HIGH-TECH LASER AND AI FOR INCREASED STEEL RECYCLING

TATA STEEL

Tata Steel Nederland, German and Austrian steel producers are co-innovating for more sustainable, energy-efficient steel production.

As the global demand for steel continues to grow, the pressure to make the steel sector more sustainable is increasing. This is because steel production is responsible for a lot of CO2 emissions, mainly due to the use of coal to produce iron, the main component of steel. Currently, about 7% of the Netherlands' CO2 emissions are caused by steel production and processing. By producing iron with sustainably-generated hydrogen in the future, this share can be significantly reduced. Additionally, it is crucial to change the way we dispose of steel products. After all, for all the steel that can be fed back into the production chain, no new iron needs to be made. This circular economy, in which steel is optimally recycled, offers many opportunities in and for the Netherlands.

Tata Steel Nederland is working every day to recycle steel. The company increases the use of scrap from 17% in 2022 to 30% in 2030. This corresponds to 65 billion cans, each containing 13 grams of steel. Tata Steel Nederland aims to further optimize its recycling process. Together with the German steel company Saarstahl and the Austrian voestalpine Group, research has been initiated to explore how digital technology can be utilized to achieve this. Under the name **'Digital Twins for Green Steel' (DiGreeS)**, the three entities are investigating possibilities for introducing new steel production routes and reducing the ecological footprint.

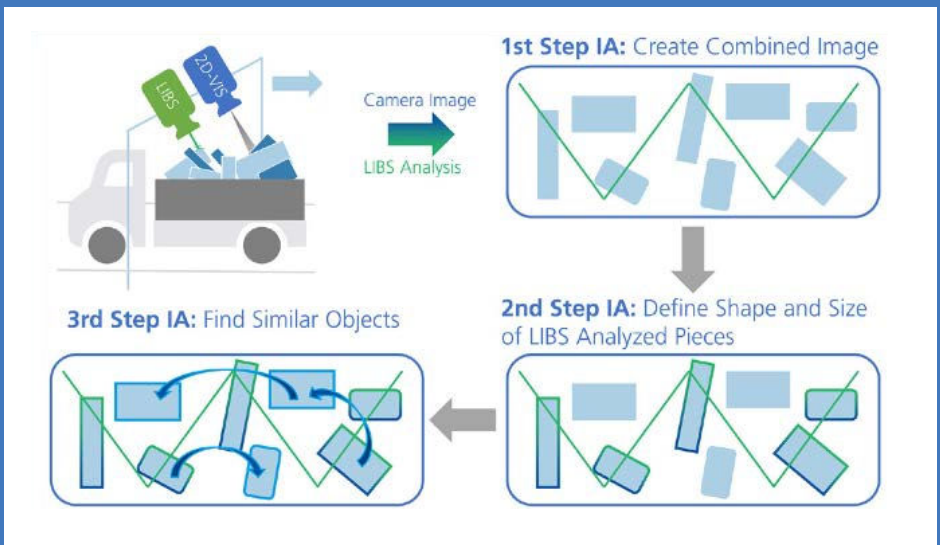
To be able to significantly increase the use of scrap in steel production in the near future, Tata Steel aims to further optimize the recycling process. A challenge in this regard is that much of the old steel, such as from old ships or railroad tracks, is too large in size and quantity for regular conveyors and difficult to analyse. Analysis is important, as not every piece of scrap may be fed into the production cycle. This has many reasons, such as the presence of a coating that complicates recycling, or because the scrap's chemical composition makes it impossible to fulfill requirements on the admissible chemical composition of the recycled steel.

To efficiently analyse large pieces of old steel, Tata Steel researches the use of Laser-Induced Breakdown Spectroscopy (LIBS), a digital laser techniques that enables to analyse the composition of scrap directly from the truck. The process works as follows: a truck carrying scrap enters a specially constructed gate with industrial laser and analysis equipment. The laser vaporizes very small pieces of the steel locally, creating a plasma, a small local gas bubble containing all the components of the scrap. A spectroscope analyses the intensity and wavelength of the plasma light and recognises the composition of the scrap. By combining this information with images of the truck load, individual pieces of scrap can, depending on the specific composition and criteria, be optimally introduced into the recycling process.

AI and digital twins for reduced waste and more CO2 reduction

Tata Steel researcher Bernard Ennis states: "In this measurement and analysis process, AI is used to more quickly recognize and analyse specific types of steel based on visual characteristics, known as 'scrap image recognition'. The manufacturing process is digitally modelled, or simulated, and tested in a computational model using digital twins." This digital twin models the change in the average composition of each type of scrap over time and can thus be used to find the right mix of scrap types that ensures the intended composition of the recycled steel. Moreover, by linking the digital twin to models for mechanical properties, logistics processes or energy management, for example,

Measurement and analysis process for steel recycling.



This innovative combination of laser, AI, and digital modelling allows for more efficient sampling, faster scrap deployment logistics, and improved product quality.

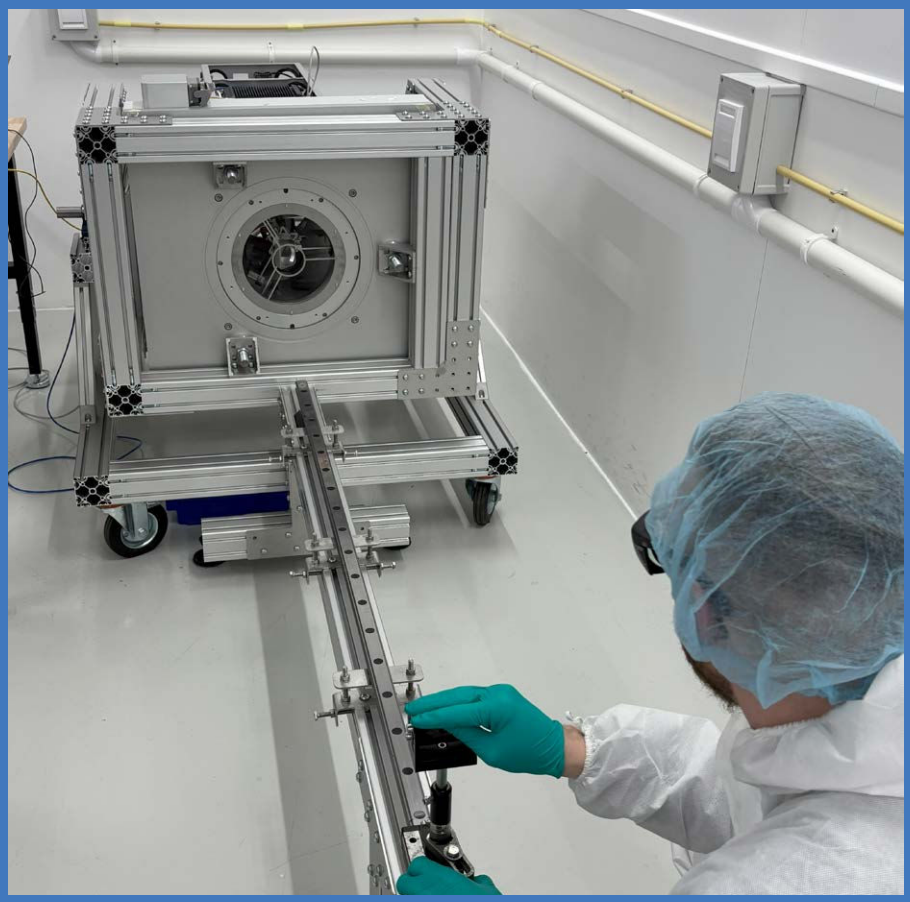
different scenarios can be probed in order to optimise the entire production process. For example, this makes it possible to determine how much scrap can be added before the quality of the recycled steel becomes unacceptable, or to determine an optimal mix of scrap to minimise production losses or energy consumption. “This innovative combination of laser, AI, and digital modelling allows for more efficient sampling, faster scrap deployment logistics, and improved product quality. Moreover, this leads to fewer process errors in scrap deployment and thus less waste and CO2 reduction”, according to Ennis.

At present, the technique is being researched and developed under the ‘DiGreeS program’. The first LIBS measurements are scheduled to take place in the first quarter of 2025, with the first results being announced. In 2026, the first prototype of the truck portal is expected to be ready for use, and the measurements and modelling will commence. Then, the implementation will follow, including the introduction of the digital twins modelled process.

A practical view on the implementation of AI

A successful application of AI stands or falls with a clear view of the intended goal, a clear overview of the strengths and weaknesses of this technology and a well-considered implementation plan.

While promising, AI is not (yet) able to solve all issues within a company, it needs good-quality data to function and it is certainly not yet self-evident to completely outsource important tasks to this technology. How do the researchers at Tata Steel look at these issues?



Laser-Induced Breakdown Spectroscopy (LIBS) testing.

Ennis: ‘At this moment, we already generate a lot of data. Data availability therefore is not the problem for us. The issue lies in the quality and connectedness of the data. The challenge for us is to identify the right data that we can use for a specific purpose and to connect the right data to properly represent a situation.’ In the specific case of the recycling process, there is already a lot of knowledge about how to mix scrap to create the ideal composition, but this knowledge is localised. ‘The trick is to pool this local knowledge and, where necessary for the final result, fill gaps.’ So with this pooled knowledge and already available data, initial AI models can now be created.

Where information is missing, it has to be identified what additional data is needed and how that can be generated, in order to extend the AI models later. This thus makes the practical implementation of AI a gradual process, without a clear on/off switch.

‘Besides, we use AI to make better decisions, not to have it make those decisions for us. If you want to use AI to make decisions, you need to see if AI can do that better than a human for a specific problem.’ This is often the case in situations involving large amounts of data and a lot of repetition. In cases where context, understanding and/or domain expertise is important, humans tend to make better decisions than AI.

Then interaction between humans and AI often leads to better results than humans or AI alone. ‘Steel making can be divided into processes that can be better understood with AI than by a human alone. However, the knowledge and expertise of the whole process cannot (yet) be grasped by AI. In that case, you can use AI to support humans in making better decisions.’ ■

Want to know more about sustainable solutions at Tata Steel? Read more at https://www.tatasteelnederland.com/en/sustainability

> **We use AI to make better decisions, not to have it make those decisions for us.**