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Research for Redesigning the Steel Scrap System

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The steel industry, which accounts for 7% of global anthropogenic CO2 emissions, is undergoing a major transition to reduce its carbon footprint, with several technologies being developed, trialled and commercialised at different scales, including scrap-based electric arc furnace (EAF), hydrogen direct reduced iron (HDRI)-EAF, hydrogen direct reduced iron (HDRI)-electric smelting furnace (ESF)-basic oxygen furnace (BOF), and iron ore electrolysis routes. All these new technologies have the potential to reduce CO2 emissions from 1.8~2.4 tonnes per tonne steel in the BF-BOF route to as low as 0.1 tonne CO2 per tonne steel if renewable energy is used. The scrap-based EAF route is particularly attractive because of its several advantages such as its proven capability at industry scale and the increasing scrap availability. World Steel Association estimates that the global end-of-life steel availability will reach about 600 Mt in 2030 and 900 Mt in 2050. In the UK the annual scrap generation is over 11 Mt, exceeding its crude steel production of about 5.5 Mt per year.

The role of scrap in steel manufacturing has been evolving from serving primarily as a coolant in the BF-BOF route to becoming the main metallic raw materials in the (scrap-based) EAF route for producing certain high-quality steels that are traditionally made via the BF-BOF route. The scrap system, from generation and processing to quality assurance (including specifications) and efficient usage in steelmaking, must be redesigned to align with the evolving steel manufacturing landscape.

This talk will present a wide range of research activities undertaken by the authors to support the redesigning of the steel scrap system. Scrap standards and specifications are first examined in light of the evolving steelmaking technologies with recommended changes. Adopting circular economy principles during scrap generation and processing can substantially improve the scrap quality and value. One example to demonstrate is the automated disassembly of the end-of-life e-machines (compared to the current practice of shredding), enabling effective recovery of steels, aluminium and critical minerals and avoidance of contamination to scraps. Considering the urgent need of quality monitoring tools for the heterogeneous scrap, we developed a faster, smarter and more robust computer vision system, powered by a unique machine unlearning framework, for specific object identification and scrap quality assurance. The optimised scrap usage in steelmaking, in combination with OBMs (ore based metallics), is modelled considering steel chemistry, cost and environmental impacts.

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