakthrough in predictive metallurgy through the development and industrial validation of a physics-based mean-field model at this year's *International Forging Conference (IFC)* organised by EUROFORGE AISBL in Germany in October. [Read more...](#)



[GUIDING INDUSTRY THROUGH CHALLENGING TIMES AT LCM 2025](#)

Eura AG and AID4GREENEST's Mary Osorio and Shashank Goyal have contributed to research presented at the *12th International Conference on Life Cycle Management* on sustainability assessments in industrial R&D: challenges and contributions to decision making. [Find out more...](#)

MEET THE NEWEST AID4GREENEST MEMBER



Emma García

IMDEA Materials
Institute

Emma García is a Laboratory Technician in the Physical Simulation group at **IMDEA Materials Institute**, under the supervision of Dr. Ilchat Sabirov. She supports experimental setups related to thermo-mechanical testing and microstructural characterisation. With a degree in Materials Engineering from the Complutense University of Madrid, she contributes to the group's experimental workflow by assisting in sample preparation and data acquisition for research on material behaviour and physical simulation.

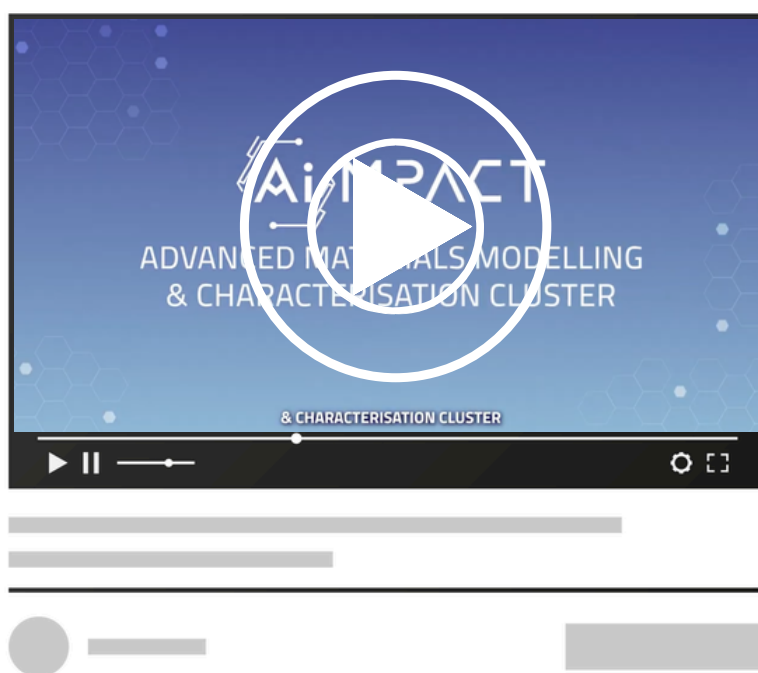
Welcome to the team, Emma!

The AID4GREENEST project actively promotes institutional collaboration through research exchanges and joint activities among consortium partners. As part of these efforts, Paula Chonillo from **IMDEA Materials Institute** carried out a two-month research stay at the **Łukasiewicz – Upper Silesian Institute of Technology (Łukasiewicz – GIT)**. During her stay, the predoctoral researcher conducted tests using the Gleeble thermomechanical simulator. This direct collaboration helped strengthen the project's knowledge base in metallographic analysis, and generate essential data to guide future low-cycle fatigue tests with the Gleeble system, contributing to the project's shared scientific objectives.

Looking ahead, fellow IMDEA Materials researcher Yufei Liu will take part in an upcoming research stay at **Fraunhofer IWM**. During this visit, he will introduce and apply the ACBICI Bayesian calibration framework to a representative Fraunhofer IWM use case, and collaborate with researchers on machine learning-based approaches for creep prediction. He will also support training and knowledge exchange on model calibration tools and data management practices.

AIMPACT ACTIVITIES

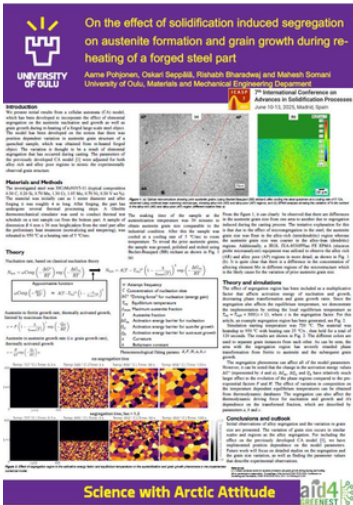
AID4GREENEST was pleased to take part in the production of the official AiMPACT Cluster video, produced by the **D-STANDART** project. The video, which features AID4GREENEST and IMDEA Materials researcher, Dr. Ilchat Sabirov, highlights the AiMPACT cluster's shared vision for accelerating sustainable, digital materials innovation across Europe by integrating advanced modelling, characterisation, and data-driven approaches. Alongside AID4GREENEST and D-STANDART, the AiMPACT Cluster official video features contributions from our sister and partner Horizon Europe projects: **AddMorePower**, **CoBRAIn**, **Knowskite-X** and **MatCHMaker**.



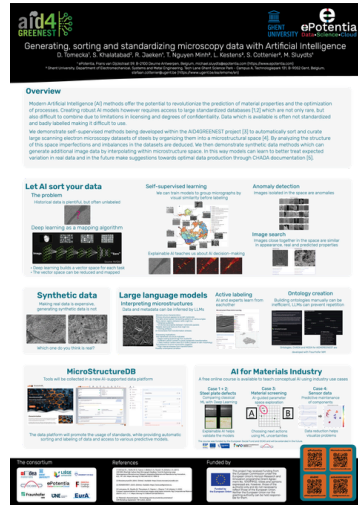
Sister and partner projects



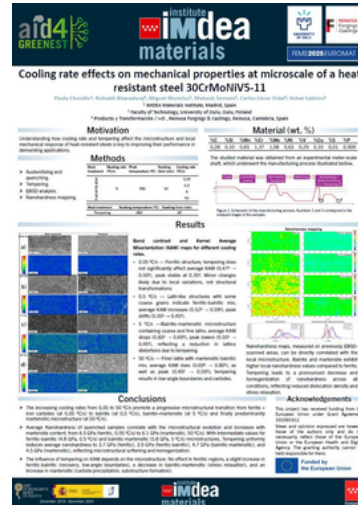
On the effect of solidification induced segregation on austenite formation and grain growth during re-heating of a forged steel part



Generating, sorting and standardising microscopy data with Artificial Intelligence



Cooling rate effects on mechanical properties at microscale of a heat resistant steel 30CrMoNiV5-11



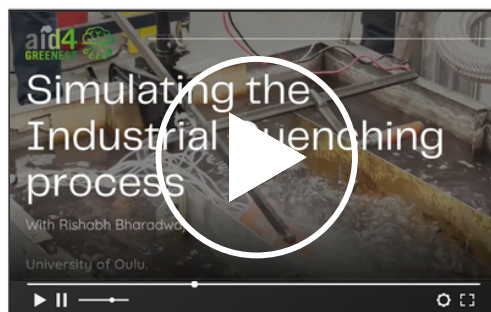
LATEST PROJECT VIDEOS



AID4GREENEST: THIS OR THAT?



REINOSA FORGINGS & CASTINGS AND EURA AG TALK LIFE CYCLE ASSESSMENT



SIMULATING THE INDUSTRIAL QUENCHING PROCESS WITH THE UNIVERSITY OF OULU

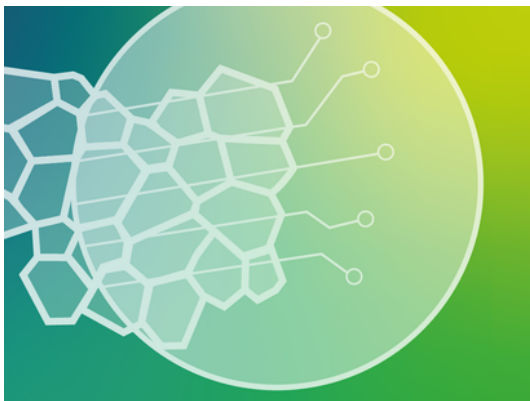


Follow us on YouTube for more multimedia content, [here](#).



AID4GREENEST TO FEATURE AT 7TH INTERNATIONAL ECCC CREEP & FRACTURE CONFERENCE (ECCC2026)

The **University of Liège** will present research carried out on mean-field modelling of creep deformation response, addressing precipitate kinetics, at May's *7th International Creep & Fracture Conference* in France. **Find out more...**



FRAUNHOFER IWM TO HOST AID4GREENEST PROJECT WORKSHOP

AID4GREENEST project partners, **Fraunhofer IWM**, will hold a project-related workshop entitled: *Materials Characterisation for Industrial R&D: From Fragmented Data Towards AI-powered Workflows*, in June. **Find out more...**



BAYESIAN CALIBRATION AND ACBICI ON SHOW AT NUMTA 2026

AID4GREENEST and IMDEA Materials predoctoral researcher Yufei Liu will present a Bayesian calibration of a steel creep model with the Python Package ACBICI at this year's *Numerical Computations: Theory and Algorithms: The 5th International Conference and Summer School* in Italy. **Find out more...**



IMDEA MATERIALS RESEARCHER TO PRESENT AT DSL 2026

Paula Chonillo, predoctoral researcher at IMDEA Materials Institute, will present on *EBSD-Based microstructural characterisation and prior austenite grain reconstruction in 30CrMoNiV5-11 bainitic heat-resistant steels* at the 22nd International Conference on Diffusion in Solids and Liquids (DSL 2026) in Greece. **Find out more...**

UPCOMING INTERNATIONAL DATES

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28/04

worldsteel Day for Safety and Health

International day to promote health and safety in the steel industry. Previously known as Steel Safety Day.

09/05

Europe Day

Organised by the European Union, marks the anniversary of the **Schuman Declaration**.

05/06

World Environment Day

World Environment Day promotes environmental protection and action worldwide.

16/07

Artificial Intelligence Appreciation Day

AI Appreciation Day celebrates the impact and potential of AI technologies in improving lives and shaping the future.



Thank you for signing up for the AID4GREENEST newsletter. Our next edition will be released in September 2026. Until then, follow us at our website: www.aid4greenest.eu.

And don't forget to follow us on our social media channels

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