Pressured Electrolytic Cell for Improved Loading

TECHNICAL AREA:

This disclosure teaches an electrolytic cell that utilizes closed-cell electrolytic technology with carefully selected electrodes for hydrogen or deuterium absorption and is adapted for higher efficiency and large-scale applications by means of pressurization. Different configurations make use of various heat exchange mechanisms for the generation of electricity from heat.

BACKGROUND:

A traditional electrolytic cell consists of two electrodes, an anode and a cathode, submerged in an electrolytic solution of water and typically a salt. A voltage is applied across the two electrodes to decompose the water. The decomposition of water separates the hydrogen atoms from the oxygen atoms and creates hydrogen gas and oxygen gas which bubble to the surface of the electrolytic solution. In an open cell, the gases escape or are channeled away from the cell. In a closed cell the gases are retained and the pressure builds up, but only to a limit determined by the production of the hydrogen gas from the electrolysis.

EXISTING TECHNOLOGIES:

US Patent 3652431A describes pressurized electrolysis for the production of H_2 and O_2 gases, whereas the present disclosure teaches a use of electrolytic cells different than normal, e.g., using it to load a hydrogen absorbing material.

PROBLEMS WITH EXISTING TECHNOLOGIES:

When a hydrogen or deuterium absorbing material is used for one or both of the electrodes, loading of the electrode during electrolysis can occur due to the presence of an applied voltage and the creation of ions during electrolysis. The loading of the hydrogen or deuterium in electrolytic cells is typically limited by the applied current, increasing with increasing current up to a critical point where it starts to decrease with further current increase. Some closed-cell electrolysis has been done that introduces pressurized gas, but with limitations due to electrolysis equilibrium i.e. introduction of product gases alone drives the reaction in the reverse direction (*Reference - Electrolytic cell w/ pressurized D2 gas*).

SUMMARY OF THE PROPOSED SOLUTION AND THE ADVANTAGES THE PROPOSED SOLUTION PROVIDES:

This disclosure describes an electrolytic cell which is externally pressurized to increase the loading of the hydrogen or deuterium into the reactant electrode. The pressurization of liquid allows for a safer design while increasing the efficiency of the reactor by decreasing the voltage required for electrolysis as the pressure increases; this occurs by decreasing the size of the gas bubbles formed in the solution at the electrodes which decrease the resistance and therefore decrease the voltage required for the electrolysis. As the resistance decreases, the voltage required also decreases, but this competes with an increase in pressure causing an increase in the voltage required according to the equation ($E=\Delta G/nF$), and the Gibbs Free Energy Equation ($\Delta G = \Delta G^o + RT \ln Q$, which will increase as the increase of partial pressure of hydrogen and/or oxygen). Finding a pressure range that balances the two competing factors allows for optimal operation of the cell and increased hydrogen or deuterium loading into the absorbing electrode.

A second method of pressurization with gas also works to encourage loading of hydrogen or deuterium at one of the electrodes by pressurizing a separated cell with a hydrogen isotope and nitrogen.

DETAILED DESCRIPTIONS OF THE PROPOSED SOLUTION AND FIGURES:

In this invention, an electrolytic cell is pressurized to encourage loading of the hydrogen isotope into the reactant electrode. The pressurization allows the reactor to reach a high temperature without the need of an external heating source. Additionally, triggering mechanisms are introduced to the reactor, e.g. optical, acoustic, electromagnetic.

The triggering mechanism can vary and can include multiple configurations of one type. An example electromagnetic triggering mechanism is a magnetic coil that surrounds part of all of the cell. The coil can be constant or pulsed, and there is an optimal range of frequencies to operate the coil in. An example optical triggering mechanism is a laser. One or multiple lasers can be used, and there is an optimal range of wavelengths to operate the laser(s) in. An example acoustic triggering mechanism comprises a port built onto the cell that allows an ultrasonic wave generator to be attached. A range of frequencies can be cycled through or an optimal frequency may be selected. Any of these triggering mechanism types can be used in the following embodiments.

In the embodiment shown in Figure 1, the cell is partially separated to allow for pressurization at each cathode with a different gas. The electrolytic solution still remains connected, and thus each side must be pressurized equally. At the electrode where hydrogen or deuterium gas is produced, the partial cell is pressurized with hydrogen or deuterium gas, respectively, to encourage loading of the absorbing electrode. At the electrode where oxygen gas is produced, oxygen is continuously removed and the partial cell is pressurized with-nitrogen gas to achieve pressure balance with the hydrogen partial cell. A membrane is placed in the oxygen partial cell that allows preferential passage of oxygen to effectively reduce the partial pressure of oxygen and, therefore, promote the electrolysis reaction. The removal of one of the products coupled with the increase in overall pressure, drives the electrolysis forward and improves the efficiency of the cell, while the pressurization of one of the partial cells with hydrogen or deuterium gas allows for better loading of the absorbing electrode. A catalytic recombiner is placed in each partial cell to allow for the recombination of any hydrogen/deuterium gas and oxygen gas.

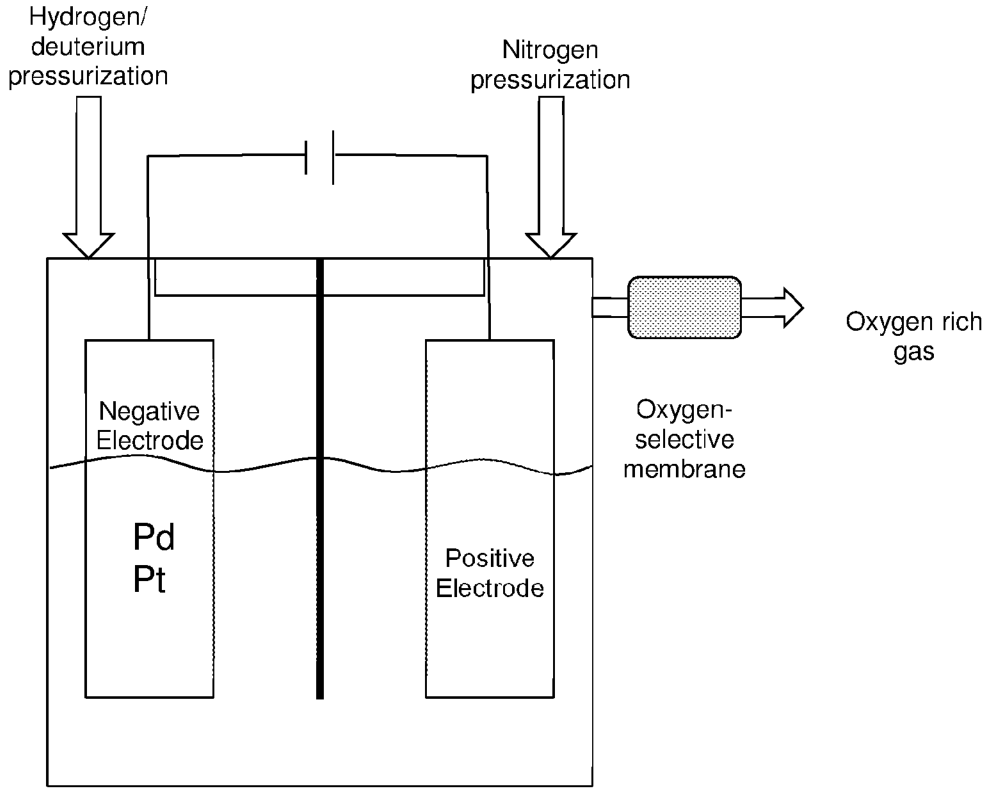

Figure 1: Schematic of gas-pressurized, partially-separated electrolytic cell

In an embodiment shown in Figure 2, a cylindrical reactor vessel is capped at each end. The electrodes inside the reactor are in electrical contact with the caps to allow for an applied voltage differential while the remaining reactor is electrically insulated. The system contains a pump to pressurize the electrolytic solution. A window is built into the side wall of the reactor vessel to allow for optical triggering of the reaction, e.g. laser. Additional triggering can be applied either around the reactor vessel such as with an electromagnetic coil or through an appropriate window.

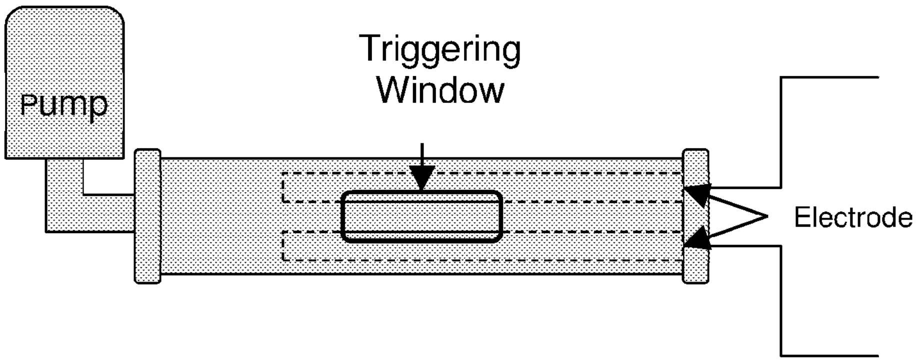

Figure 2: Schematic of cylindrical pressurized reactor vessel with triggering window

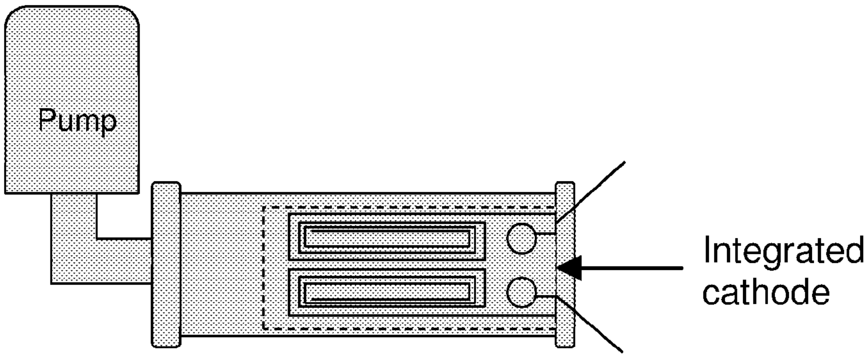

Figure 3: Schematic of cylindrical pressurized reactor vessel with PCB-style electrodes

In the embodiment shown in Figure 3, a capped, cylindrical reactor vessel is used with no triggering window. Heat exchange fluid flows over the vessel to transfer the generated heat farther down the system. Multiple reactor vessels may be used in conjunction and cooled with the same heat exchange fluid, as shown in Figure 4.

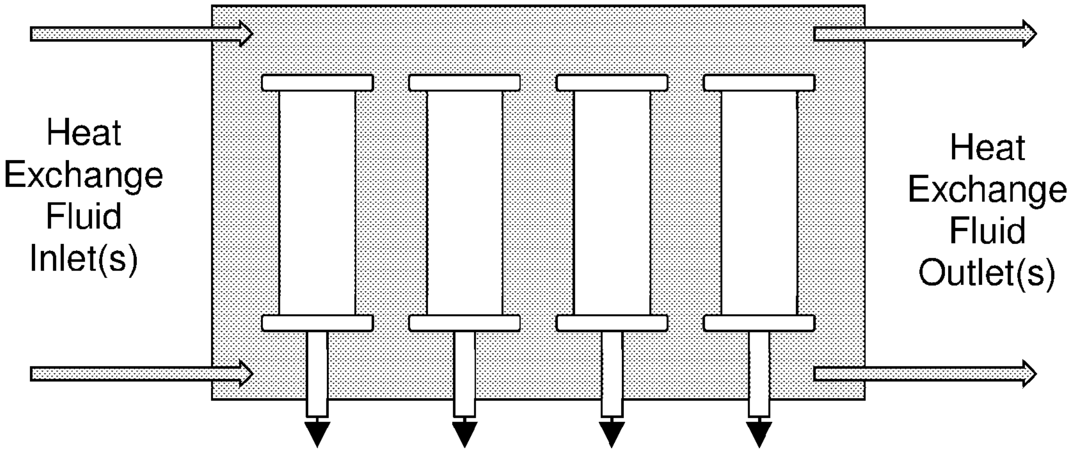

Figure 4: Schematic of multi-reactor setup with heat exchange

In the embodiment shown in Figure 5, the fluid in the reactor vessel is allowed to flow and serves two purposes: 1.) as the electrolytic solution and 2.) as the heat exchange fluid. The pressurized fluid circulates from the reaction vessel, where it is exposed to the electrodes and the triggering mechanism(s) is introduced, out to a heat exchanger.

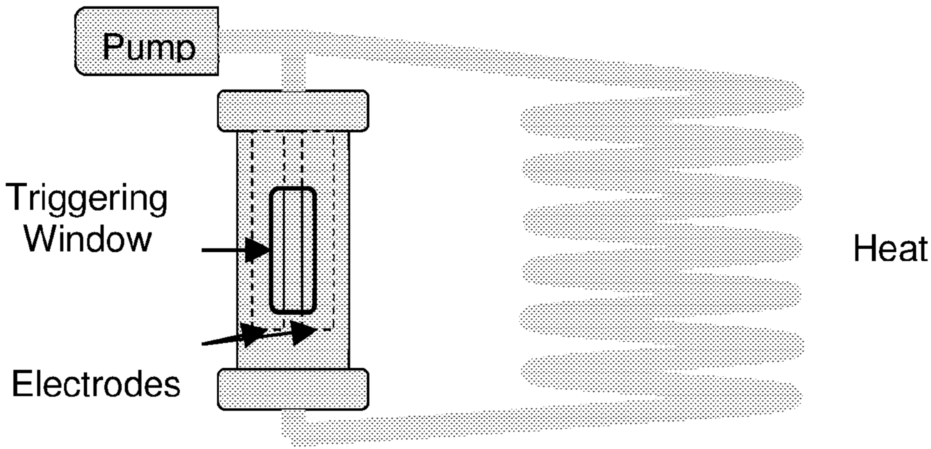

Figure 5: Schematic of free-flowing pressurized reactor/heat exchange fluid