

The Potential Miscalculation of COE for Pressurized Gas LENR Systems

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Abstract:

A potential miscalculation of the coefficient of energy, or COE, for high-pressure gas-type Low Energy Nuclear Reactors (LENR) is discussed. The mechanism for this potential miscalculation is explained, and a numeric example is given to estimate the magnitude of the effect. The importance of thermodynamics to LENR systems is emphasized.

Keywords—Adiabatic Heating, LENR, Pressurized-gas hydrogen LENR systems, COE.

Introduction:

One common type of a Low Energy Nuclear Reactor (LENR) is a pressurized gas reactor, in which hydrogen gas, either ^1H or ^2d , is pressurized and placed in direct contact with a metallic sample, such as palladium or nickel. The gas is absorbed into the lattice of the metal with a high density, allowing possible fusion events to occur between the hydrogen ions. Measurements of the excess heat released by these nuclear reactions are made, and the coefficient of energy, or COE, for the system is calculated.

The parameter of COE is a measure of how much output energy is being released by the reactor, compared to the amount of input energy going into the reactor. If this coefficient is greater than 1, then this is a possible indication that nuclear reactions are occurring within the reactor. The definition of COE is the ratio of output energy over input energy, as shown in Eq. (1).

$$COE = E_{output}/E_{input} \quad (1)$$

Frequently, the calculations for COE for LENR experiments will modify the input term such that the denominator is only comparing the electrical input energy, as shown in Eq. (2).

$$COE_{erroneous} = E_{output}/E_{input_electric} \quad (2)$$

However, using only the electrical input energy to calculate COE is a potential source for the miscalculation of COE.

Examples of Miscalculated COE:

For example, consider a Low Energy Nuclear Reactor in which an experimenter charges a rechargeable battery with several joules-hours of energy, charging this battery externally to the actual LENR set-up. This energy in the battery is stored energy. The experimenter then connects this charged battery to a heater, and puts this heater inside the set-up, where it will affect the measured output heat. If the calculation of COE for the LENR set-up does not take into account the energy of this battery, then the COE will be inflated as a result. Obviously, this is not a fair determination of COE, because there is energy going into the apparatus that is not measured as input electrical energy. The stored energy in the battery is creating heat that is not being accounted for, as input electrical energy.

As another example, consider the situation wherein an LENR experimenter put a certain quantity of kerosene into the set-up, and lit a small flame to burn that kerosene, adding heat into the apparatus. The heat of the kerosene flame affects the output heat. Again, this is obviously not a fair determination of COE, since there is an input of energy going into the LENR apparatus that is not coming from the nuclear reactions of the reactor, but rather from the stored energy of the kerosene. The stored energy in the kerosene is creating heat that is not being accounted for as input electrical energy.

For a third example, consider the situation wherein a large quantity of high-pressure gas is pumped into a tank inside the LENR system. This pressurized gas is stored energy. Thermodynamics state that if a quantity of gas goes initially from a low pressure and a large volume to a final higher pressure and smaller volume, then its temperature will increase. This is called adiabatic heating, and it is simple thermodynamics.

Brief Review of Adiabatic Heating:

Adiabatic heating [1, 2] occurs when the pressure of a gas is increased and its volume simultaneously decreased, with these effects being due to some form of externally applied energy. For example, when a piston compresses a gas contained within a cylinder, external work is applied to the piston to compress the gas. As a result of this compression, the pressure increases, the volume decreases, and the temperature of the gas inside the piston rises. This type of gas compression occurs in combustion engines, and it can be understood using the ideal gas law of thermodynamics, shown in Eq. (3).

$$PV=nRT \quad (3)$$

where P is the gas pressure, V is the gas volume, n is the amount of gas in moles, T is the temperature of the gas in °K, and R is the gas constant with a value of 8.314 in standard units.

The mathematical equation for an ideal gas undergoing a reversible adiabatic process can be represented by the polytropic process, shown in Eq. (4).

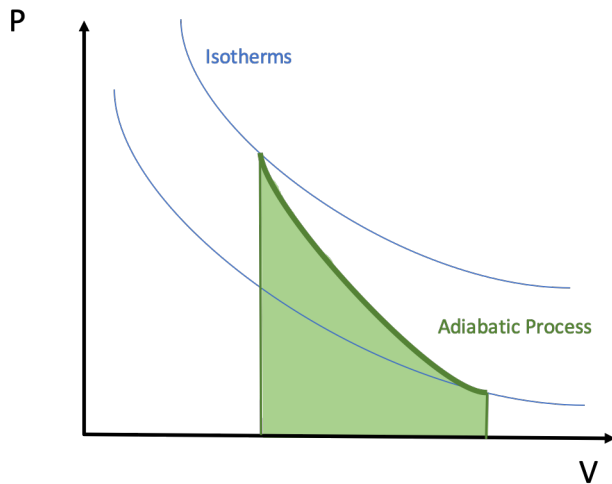
$$PV^\gamma=\text{constant}_{\text{adiabatic}} \quad (4)$$

Where $\text{constant}_{\text{adiabatic}}$ is the adiabatic constant, γ is the adiabatic index--which is the ratio of the specific heat for constant pressure, C_p , over the specific heat for constant volume, C_v . The adiabatic index can also be expressed as a function of the number of degrees of freedom, f, within the gas, as shown in Eq. (5).

$$\gamma = \frac{C_p}{C_v} = \frac{f + 2}{f} \quad (5)$$

where f is the number of degrees of freedom. For a di-atomic gas, the number of degrees of freedom is 5. Thus for a deuterium or hydrogen gas, γ is 7/5. The above formulas are applicable to classic ideal gases (that is, gases far above absolute zero temperature.)

For an ideal gas, Figure 1 shows the simple adiabatic process. As the volume of the gas decreases, the pressure increases, and its temperature rises. The area under the adiabatic curve, shown in green, is the energy required to compress the gas. (If the adiabatic process is going the other direction, from small volume to larger volume, then the area in green is the work produced by the gas.)



For a simple substance, during an adiabatic process in which the volume decreases, the internal energy of the substance must increase.

Figure 1. The adiabatic process, in terms of pressure and volume.

Example Calculation of Compression and Adiabatic Heating:

Consider a pump that is used to pump deuterium gas into an insulated Dewar to obtain a high pressure within the Dewar. Deuterium gas is a diatomic gas, thus $\gamma = 7/5$. The initial volume of the uncompressed gas is 10 liters = 0.01 m³ at 1 bar, and it is going to be compressed by the pump, into a 1-liter volume. The uncompressed 10 liters of gas is approximately at room temperature, 300°K, and at sea-level air pressure = 1 bar = 100,000 Pa. Thus, using Eq. (4), the initial conditions before the pump does any work is:

$$P_{initial} V_{initial}^{\gamma} = \text{constant}_{adiabatic} = 100,000 \text{ Pa} \times (0.01 \text{ m}^3)^{7/5} \\ = 10^5 \times 1.58 \times 10^{-3} \text{ Pa m}^{21/5} = 158 \text{ Pa m}^{21/5}$$

Thus, the adiabatic constant for this example is about 158 Pa m^{21/5}.

The pump is used to compress the deuterium gas into a volume of one liter within the Dewar. Since the Dewar is insulated, this compression happens quickly enough that negligible heat escapes the Dewar by the time the final pressure inside the Dewar is reached; thus it is an adiabatic process. The adiabatic constant remains the same, but the resulting pressure inside the Dewar has changed to P_{final} . Solving for P_{final} :

$$P_{final} = P_{initial} \left(\frac{V_{initial}}{V_{final}} \right)^{7/5} = 100,000 \times \left(\frac{0.01}{0.001} \right)^{7/5} = 2.51 \times 10^6 \text{ Pa} = 25.1 \text{ bar}$$

The pressure increase is more than a simple 10:1 compression ratio would indicate, because the gas is not only compressed, but it is also heated. We can solve for the temperature of the compressed gas in the Dewar, using the ideal gas law of Eq. (3). Solving first for nR :

$$nR = \frac{P_{initial} V_{initial}}{T_{initial}} = \frac{(100,000 \text{ Pa})(0.01 \text{ m}^3)}{300} = 0.333 \text{ Pa m}^3 \text{ } ^\circ\text{K}^{-1}$$

Now, solving for the final temperature T_{final} :

$$T_{final} = \frac{P_{final} V_{final}}{nR} = \frac{(2.51 \times 10^6)(0.001)}{0.333} = 753 \text{ } ^\circ\text{K} = 479^\circ\text{C} = 896^\circ\text{F}$$

Obviously, this temperature is high enough to cause errors in the calculation of COE, if this adiabatic heating is not properly taken into account.

Effects of Adiabatic Heating:

Since the Dewar is not an ideal insulated Dewar, it will allow some heat to escape over time, until the Dewar reaches thermodynamic equilibrium with its surroundings. If this Dewar were inside an LENR system, then heating of the system occurs. Because the input energy going into the LENR system is more than just the input electrical energy, this adiabatic heating causes the LENR set-up to appear as if it is generating excess heat.

The characteristic signature for excess heat recorded by this adiabatic process would be a relatively rapid spike in the temperature, followed by a slower decrease in temperature, as the Dewar cools off. The exact shape of the curve would be strongly dependent on the insulatory properties of the Dewar, and on the behavior of the pressure regulator attached to the Dewar—specifically, whether or not the regulator adds more gas into the Dewar as it cools off.

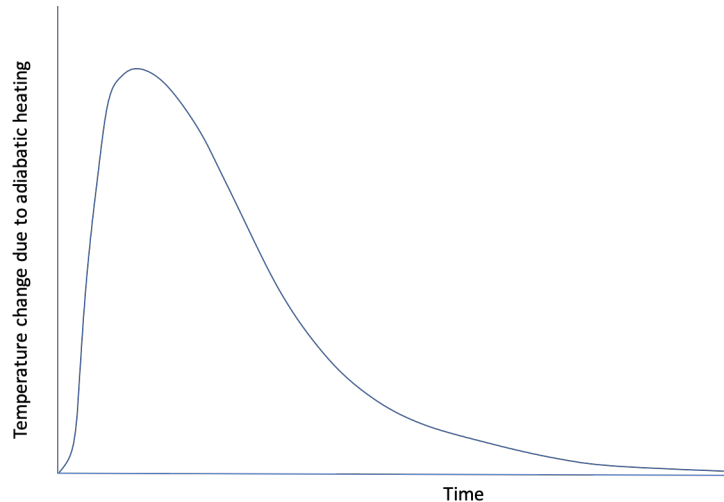


Figure 2. Characteristic temperature curve of adiabatic heating, with rapid temperature increase as the gas inside the container undergoes the adiabatic transition, followed by a slow decrease in temperature as the gas in the container cools off.

Other Variations in pressurized-gas LENR Set-ups:

Even if a large reserve tank of gas is used, instead of a pump, to input the pressurized gas into the Dewar, the effect is the same, (albeit the numbers will be slightly altered.) The Dewar will still heat up due to adiabatic heating. Minor variations of the set-up will not mitigate or abrogate the adiabatic heating.

For example, adiabatic heating is a well-known phenomena observed when filling scuba tanks. Even if the scuba tank is filled with a high-pressure reserve tank, rather than a pump, the temperature rise in the scuba tank will still occur. The scuba tank becomes very hot, which is why scuba tanks are filled in a cooling water bath to prevent the tanks from getting overheated during the filling process.

Similarly, if a Dewar is filled from a high-pressure reserve tank, the Dewar will increase in temperature as high-pressure gas flows from the larger reserve tank into the smaller Dewar. If that Dewar is part of an LENR set-up, then this energy going into the LENR system must be considered as part of the input energy when evaluating the COE.

Discussion:

Similar to the two previous examples of miscalculating COE, the situation of adiabatic heat occurring within an LENR set-up would create an error. Thus, $E_{out}/E_{input_electric}$ is not a fair determination of COE. There is input energy going into the apparatus that is not coming from electrical input energy. Rather, the input energy is coming from the stored energy of the compressed gas. In an LENR system, this would result in a false and inflated reading of COE (and COP) as a result.

This process of adiabatic heating--of releasing high pressure gas from a reserve tank into a smaller tank inside the LENR set up--is frequently done, such as for $Pd\text{-}^2d$ or $Ni\text{-}^2H$ pressurized-gas LENR systems. For such set-ups, in order to get a realistic and true reading of the actual COE, some type of inert material of similar volume and thermal mass should be placed inside the Dewar. The baseline heat measurements should be taken when the pressurized gas is released into the inert-material set-up. The temperature of the inert set-up will rise very quickly, when the gas inside the Dewar is pressured. Using the inert material of the same volume and thermal mass, measurements can then be made to determine the effect of adiabatic heating. This measurement would determine the base-line, to be used as a comparison for any actual excess heat from the nuclear reactions.

Thermodynamics is a very important consideration for all LENR systems—for both theoretical models and experimental set-ups. No viable theory for LENR can violate thermodynamics [3, 4]. Quoting from Storms [4]:

“The Laws of Thermodynamics apply to how the deuteron or hydrogen ions behave before fusion takes place. In addition, formation of the structure in which the fusion process occurs must be consistent with the

thermodynamic properties of surrounding atoms.... Consequently, neither the Laws of Thermodynamics nor behavior expected based on quantum mechanics may be violated....

“The Second Law states that energy always moves spontaneously from a higher value to a lower value. In other words, energy cannot spontaneously concentrate at a location in a material.”

(Note: extremely small energies with extremely short durations may be violated, if the product of these two variables is below detection by the quantum uncertainty principles, as is described by Vosotskii et al [5, 6].)

If an LENR experiment shows rapid peak-like heat occurring as soon as the ^1H or ^2H gas is introduced into the system, then this is a strong indication that the reactor is being heated as a result of adiabatic heating. Such experimental results should be viewed cautiously, especially if the experimenter did not run base-line measurements to subtract out the adiabatic heating.

Furthermore, any form of rapid excess temperature increases in an LENR set-up, as seen in Figure 2, should also be viewed with dubious considerations. This is because nuclear reactions, inside a controlled reactor, tend to build up slowly, growing with a steady increase of the internal chain reactions before reaching a steady state condition. Thus, rapid peak-like temperature increases in a high-pressure gas-type LENR system are most likely the effect of the characteristic adiabatic rapid temperature increases.

That is not to say that all high-pressure gas-type LENR systems have produced false readings for COE. This article does not claim that, in any way. Some of the LENR systems reporting $\text{COE} > 1$ may, indeed, be seeing the effects of low-energy nuclear reactions. This article is merely stating that care must be taken, as with for any LENR system, to account for all possible input energies when calculating COE. Experimentalists, who are using a high-pressure gas-type LENR set-up, must take into account the adiabatic heating that inevitably occurs.

Conclusions:

It is important for all members of the LENR community, both experimental and theoretical, to have a strong working knowledge of thermodynamics. Otherwise, this lack of understanding for thermodynamic processes—be it the unintentional disregard of adiabatic heating or the naive theoretical modeling of spontaneous energy increases—would cause errors.

In conclusion, thermodynamics must be considered in any and all LENR systems, both experimental and theoretical. For an experimental set-up, all external energy going into the LENR experimental set-up must be accounted for—whether it is electrical or not. Similarly, any theoretical model that violates the Laws of Thermodynamics must take appropriate steps to remove that violation from the model.

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