4. Cold Fusion Demonstration Experiment

Previous blogs have indicated that many scientists have been working on cold fusion since its discovery in 1989, due to the amount of energy that can be produced per reaction compared with chemical reactions. Some have been able to develop rudimentary prototypes that demonstrate energy production and/or reaction products, such as helium. The purpose of this blog is to proceed down a parallel path to advocate design for a test device that is an amalgamation of earlier concepts reported in the literature and should, therefore, be possible to be used successfully in cold fusion demonstrations. Successful prototype demonstration can subsequently be extended for greater outputs.

About two dozen theories were proposed by the mid-1990s to explain how cold fusion could occur. Cold fusion theory today is still in about the same place in that it lacks firm understanding. Experimental results in science and engineering, however, frequently precede theoretical understanding. From experimental results over the last 20 years, scientists have been able to conclude that the cold fusion reactions must occur in the extremely small, linear defects, cracks and crevices of the cathode reaction material, rather than in perfect bulk material devoid of defects as previously thought. This appears to be important for cathode design and development. Scientists then theorized that cold fusion reactions in the cathode are caused by the small, high frequency vibrations of atoms in the cathode material interacting strongly with electrons of adjacent deuterium and hydrogen atoms in the defects. The atomic vibrations are called "phonons" and have energies and vibration frequencies related to temperature of the cathode material. As few as 10^{15} atoms reacting per second should produce about a kilowatt of power. So, some researchers suggested that the deuterium or hydrogen atoms should be able to be provided by high pressure deuterium and hydrogen gas directly, rather than relying on the more common practice of liquid electrolysis with heavy water (D_2O). High purity deuterium gas can be obtained from Advanced Specialty Gases in Reno, NV [https://www.advancedspecialtygases.com] and other suppliers. High purity hydrogen is usually available from local suppliers.

Design Background
An amalgamation of these concepts was used in designing the test device in Figure A. The cathode is made of consolidated nickel powder containing a great many microscopic-sized cracks and crevices. The device contains a heater that enables the cathode to be heated to high temperature, and uses high pressure deuterium and hydrogen gases rather than liquid D_2O. Readers of this blog are encouraged to compare these features with similarities on the web, e.g., in: (1) "Energy Generation and Generator by Means of Anharmonic Stimulated Fusion," by S. Focardi et al., August 3, 1995 (WO 95/20816); (2) the Hyperion system designed by Defkalion Green Technologies, S.A. in Athens, Greece; (3) "Method and Apparatus for Carrying Out Nickel and Hydrogen Exothermal Reactions," by A. Rossi, January 13, 2011 (US2011/0005506A1); and (4) "Method for Production of Renewable Heat Energy," by Gyorgy Egely, April 10, 2014 (US2014/0098920A1).

INSERT FIGURES A-D HERE

Construction
The cathode where the reactions are to occur has an approximate volume of 200 cm^3, is 4 inches long, has an inner diameter of 1.5 inches and an outer diameter of 2.5 inches. It is inside a stainless steel pipe that is 8 inches long, has an inner diameter of 2.5 inches and an outer diameter of 2.906 inches. Each end of the pipe (about 0.5 inch) is threaded so as to be joined to the pipe extensions in Figures B and C. Small gaps at the joints help to reduce heat from traveling from Figure A up into Figure B and down into Figure C. Threaded insulator couplings are used to join the pipe extensions in Figures B and C with the pipe in Figure A.

Cartridge heaters can be obtained from Dalton Electric Heater Company in Ipswich, MA.
[http://daltonelectric.com/index.php/product-data/cartridge-heater-sizes] Figure A shows a cartridge type of heater that is also able to serve as anode in the center of the cathode because its outer sheath is electrically isolated from internal heating coils. Importantly, the heater is not operated and its electric circuit is isolated while high voltage

(approx. 1000 volts), low current electricity is applied to the anode. The hot section of the sheath has a length of 4 inches and an outer diameter of 0.5 inch. A puller plug on the upper end of the sheath is used to attach the high voltage anode wire. On the other end is a one-inch long unheated section and flat flange for mounting the heater. Power for the heater is provided by two wires from this end. The flange is mounted to a ring type of insulator that contains holes so that gas can flow through it into the space between the cathode and anode/heater. The anode wire travels through another ring insulator above the heater. The manner in which these insulators are secured to the surrounding pipe is not shown. An additional ring insulator is used to support the cathode.

The outer part of the device consists of a flow calorimeter with an internal fluid volume of approximately 2 liters. It is made from a 6 inch long piece of stainless steel pipe with an inner diameter of 6 inches and outer diameter of 6.56 inches. Top and bottom of the calorimeter are made of stainless steel disks welded to the ends of the pipe and to the inner pipe, while still exposing threads to mate with Figures B and C. The calorimeter contains spray nozzles that are exercised when needed for rapid cooling. It contains thermal sensors and inlet and outlet pipes for adding and removing water need for thermal measurements with the calorimeter.

Electric connections are made to the anode and heater, and high pressure deuterium and hydrogen gases are provided through the pipe extensions depicted in Figures B and C. The pipe extensions provide easy access to gas ports and enable feedthroughs to operate at relatively low temperature. High pressure feedthroughs can be obtained from Solid Sealing Technology, Inc. (SST) in Watervliet, NY .
[http://www.solidsealing.com/parts/category.cfm?pcid=6&dist=0]

Figure D depicts the basic experimental device connected with the two pipe extensions. A tight fitting, high-Z tungsten metal energy shield and thermal insulation fabric layer are also added around the calorimeter. The energy shield converts some of the radiation produced by the cathode into heat adsorbed by the calorimeter. Thermal insulation is needed to ensure that heat is retained in the calorimeter, and increases accuracy of temperature determinations. Tungsten parts are available from Midwest Tungsten Service in Willowbrook, IL [https://www.tungsten.com]; thermal insulation fabric is available from many sources on the web.

Assembly and Operation

Before installation of the cathode, heater and insulators, great care is required to cleanse the internal metal body of the device and pipe extensions in Figures A-C of any residue and organics used in manufacture and assembly of the parts. Steps of inspection also ensure that the cathode, heater and insulators are not contaminated. Parts must subsequently be handled with clean gloves. After inspection, the gas supplies and vacuum system are connected to ports in the pipe extensions. Thermal and pressure (not shown) sensors and power for the electric heater and high voltage anode source are connected. Control and measurement software is loaded into its computers and exercised to demonstrate that all operations can be appropriately performed. The computer/data acquisition system should be set to record data continuously (e.g., each second) from current and voltage sources and temperature and pressure sensors.

Subsequent steps should be from behind a suitable safety shield according to standard laboratory procedures and include the following. A vacuum is pulled on the system and power for the heater is turned on in an attempt to remove oxygen from the system. The device should be subjected to a sequence of vacuum and high temperature cycles, and the system allowed to bake out until no further pressure changes occur. Care is needed to limit heater power to less than its standard operating power rating. The sequence of steps from this point vary according to experimental objectives. After power is removed from the heater and the device allowed cool, pressurized deuterium gas is added and pressure readings recorded over time to check for leaks. If no leaks are found, additional deuterium can be added to reach approximately half of its operation pressure. Pressure readings are again recorded to check for leaks. Readings are also monitored to determine loading of the cathode with deuterium gas; and, loading steps are repeated as needed. After sufficient loading, the cathode would be subjected to high temperature from the heater. The spray nozzles would be cycled briefly to cool the inner surface of the calorimeter, and hence the outer part of the adjacent cathode. These loading steps are repeated as additional deuterium and/or hydrogen are loaded into the cathode. Water flow through the cathode is established and the rate adjusted to ensure that it does not cool the adjacent cathode below its operating point. At this point, measurement of heat generated in the cathode can be made with the calorimeter. Also, small samples of reaction product gases can be extracted through one of the ports and subjected to isotopic analysis.