Market Sector:
POWER & ENERGY

Technology Theme:
LIFE CYCLE ASSESSMENT

RECHYCLE:
EMBODIED CARBON ANALYSIS

EMBODIED CARBON ANALYSIS OF TITANIUM ELECTROLYSER STACKS

The MTC has proposed several novel manufacturing routes for the production of electrolyser stack titanium components. An embodied carbon analysis has been developed to quantify the reduced cradle-to-grave environmental impact of implementing these methods in order to inform on the most sustainable manufacturing route to pursue.

The work completed by the MTC has identified the feasibility for a future circular titanium electrolyser stack supply chain for the sustainable production of hydrogen, whilst the Embodied Carbon Analysis Method presents a new high level alternative to a full life cycle assessment. This could aid in understanding the environmental impact of decisions early in the conceptual stages of a project.

THE CHALLENGE

The MTC identified Polymer Electrolyte Membrane (PEM) electrolysers as an opportunity to make the hydrogen production process more sustainable and cost-effective. However, the current production of bipolar plates and porous membranes for electrolyser stacks from titanium is highly energy and resource intensive.

A method was required to assess the reduced environmental impact of several novel manufacturing routes in comparison to the current supply chain of titanium electrolyser stack components.

MTC'S SOLUTION

- The current conventional use cycle of the titanium in an electrolyser stack was investigated and split into use cycle stages.
- An embodied carbon analysis method was developed to calculate the embodied carbon of the titanium in a single electrolyser stack for a single use cycle.
- 18 manufacturing scenarios were compared, with the model outputting both the total embodied carbon, and the embodied carbon associated with each use cycle stage to identify key emission drivers.

THE OUTCOME

- The embodied carbon analysis enabled calculation of the total embodied carbon dioxide equivalent (CO2e) for all scenarios against the current baseline scenario
- From this, the following key conclusions were drawn:
  - Recycling titanium machining swarf within the current manufacturing route, as is commonly done at present with an average recovery rate of 40%, results in reducing the embodied carbon by 12500kgCO2e per electrolyser stack.
  - The use of titanium sponge drop out waste as feedstock for spark plasma sintering (SPS), demonstrated by the MTC's RecHycle project, achieves a significant reduction of 21800kgCO2e per stack.
  - The route resulting in the least embodied carbon was through the remanufacturing of end of life parts as feedstock into net shaping by SPS with salt spacers produced by uniaxial pressing.

BENEFITS TO THE CLIENT

- Implementing spark plasma sintering during the titanium electrolyser stack manufacturing stage, was identified as having the greatest impact on reducing the embodied carbon compared to all other contribution categories. From this, the recommendation could be made for the introduction of spark plasma sintering into the titanium electrolyser stack supply chain to be the focus of continued study.
- The developed Embodied Carbon Analysis Method presents a new high level alternative to a full life cycle assessment. This could aid in understanding the environmental impact of decisions in the conceptual stages of a project.

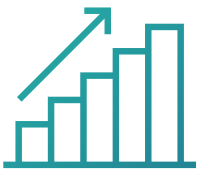
The amounts of CO2e per electrolyser stack can be converted into an equivalent number of barrels of oil.

*Barrels of oil calculated using the EPA's Greenhouse Gas quivalencies Calculator (EPA, 2021)

RECYCLED POWDER METAL

LOW ENERGY PROCESSING

MINIMAL MATERIAL WASTE



IMPROVED ELECTROLYSER DESIGN & EFFICIENCY

ENABLING LOW COST HYDROGEN FUEL

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