

HDR PROJECT SUMMARY

ENHANCING COMBUSTION EFFICIENCY AND REDUCING EMISSIONS IN HYDROGEN-DRIVEN INDUSTRIAL PROCESSES

HDR PROJECT DESCRIPTION AND MOTIVATION

The transition to a net-zero economy necessitates decarbonising energy-intensive industries, such as iron/steel production and cement manufacturing. Hydrogen (H₂) is a promising alternative to natural gas (NG) and other hydrocarbon fuels for high-temperature processes due to its zero carbon emissions. However, challenges remain in optimising heat transfer, mitigating nitrogen oxide (NO_x) emissions, and understanding the operational implications of H₂ use. This project aims to address these gaps to ensure efficient and sustainable integration of H₂ into heavy industry, with the expected outcomes being development of scalable technologies for integrating H₂ into heavy industry processes while minimising emissions, and contributions to the global transition toward sustainable industrial energy systems.

The PhD activities will complement the on-going activities in the HILT project [RP2.007 Feasibility combustion study to identify challenges and opportunities for hydrogen into iron and cement sectors](#). The projects will address three key objectives of relevance to many appliances, including EAFs, reheating steel and hot gas generators for the iron/steel sector, and rotary kilns for the cement/lime sector.

PROJECT OBJECTIVES

1. Enhancing radiation from hydrogen flames

- Investigate strategies to improve the radiative heat transfer efficiency of H₂-based flames in rotary kilns and steel reheating furnaces.
- Explore the role of additives, flame shaping and advanced burner designs in optimising radiation.
- Use experimental setups and computational fluid dynamics (CFD) modelling to quantify and enhance radiation performance.

2. Supersonic hydrogen lances for electric arc furnaces (EAFs)

- Study the fundamental implications of switching from NG to H₂ in supersonic lances related to EAFs.
- Examine flow dynamics, heat transfer and chemical reactivity using high-fidelity CFD simulations.
- Assess operational impacts on material quality, energy efficiency and equipment design.
- Minimising NO_x formation in high-temperature appliances.

3. Develop and optimise novel combustion strategies, such as moderate or intense low-oxygen dilution (MILD) and high-strain flame concepts.

- Investigate flame stability and NO_x reduction mechanisms through experiments and machine learning-assisted analysis.
- Propose scalable solutions for implementation in industrial burners and kilns.

QUALIFICATIONS AND EXPERIENCE

Candidates are required to have:

- an interest in combustion, hydrogen utilisation and high temperature reacting flows
- a chemical, mechanical and/or data science background
- past experience in experimental combustion, CFD and/or machine learning/artificial intelligence (ML/AI) is a plus, noting that the project can be focused on either experiments and/or CFD/ML for the right candidate.

To determine your eligibility for studying at The University of Adelaide, visit adelaide.edu.au/graduate-research.

Further enquiries: Dr Alfonso Chinnici, alfonso.chinnici@adelaide.edu.au

SUPERVISORS

- Dr Alfonso Chinnici

PROJECT PARTNER

- The University of Adelaide

PROJECT TYPE

- PhD

DATE ADVERTISED

- February 2025

HILT CRC POSTGRADUATE PROGRAM

Are you interested in receiving training from world-leading researchers, whilst working with industry partners on real-world problems?

Join the HILT CRC postgraduate program for a research career in de-risking decarbonisation for heavy industry.

Through engagement with industry and universities we are committed to training the heavy industry workforce of the future through practical, demand driven research projects with world-leading teams and facilities.

We offer Higher Degrees by Research (HDR) through a PhD or Masters qualification for up to 3.5 years duration, providing you with the opportunity to acquire world-leading training in a field of growing demand to take your engineering career further.

By joining our postgraduate research program, you will work on real industry problems and challenges with the potential for immediate high-impact practical results to decarbonise heavy industry.

When undertaking a research degree with us, you will also gain:

Expert knowledge – designed specifically for the heavy industry sector and draws on your foundation of engineering knowledge by developing further skills tailored to transitioning the steel, iron, alumina and cement industries to reduce heavy industry's carbon emissions.

Invaluable networking opportunities and professional development – benefit from opportunities to collaborate and network with multiple industries and research experts and teams via participating in the HILT CRC specialised webinars, yearly conferences, and master classes.

Career outcomes – linked with industry and government, you will gain hands on industry experience to help you develop the skills required to operate in a new low-carbon economy, become an expert in your field, and enhance your employability.

A platform for communicating your findings – your research findings may be presented at industry conferences, published, commercialised and in turn, create a positive impact on society.

Financial Support and Scholarships

We can provide full, co-funded or top-up scholarships to eligible postgraduate students (Higher Degree by Research students at both Master and PhD levels) across our three research programs at our partner universities. The distribution of funding is at the discretion of the principal (main) supervisor of the project and may be used for student stipend, costs associated with the research project or other expenditure related to the project.

Any student interested in undertaking a postgraduate scholarship is encouraged to review the [Scholarship Guidelines](#) and complete the [HDR Scholarships Application Form](#). Details for how to apply for postgraduate scholarships are included in the guidelines.

How to Apply

All HILT CRC prospective postgraduate students are required to enrol in their degree through their host institution as per the normal university application process. Therefore, students need to meet the requirements stipulated by the host university to enrol (e.g. appropriate Honours or Masters degree).

Further Information

For more details about the postgraduate research opportunities and projects, and financial support with HILT CRC, contact us at hdr@hiltcrc.com.au