CFD Driven Optimisation of Thermal Flow in EAFs by Injecting Biomass for Sustainable Steelmaking

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GLOBAL STEELMAKING INDUSTRY

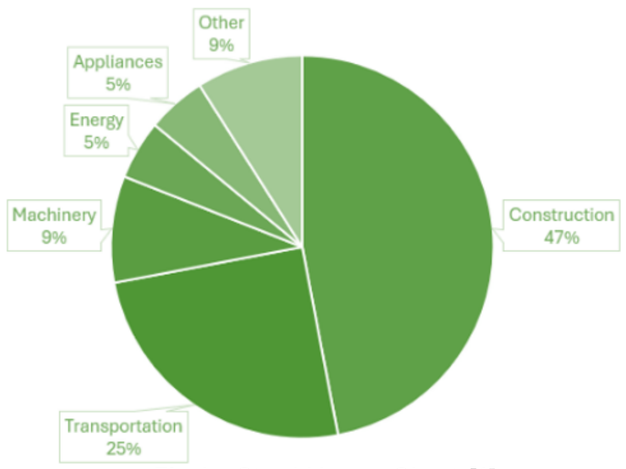

Fig 1 - Steel Usage Chart [1]

Globally **2B** tonnes of steel produced in 2024

Contributing **$2T** in 2024 to global economy

Steel production accounts for **8%** Global CO_2 emissions

BOF production emits **1.7t** CO_2/tonne of steel produced

EAF production emits **0.2t** CO_2/tonne of steel produced

2024 Global BOF Steel Production	70%
2024 Global EAF Steel Production	30%

Electric Arc Furnaces (EAF) offer a promising solution to reduce steel production's carbon footprint [2]. Unlike traditional Basic Oxygen Furnaces (BOF), which rely on carbon-intensive materials, EAF uses electricity to melt scrap steel and recycle it, making it more energy-efficient and sustainable.

CHALLENGES IN EAF HEAT DISTRIBUTION

The EAF consists of a refractory-lined shell, a detachable roof and a hearth to hold molten metal. It uses graphite electrodes for melting scrap steel.

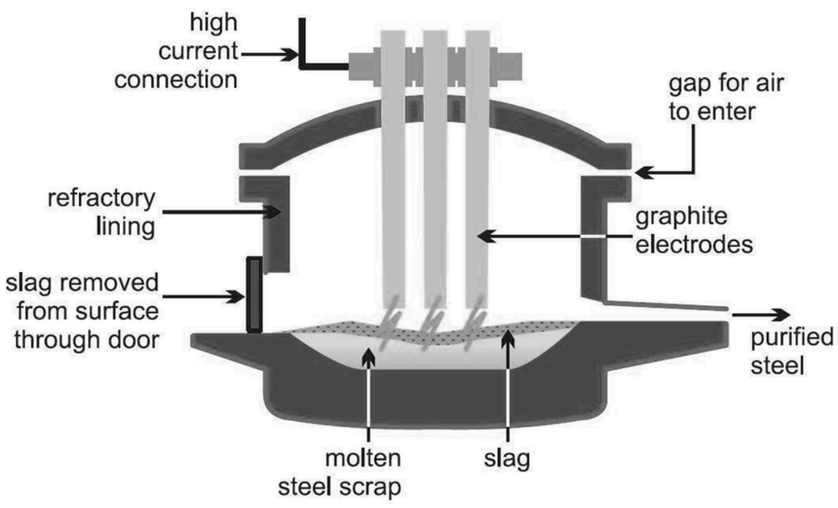

Fig 2 - EAF Schematic [3]

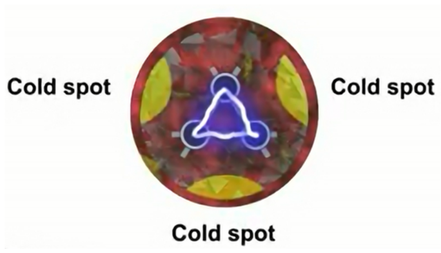

Fig 3 - Cold Spot Formation in EAF

Electric arcs generate high temperatures near electrodes, leaving some areas cooler

Cold spots cause uneven melting, increase energy consumption and lower steel quality

Oxy-fuel burners in EAFs use natural gas and oxygen for combustion, generating additional heat to preheat scrap, accelerate melting, reducing electrode power demand and minimising cold spots

Fig 4 - Oxy-fuel burners

Fig 5 - Biomass

However, fossil fuel reliance raises EAF emissions, making biomass-based fuel injection promising for reducing cold spots and environmental impact.

RESEARCH OBJECTIVES

- Develop a CFD model to simulate thermal and fluid flow dynamics of the EAF process
- Analyse and optimise cold spots in EAFs through CFD simulations
- Investigate the impact of biomass-based fuel injection on thermal efficiency, heat distribution and carbon emissions
- Validate CFD simulation results through experimental trials ensuring real-world applicability

CFD MODELLING METHODOLOGY

CFD Model Development
Develop a 3D CFD model of the MPI 7-tonne EAF in Ansys Fluent, defining geometry, boundary conditions and material properties

→ **Baseline Simulation**
Simulate thermal and fluid flow using oxy-fuel burners, analysing cold spot formation and heat transfer efficiency

↓ **Biomass Injection Study**
Introduce biomass in CFD simulation, optimising injection frequency, flow rates and combustion efficiency.

← **Experimental Validation**
Conduct trials on the MPI 7-tonne EAF, measuring temperature distribution, energy efficiency and emissions, and compare results with CFD predictions.

↓ **Industrial Scaling**
Evaluate the feasibility of implementing biomass injection in large-scale 300-tonne industrial EAFs.

EXPECTED IMPACT ON EAF STEELMAKING

Achieve 10% decrease in EAF energy consumption via CFD thermoflow optimisation and biomass injection [4].

Fig 6 - Average EAF Energy Consumption Chart

Reduce cold spots by CFD optimisation and biomass injection for more uniform heat distribution

Lower carbon emissions by replacing natural gas with biomass, making EAF steelmaking more sustainable.

Provide a scalable CFD-driven optimisation framework that can be adapted for large-scale 300t EAF operations

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[4] Oliveira, T. L., Assis, P. S., Leal, E. M., & Ilídio, J. R. (2015). Study of biomass applied to a cogeneration system: A steelmaking industry case. Applied Thermal Engineering, 80, 269–278.