Extracting Hydrogen with Enhanced Pyrolysis.

BACKGROUND

As the effects of global warming accelerate, the quest for a solution intensifies. The combustion of fossil fuels with oxygen both in the production and end use is thought to be the cause of recent natural disasters. When the cost of these disasters are added to the process costs, the overall economic efficiency is lowered,reducing the competitive edge and allowing for the advancement of smarter processes.

Hydrogen, as a fuel, is the ultimate in clean energy, producing only water when reacted with oxygen. Unfortunately, hydrogen is not abundant in molecular form. Presently, copious amounts of fuels are consumed to create pure hydrogen, negating its clean value. This paper is focused on a method to enhance the use of pyrolysis as a method for the extraction of hydrogen from a fuel.

KEY POINTS:

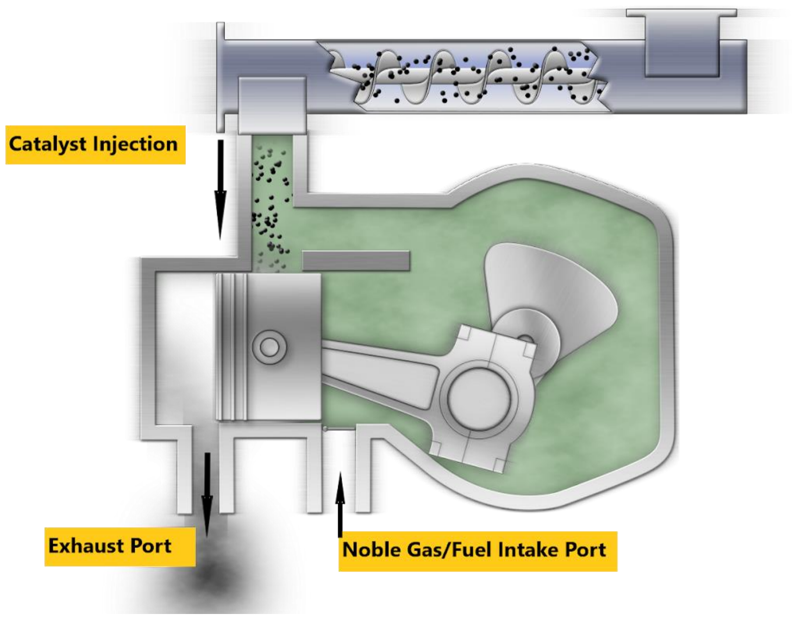
- Hydrogen extraction
- Pyrolysis reaction
- Adiabatic compression
- Noble gas recirculation
- Mobilized catalysts
- Real-time Catalyst regeneration
- Recirculating cycle to compensate for short residence time
- Ported 2 stroke compressor
- Pressure Swing Adsorption and membrane separation
- Conserving mechanical and thermal energy

THE METHOD: PYROLYSIS

One potential path is the use of pyrolysis, the thermal decomposition of fuels into Hydrogen and Carbon by heating in the absence of oxygen. The pyrolysis reaction of hydrocarbons is straightforward, however, this well known, highly endothermic reaction is not a simple solution. One must consider the entire envelope of the reaction, including the source of energy to drive the process as well as the losses to rejected heat and friction. Additionally, some refinement is needed to prepare a fuel that is capable of undergoing the pyrolysis reaction. Regardless of these issues, the reaction is worth exploring as a way to contribute to the reduction of CO2 emissions.

THE PROCESS

The purpose of the present invention is to find the optimum conditions to create hydrogen using the compressive pyrolysis of fuels. Rather than use heat to drive the reaction, the method uses the adiabatic compression of a noble gas to reach the high temperatures needed to break molecular bonds. More importantly, the process utilizes catalysts and seeks to mitigate loading or fouling by continuously introducing fresh catalysts into the compression chamber to ensure that the reaction runs at an optimum. By integrating a recirculation system with the compressor/reactor, fresh catalysts can be injected and incomplete products can be continuously returned to the reaction chamber. As the gasses are ejected from the chamber, they are separated in a pressure swing adsorption unit to separate the pure hydrogen from the mixture.



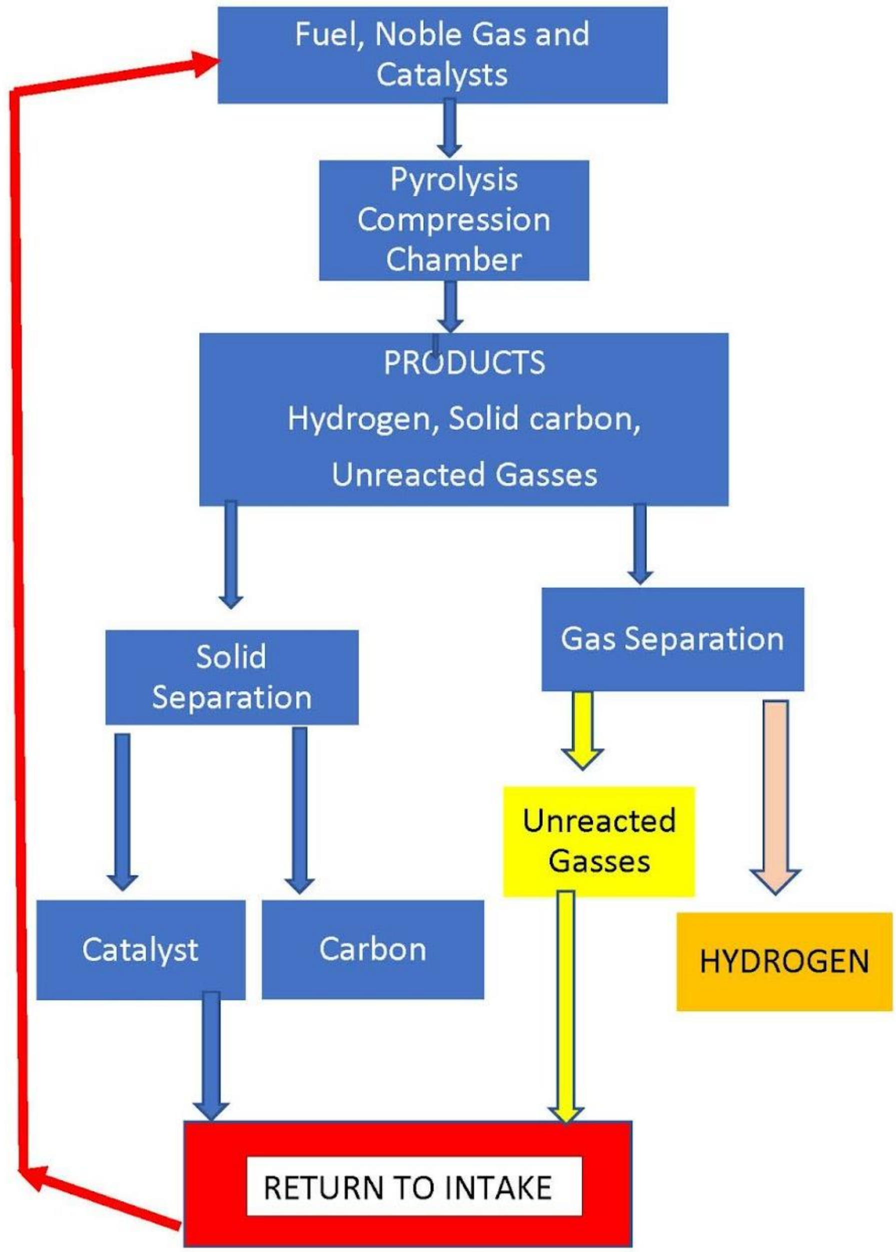
THE VARIABLES

Type of fuel
Type of Catalysts
Inlet temperature and pressure
RPM
Compression ratio

Minimum final pressure and temperature
Rate of Catalyst feed

THE CYCLE

1. Fuel, noble gas and catalysts are injected through the intake port of the reactor. At this period, the piston is descending and the intake port is uncovered. The exhaust port is also open, allowing the fresh materials to purge the chamber and eject the previous cycle. The advantage of noble gasses are two fold. First, the non-reactive atmosphere needed to cause pyrolysis. Secondly, the high gamma ratio of specific heats promotes intense heating when compressed.
2. The piston ascends, first closing the exhaust port then the intake port, allowing for the compression of the mixture, causing pyrolysis, creating solid carbon, hydrogen and other products.
3. Once ejected, the solids and gasses are separated. The solid carbon and catalyst are parted. The carbon must be stored, the catalyst is returned to the cycle after being regenerated. Catalysts can also be rejected and replaced with fresh material as needed to keep the reaction constant.
4. The gasses are separated either by membrane, filter or pressure swing adsorption, to yield pure hydrogen. Other partially reacted gasses are returned to the cycle for further processing along with a fresh charge of fuel.
5. The compressor is highly insulated and all efforts are made via flywheels to retain angular momentum and to harness the expansion of gasses in the cycle.


Fuel, Noble Gas and Catalysts
Pyrolysis Compression Chamber
PRODUCTS
Hydrogen, Solid carbon,
Unreacted Gasses
Solid Separation
Gas Separation
Unreacted Gasses
Catalyst
Carbon
HYDROGEN
RETURN TO INTAKE

TRACKING THE ENERGY

- **Energy needed to rotate the compressor, performing work on the gasses**

- **Recouped energy of expanding gas, captured in a flywheel or driving companion cylinders**

- **Heat rejected in gasses and solids**

- **Heat losses in the processing of Catalysts**

- **Heat losses to the separation of products**

- **Reactive energy of pure Hydrogen**

THE CHALLENGE

Through experimentation and modeling, find the optimum parameters to drive this reaction, resulting in a net production of energy. Retaining as much momentum and heat to maximize efficiency. Minimize or eliminate the production of Greenhouse Gasses. Once accomplished, integrate the process into Fuel Cells, or Hydrogen Combustion.