Laminar burning velocity of hybrid methane-iron-air flames

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METAL FUEL CYCLE

Clean energy like wind and solar cannot be generated anywhere or at all times. Therefore, a storage medium is needed. Using hydrogen or electrolysis this energy can be stored in iron powder.

This iron powder can then easily be stored and transported to regions in need for clean energy.

The stored energy can be extracted from the iron powder by combustion, creating iron oxides, which can be transported back to regions with an excess of clean energy. Here, the powder is regenerated back into iron closing the metal fuel cycle.

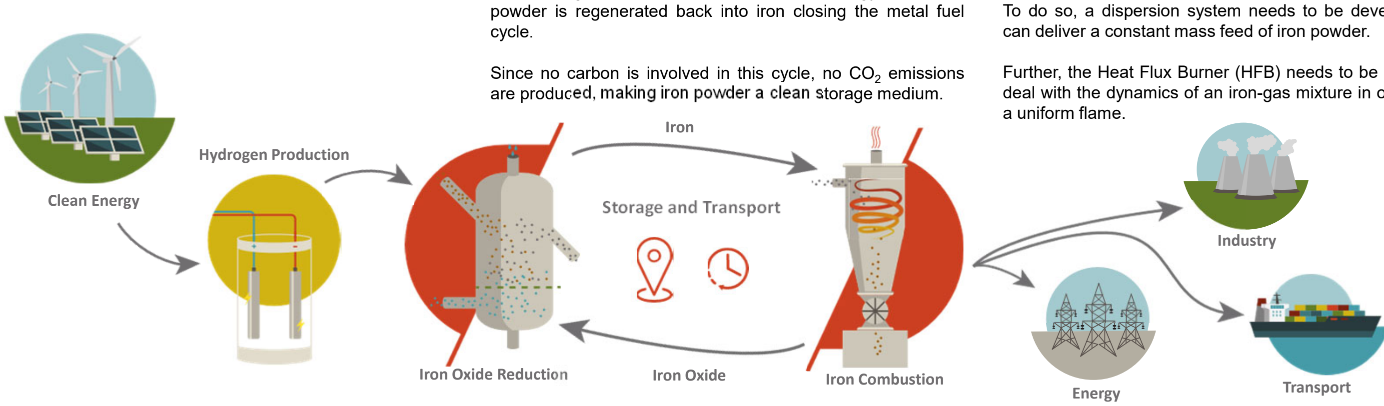
Since no carbon is involved in this cycle, no CO_2 emissions are produced, making iron powder a clean storage medium.

PROJECT OUTLINE

In order to make the metal fuel cycle efficient, more knowledge about the combustion process is needed. In this project, hybrid methane-iron-air flames are considered. Using the Heat Flux Method (HFM) as basepoint, the laminar burning velocities of these hybrid flames will be investigated.

To do so, a dispersion system needs to be developed that can deliver a constant mass feed of iron powder.

Further, the Heat Flux Burner (HFB) needs to be adapted to deal with the dynamics of an iron-gas mixture in order to get a uniform flame.

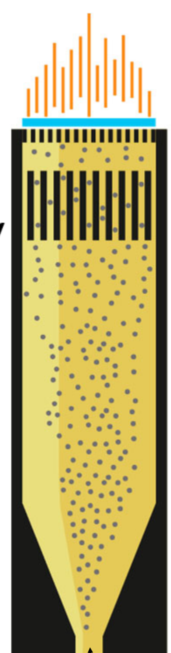


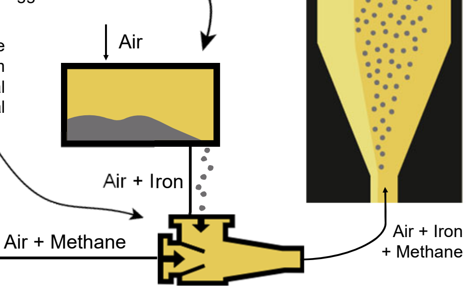
HEAT FLUX METHOD

- The heat flux method was developed to measure the adiabatic burning velocity of gaseous flames.
- A perforated plate which is heated at the rim is used to stabilize a flat flame.
- Thermocouples are installed at the bottom of the burner plate to measure the heat flux inside the perforated plate.
- By varying the gas velocity, a state of zero net heat flux can be found for each specific flame, corresponding to the adiabatic burning velocity of that mixture.

ADAPTIONS OF FOR HYBRID FLAMES

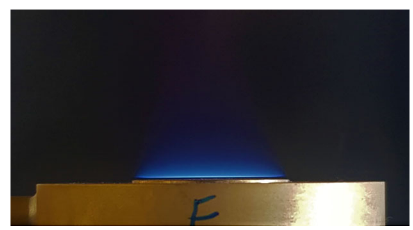
- Due to the relatively high terminal velocity, a contraction cannot be used to create a uniform flow. Therefore a honeycomb grid will be installed to stratify the flow.
- For iron dispersion, a vibrating conveyor and hopper are used. The conveyor and hopper are sealed of from the ambient with a lid to avoid ambient air entrainment in the mixture. To avoid a vacuum, air is supplied and controlled by an MFC.
- The iron dispersion is equipped with a loadcell. This way the iron mass flow in the mixture can be logged
- The iron is combined with the main gas flow using a vacuum ejector. Here, high local velocities cause potential agglomerates to break up.





HYBRID IRON-METHANE-AIR FLAMES

- With the adapted burner, hybrid iron-methane-air flames were produced with a molar iron-fuel ratio of around 0.1.
- First results show a slight decrease in burning velocity when iron is added to a lean methane flame.
- More experiments are needed to give quantitative values for the burning velocity.



A flat methane flame produced by the adapted HFB.

The adapted HFB. Installed with thermocouples, cooling and heating hoses.

A hybrid methane-iron-air flame produced by the adapted HFB.

DEPARTMENT OF MECHANICAL ENGINEERING, GROUP OF POWER AND FLOW

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