TALES FROM THE LABORATORY OF EXPERIMENTAL PHYSICS Part 1.

Recent LENR Research In Ukraine And Russia. By Alan Smith.

This article –more accurately an attempt at clarification with limited commentary - is closely based on extensive information available in English at http://tet.in.ua/index.php/en/. However, much of the material there is concerned with describing and discussing the work of Andrea Rossi and Alexander Parkhomov, and since it will be familiar to most readers here, I have ignored that material and confined my comments and observations to the innovative work carried out over the last 3 years by Andrew Hrischanovich and colleagues at the Laboratory of Experimental Physics, Zaporozhye near Kiev, Ukraine and by others based at their sister laboratory in Moscow. For those that ponder motives (pun intended) my aim is to clarify and condense the work of the group. I apologise in advance if my unpick and re-knit attempts have led to any errors of fact or interpretation.

BRIEF HISTORY OF GLOW/CORONA DISCHARGE EXPERIMENTS.

It has been known since the first experiments in 1932 by Rutherford – and subsequently by Cockroft and Walton - at the Cavendish Laboratory (Cambridge UK) that passing an electrical discharge through gas at low pressure produces charged atoms and molecules A large number of protons can be easily obtained by passing a current through hydrogen, and likewise deuterons produced from deuterium. In order to give them greater speed, and thus energy, particles were exposed to a strong electric field by establishing an electrical potential gradient inside the test chamber.

Rutherford and Co. showed for the first time that transmutation of lithium and boron targets could be achieved by bombardment with protons and deuterons using an accelerating voltage of only 100kV. This transformation was accompanied by the appearance of helium nuclei, with a significant energy release calculated to be 128 times greater than the power required to initiate the collision. While this sounds exciting, it is not a useful method of producing energy due to the low collision cross section of lithium and boron. For every 100,000 accelerated protons or deuterons, only one enters a target metal nucleus.

MORE RECENT WORK.

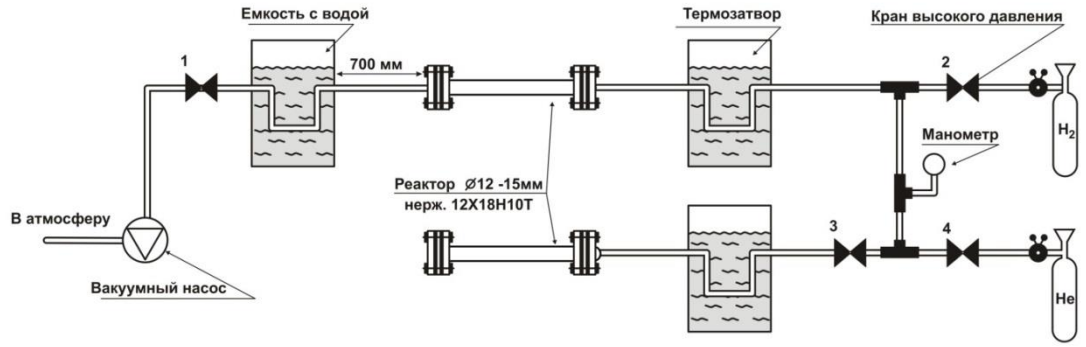
In the early 1990's Karabut and co-workers(Karabut, A. B. , Kucherov et al 1992; Savvatimova, I. , Kucherov et al 1994) at LUTCH in Russia studied gas discharge in Deuterium at potentials between 100 and 500 Volts. They detected heat, radiation, and transmutation products and an increase in helium of between 4 and 100 times background. Heat production as well as transmutation products were detected during later work, but a quantitative relationship was not established.

They investigated elemental and isotopic shifts in a Titanium cathode before and after irradiation by glow discharge in Deuterium plasma on the sample that showed excess heat. Irradiation was performed with Deuterium ions at a discharge voltage below 1kV at currents of 10-20mA resulting in anomalous heating of the small (0.7g) Titanium target. Further experiments using Mo, W, Zr target materials showed no positive thermal effects.

Over the last 3 years the Laboratory of Experimental Physics (LOEP) has built several plasma reactors to study interaction between Hydrogen plasma and a Titanium/Titanium Hydride cathode. Early experiments showed that when electricity was passed through the cathode, Hydrogen began to evolve from the Hydride at temperatures below 70°C. Upon further heating, the target temperature rapidly rose to 300-400°C and Hydrogen desorption accelerated. Additional experiments were performed with the Hydride powder in a quartz tube containing electrodes. When AC or DC voltages of 220, 300, 2kV and 7kV were passed through the tube, a spark discharge was visible between the powder and the Hydrogen atmosphere. These studies were conducted with the aim of selecting the optimal voltage, current type (AC or DC) and finding an optimal reactor geometry.

Before setting up our laboratory studies on metal-Hydrogen interactions (Ni, Ti, Fe.) a task completed in November 2012, we studied research on this topic published by many institutions and laboratories. These showed anomalous physical phenomena leading to excessive heat generation were not uncommon. Because of the huge cost of nuclear diagnostic equipment we decided to make 'excess' heat the main focus of our study, and to use the methods of classical physics (measurement of pressure, temperature, reaction volume, etc.) to identify surplus energy.

FOR THIS RESEARCH WE DESIGNED A TWO-REACTOR TEST-BED.



The second reactor is loaded with Titanium Hydride, which when heated to 500-600 degrees emits 99.9% pure Hydrogen at pressures up to 10Bar. Pure Hydrogen gas is essential for the powder absorption and activation tests in the first reactor. Commercial-grade Hydrogen (the cylinder shown in the diagram) may be used, but initial activation of Titanium powder needs pure Hydrogen. Incidentally the Titanium was pre-annealed at 500-600C in a vacuum oven to eliminate any oxide film. Please note we use commercial-grade Hydrogen for two reasons. Firstly the 10X higher cost of purer gas, and secondly because of cost a real scarcity of storage cylinders for it. The Helium tank also shown is to provide gas for leakage testing under pressure, and to purge air from the system without requiring high vacuum de-gassing of the reactors.

Thermal barriers were not deemed necessary in the system since the thermal conductivity of the 12X18H10 grade stainless steel used is very low. For example, the reactor is 550mm long and 12mm outside diameter. If the central zone of the reactor was at 650C the ends of the reactor (at inner flange) were measured at 200-250C.

After testing various kinds of O-rings (aluminium, PTFE) between the reactor flanges we settled on using PTFE throughout. Gas tightness of PTFE sealing rings is better, and the thermal conductivity much lower than Aluminium. Under test PTFE flange rings withstood reactor tube central zone temperatures of up to 600 degrees. The PTFE surface appears to be

coated with a thin film but without apparent loss of performance. (Editor's note. Caution! Heat-degraded PTFE can degrade releasing oily Hydroflouric Acid which can give rise to ulcerating skin burns which are very hard to treat.)

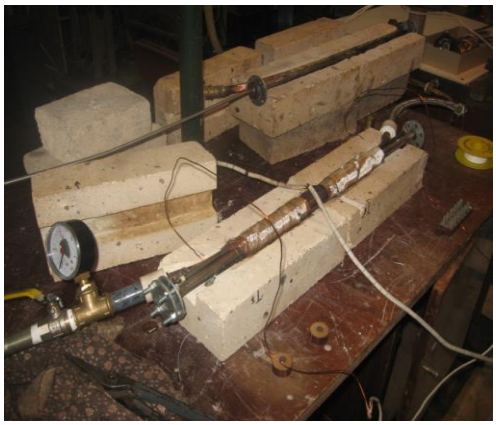
In all experiments, the temperature of the outer flange was only just above ambient when the temperature of the 100mm long active zone was 650-800C. We found no necessity in practice to use very long (up to two meters, which was done for security purposes) inlet tubes. It is worth noting that the inner surface of the flanges must have O-Ring grooves as can be seen in the photographs below. In our first reactor this was not done and even using high temperature sealant, there was a hydrogen leakage problem at room temperature and pressures up to 5Bar.

REACTOR GEOMETRY AND CHOICE OF MATERIALS.

The use of stainless steel is essential because this material is not very prone to Hydrogen embrittlement and has low permeability for Hydrogen at temperatures up to 1000C. Our choice of a long thin tube for the reactor is to exploit the low thermal conductivity of stainless steel to reduce heat transfer and consequent loss of heat developed by the materials under test Also the smaller the inner diameter of the reactor, the higher the rate of thermal transfer between the working powder and the inner surface of the reactor. It is better to design your reactors with a smaller diameter and greater length and increase powder volume that way than seek equal reactor capacity by building a shorter, fatter one with consequent larger

radial distance from the inner layers of 'hot' test powder to the reactor wall. Experiments and experience gained by building our systems suggests that reactor diameters above 20mm are impractical.

For these reasons we chose a reactor length of 550mm, an OD of 12mm and wall thickness of 1.5mm. A heat-sink was made from 12mm copper pipe with PTFE adapters was used to ensure normal working temperature of hydraulic valves and connecting hoses. In the first build we used four thick copper wires to improve heat transfer, between the two heating elements and the reactor and copper pipe, all wrapped in 0.4mm copper foil and overlaid with glass/asbestos wrapping tape. This can be clearly seen in the pictures below.



Next we connected a 4-way hydraulic system. This allows for direct flow of cooling water through two reactors in series, parallel or individually.

INSTRUMENTATION

Four thermocouples - two for each reactor, one on the reactor wall and the other on the cooling copper pipe reading to 350C max. Radiation detection was by 'Terra P' household dosimeter "Terra-P" Eco-test company (Kyiv). We also deployed high and low pressure balloon reducers, vacuum gauge and pressure gauge reading up to 2Bar.

V/A meters of the regular kind recorded the electrical power consumption of the reactor heaters. We fitted two heaters per reactor because we discovered that the elements are not happy working under an insulating blanket and were prone to failure. In this case, without dismantling the system electric power can be supplied to the reserve heater immediately.

PRELIMINARY RESULTS.

The first control runs (empty) showed clearly that without the presence of powder in the reaction chamber overall efficiency of the heating system was 50%. This large loss is due to heat escaping through 'windows' in the refractory brick, heat conducted through the bricks themselves, and heat lost at the edges of the cooling copper pipes and via the metal-braid covered hoses – all of which can be considerable when heating the system at up to 500C. When water inside the cooling circuit boils, steam passes into the buffer tank too – something to be avoided. Knowing the nature and amount of all the various heat losses we felt confident about continuing to experiment and research the essence of the processes under investigation.

The first test run was with Nickel powder. Lacking prepared Nickel powder we made our own by circular-sawing thick Nickel sheet and separating the finer dust fractions. Since Nickel increases in volume up to 30-40% when hydrogenated we reduced the powder load to allow for expansion. Both ends of the reactor had stainless mesh screens to confine the powder in the central zone. We loaded 70 g of powder and by shaking tried to distribute the powder throughout the available reactor volume. After evacuation of air we introduced pure Hydrogen produced by heating the second reactor, which contained 30 g of titanium hydride. We have not yet accurately measured temperature rise during the first introduction of Hydrogen. Multiple attempts to activate the Nickel powder gave no significant results. The saturation temperature (?) of pure Hydrogen was adjusted to 500C. at a pressure up to 3 atm. We also supplied high pressure commercial Hydrogen from the cylinder at pressures up to 8 Bar. Special effects were observed (sic) but this series of Nickel tests were inconclusive.

Pure Titanium powder appears to be a more responsive material. The loaded reactor is capable of holding 42 grams of Titanium powder. Ti shows less increase in volume during hydrogenation than Nickel, but in order to avoid breaking the reactor we restricted the load to 30 grams of powder. The heater power was 750 watts and heater length 380mm. Checks showed that temperatures in the reactor central zone (about

100mm long) rose to 640C, falling to 380C at each end. This implies that only one-third (10grams) of the powder was heated effectively.

The first step was to anneal the Titanium powder at a temperature of 500 degrees under vacuum (we used a modified refrigerator compressor as vacuum pump achieving a pressure drop to 0.9 mBar.) Then we periodically introduced pure Hydrogen from the secondary reactor to increase the rate of destruction of the oxide film and re-evacuated each time. At the end of this process we activated (hydrogenated) the powder. Hydrogenation level is easy to check. The reactor is heated from room temperature we see an increase in pressure of up to 5Bar in the system when the temperature rises above 550 C, at which point desorption of Hydrogen from the Titanium begins. If we now switch off the heating and without pumping cooling water allow the temperature to drop slowly over 20-30 minutes the pressure drops back to the start level. Our method is to compare the process of cooling the reactor over time with and without Hydrogen under pressure in the system. Further experiments varied the mix of pure Hydrogen (from Titanium Hydride) and the relatively impure commercial bottled gas at up 8Bar and temperatures of 300 to 600C. We also varied the temperature of the powder at the moment of initial exposure to pure Hydrogen. Before each experiment, especially those at temperatures above 300C the system was double-checked for leaks using pressurized Helium. We used inert gases for this because any Hydrogen leaks from the system during pressure-testing were considered to be detrimental to the safety of personnel. During runs we require the presence of a staff member next to a fire extinguisher and close by the emergency power breaker switch.

When heating the reactor to 300-500C with Hydrogen present there was –discouragingly - no strong heating of the reactor. According to pubished research hydrogenating Titanium powder under these conditions should raise the powder temperature to 800C. In these tests, Hydrogen pressure fell slowly and the obvious signs of absorption occurred. This slow pressure reduction we realise could indicate adsorption and/or Hydrogen leaking from the reactor which could occur at such high temperatures.

Everything changed changed after we started pumping cooling water though the copper pipe surrounding the system.

Editors Comment: Here I confess the description of events following the introduction of cooling water both complex and confusing. If you have doubts about the accuracy of my interpretation, I can only suggest you refer to the source document.

With water present in the cooling system for the first time the reactor temperature rises above 100C. After having reached the temperature inside the "dolls" above 100 degrees and the water can be heard boiling and steam and hot water escapes vigorously with a loud hissing noise. We allow this water to boil away and when it is gone there is a swift rise in temperature to 550C. The Titanium hydrogenate gives up its Hydrogen, and the reactor internal pressure quickly goes up to 6-8Bar maximum. At this point we release pressure to reduce stress on the system- we do not delay doing this, because the thermal inertia of the system means that pressure will keep rising fast.

If at this stage the reactor is cooled further (to 200-300C) by allowing more water to flow through the copper water-jacket, re-adsorption of the Hydrogen takes place slowly over 5-6 minutes. It should be noted that admission of cooling water needs to be done carefully, otherwise there is a sound of sharp 'steam-hammering' in the pipes and considerable thermal stress on the reactor walls. This is potentially one process which could cause an accident, but happily our 'continental aircraft pump' is perfect for controlling water flow.
Here another cycle begins. Pressure –which now may be as high as 8Bar falls back to zero as indicated by the pressure gauge. Then, with a delay of just 1-2 sec the temperature rises very sharply again from the original 200-300 degrees. This surprising experiment was reproduced 6 times to identify the optimum temperatures to start cooling, and what was the best temperature to cool down to.
It was also established that if the system was pressurised from the external Hydrogen cylinder to 15-20Bar, the rise in reactor temperature may not stop at 600 degrees. There is a need for much more research into ideal system powder volumes, and the optimal handling of temperature and pressure to maximise the effect.

FACTS AND FIGURES.

Total internal volume of the reactor = 92.2 c.c. A small amount of unfilled space was present during the 'powder' tests.

Hydrogen used in the experiment based on the 'ideal gas equation of state. (Mendeleev - Clapeyron.) $P * V = n * R * T$'.
Where P = Pressure in Pascal's. R = 8.314 universal gas constant. T= Temperature ^{o}Kelvin. V = Volume in CM_3. n = Amount of gas in moles.

Using this formula, we find at 600 degrees and a pressure of 5Bar, the weight of hydrogen is only 0.012g = 0.139L. In a separate test and measurement at room temperature with a system pressure of 5Bar, we received 0.6L of hydrogen, while according to the formula we should have had 0.44L. This we believe is due to inaccuracy of the analogue pressure gauge.

A SMALL SETBACK (MELTDOWN!) AND A DISCOVERY.

In one experiments, the temperature after cooling jumped up sharply from 440C to 880C. Hydrogen pressure was not recorded (we were very busy at this moment) but probably no higher than 8-10 ATM. We started to pump water to cool the system, but the copper cooling tube was broken.

Photo melt the silver solders and copper pipe penetration

Steam began to escape between the bricks and… (the next part is not clear exactly)… the gaps (?) did not reach the cooling vessel. The silver-soldered connections melted (Editor's note: 750C approx) and holes appeared in the copper pipe.

This disaster taught us a lot of lessons about ways of quenching the reaction and detecting/creating the conditions necessary for generating excess heat. Truly a blessing in disguise.

Work carried out after this gave us a clear understanding of the mechanism of absorption / desorption of behaviour of Hydrogen into Titanium powder. As can be seen from the description above of our process and mechanism for obtaining additional heat from the system, we have stumbled on an important phenomenon! In particular, the role of cooling/ quenching the reactor in ways that produce a sudden burst of heat.

Most investigations of Hydrogen/Deuterium absorption looked at Nickel and Palladium and have not used water cooling (with the exception of Andrea Rossi, so it probably helped him to get results). While water quenching introduces difficulties, simple engineering enabled us to solve them.

Others have found similar heat effects however. For example, Professor Arata in Japan – a highly respected scientist - detected the presence of Helium in the reactor containing Deuterated Palladium. He determined that Palladium can saturated with Deuterium at room temperature and a gas pressure of 30Bar. He also saw a rise in temperature of the reactor from room temperature to 70-80C. An increase which persisted for some time

END OF PART ONE. Alan Smith 21 Jan 2016.