Digital transformation and sustainable innovation in steel manufacturing: The AID4GREENEST project



ESTEP 2024 Annual Event

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European Steel Technology Platform

20 years together

voestalpine



FOR GREEN STEEL 3rd INTERNATIONAL CONFERENCE A CIRCULAR ECONOMY DRIVEN BY THE EUROPEAN STEEL



Challenges of R&D in the EU steel sector

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- Traditionally, steel metallurgical processes have been developed using a 'trial and error' approach, where chemistry and processing parameters are screened to achieve the desired microstructure and properties.
- Cons: time-consuming, labour-intensive, and generates high material waste and emissions; It can also lead to high rejection rates of up to 10% in manufacturing, with design flaws often identified too late in the process.
- Time-consuming nature of experiments for steel design, characterization and quality control.
- One **EBSD) scan of a sample can take several hours**. Multiple characterizations are needed at various stages of thermo-mechanical processing (e.g., hot rolling, cold rolling) to ensure quality.
- High temperature standard creep tests, which assess steel performance in high-temperature applications, can take up to 10.000+ hours.
- Industrial data is gathered from sensors monitoring various processes. Ensuring accurate data classification, storage, and auditing is critical but lacks standardized approaches. This inconsistency leads to difficulties in reproducing results between laboratories.
- Different terminologies used by IT experts, engineers, and metallurgists hinder collaboration across disciplines.





AID4GREENEST project: key facts



aid4 AID4GREENEST (GA Nº 101091912)

- **Call**: HORIZON-CL4-2022-RESILIENCE-01
- **Topic**: HORIZON-CL4-2022-RESILIENCE-01-19 -Advanced materials modelling and characterisation (Research and Innovation Action)
- Start date: 01.09.2023 End date: 31.08.2026
- **Total budget**: € 4,946,876.25
- 10 partners from 4 countries
- 3 companies + 3 universities + 2 research organizations
 + 1 standardization body + 1 consulting company



AID4GREENEST project: key facts





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Six AI-powered tools / methods (results)

- A model-enabled method for rapid characterization of steel microstructure.
- Two AI-based chemistry-process-structure modelling tools that enable the design and processing of robust steels, and the development of production routes with reduced carbon impact.
- Sequential computational model predicting microstructure during forging and quenching of meter-scale parts.
- A ML-based tool predicting creep life of the heat resistant steels.
- A model-enabled method for accelerated creep testing.









Main objectives

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Development and design of advanced materials through sustainable innovation processes

- Life cycle assessment of the benchmark methods/tools value chain.
- Comparative environmental assessment of developed methods/tools and benchmark.
 - Roadmap to uptake best practises to increase efficiency and reduce environmental burdens at all stages.



Standardization activities

- Analysis of the applicable standardization landscape.
- Contribution to the ongoing and future standardization developments.



Life Cycle

Assessme



Rapid characterization



EBSD analysis: *t* >> 100 min Sample preparation is tedious



- Phases
- Volume fractions
- Size
- Aspect ratio
- Homogeneity
- etc.



SEM image + AI: $t \approx 1$ min Sample preparation is simpler

Lots of data is needed to train AI tool! Real and synthetic.



Predicting "microstructure" \Leftrightarrow "process parameters"

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Microstructure

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27 November 2024

- Thermo-mechanical processing.
- Quenching meterscale products.



Advantages:

- Elimination of *trail-and- error* approach.
- Acceleration of the development of new materials.
- Acceleration of process optimization.
- Reduction of material waste.



Thermo-mechanical processing parameters



Accelerated creep testing (ACT)



 Materials and products for high temperature applications



Advantages of ACT:

- Dramatic reduction of testing time and energy consumption by 10³.
- Dramatic acceleration of the development of new materials and products.
- Dramatic acceleration of product acceptance.





Accelerated creep test + ML: t ≈ 10 h 4 kW





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ePotentia Data-Science-Hosting Database design, missing data completion, explainable AI, automated annotation using NLP, open platform...





Open Data Platform

ePotentia

Data-Science-Hosting

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Open data platform can be found on <u>https://www.microstructuredb.com</u>:

- Early access and credits for contributors of data
- Different levels of openness
 - Fully open
 - Model-training only
 - Private



Local versions of data management and prediction platform planned.

Sign up for the Newsletter!



Interoperability and reproducibility



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🗾 Fraunhofer

EMMC ★

IWM

- AID4GREENEST addresses the objectives of the European Materials Modelling Council and European Materials Characterization Council to improve the industrial utilization of advanced modelling and characterization techniques.
- AID4GREENEST is fully committed to development and implementation of CHADA and MODA standards along with EMMO ontologies to ensure seamless data interoperability between materials characterisation and modelling.





Lean more about AID4GREENEST at:

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