# IMPORTANCE OF NON-DIMENSIONAL NUMBERS AND OPTIMAL OPERATING POINTS IN COLD FUSION

Mitchell Swartz [1], Gayle Verner [1], Alex Frank[1], Hal Fox [2]

## ABSTRACT

We propose reexamination of the use of non-dimensional numbers and optimal operating points as methods to improve the performance and reliability of cold fusion systems. In particular, we suggest the use of the peak power gain at the optimal operating point (OOP), and OOPs in general, to better characterize a material and its configuration in a cold fusion system. OOPs are observed when cold fusion systems are analyzed by careful calorimetry and thermal power spectroscopy [1-7]. Driving a cold fusion system at the optimal operating point may enable increased outputs, more accurate determinations of the activity of these materials, and a better understanding of how activity changes during loading or at different locations along the input electrical power axis.

## NON-DIMENSIONAL NUMBERS

Non-dimensional numbers are ratios of several parameters such that the dimensional M,L,T, etc. all cancel leaving a dimensionless number. Where complex parameters control complicated systems, during engineering analysis it is often possible to reduce the complexities to some type of non-dimensional ratio which focuses attention to a controlling variable.

By such means, analysis then becomes something that can be measured, plotted, evaluated, etc. For example, initial investigations into fluid flow had to be satisfied with the fluid equivalent of Ohms law and other limited flow equations until such non-dimensional numbers were derived. These did enable equations which cannot be easily exactly solved [non-linear, partial differential and integral equations] to be examined closer for ultimately useful improvements in performance. For example, the Reynolds number (for pipe flow) is the ratio of fluid inertia and sheer stress due to viscosity and is dimensionless. The result is that the change from laminar flow to turbulent flow can be expressed in terms of the Reynolds Number. This concept is widely used in heat and mass transfer applications with dozens of non-dimensionless numbers having greatly clarified engineering issues in many fields.

## OPTIMAL OPERATING POINTS

The OOP is the maximum point of product production or power gain in the phase space of electrical input power. OOPs can be peak product production points (e.g. watts or moles of He-4 produced, confer Fig. 1 in "Further Confirmations of Optimal Operating Point Behavior" this issue, page XX) or can be the non-dimensional number which the power gain (Fig. 2 in the same article, also refs. 1-3). In these figures, the nickel light water data {from Swartz [1-6]} and the palladium heavy water excess heat data {from Miles [8,9], Szpak [10], Arata [11], and Storms [12]}. The optimal operating points (shown in Fig. 1 noted above) are seen in output plots of excess heat and ash production as a function of input electrical power. Figure 1 represents the superposition of many separate types of cold fusion experiments. The horizontal axis represents the electrical input power and is logarithmic. The vertical axes indicate absolute values proportioned between each cohort of experiments. The five curves

[1]JET Energy Technology, Inc., P.O. Box 81135, Wellesley Hills, MA 02481

[2]Trenergy, Inc., 3084 E. 3300 South, Salt Lake City, UT 84109

connect the operating points in the electrical power phase space for each group of experiments.

Figure 2 shows Storms' data (12) through transformations to power gain and input electrical power. The cathode, palladium IMRA sample #42, had a previous pedigree of ~4.5 watts of excess power and was reloaded in experiment. The lower curve on the right is when the sample was initially deloaded. A current of 1.5 Amperes followed and after 7 days, the optimal operating manifold is shown in the upper curve of Figure 2 [Storms' data set #18]. Storms' data, viewed through the parallax of the optimal operating point manifold, demonstrates that the manifold's peak height is time-dependant and grows on loading seen in the movement over 7 days from the lower to the upper curve [Figure 2].

The important issue is that separate low energy nuclear experiments of several systems all appear to demonstrate biphasic character of product creation and power gain [non-dimensional] as a function of applied input power. Thus OOPs appear to be characteristic general behavior for many cold fusion systems. As figure 1 and 2 herald, there appear to be similar optimal operating points for palladium-heavy water production rates of the excess heat and ash - helium and tritium. This was also observed extensively for the generated excess heat with anodes of nickel, gold, and graphite in nickel systems. Therefore, understanding the existence of these curves, and the peak of each biphasic response -- the 'optimum operating point' of each curve -- therefore seems crucial to understanding the control of these in their operational phase space.

## IMPORTANCE OF OPTIMAL OPERATING POINT BEHAVIOR

These optimal operating points are important for several reasons.
First, at the center of the optimal operating point, the peak power ratio or the peak power gain appears to be at a relative maximum and therefore driving with electrical input power beyond this operating point yields a typical falloff of the observed power ratio for increasing input power or current levels toward a power gain ratio of 1 and less. This explains many failures of operating these systems. This failure to reproduce the cold fusion phenomena may have occurred because those experimental systems may have been inadvertently driven outside of optimal operating point manifold. The biphasic behavior associated with the optimal operating point of the excess heat -- combined with the now well-known problems of achieving adequate loading of properly prepared suitable electrode materials -- may account for some of the widespread difficulties in observing the phenomena.

Second, as a corollary, because as a function of input electric power drive, there is only a narrow locus of optimal system operating points, these systems must be understood and operated correctly to work. Therefore, optimal operating points will help show the way to improving system operation and improving replication success rates.

Third, the optimal operating (OOP) points enable a meta-analysis of diverse cold fusion results, and show a commonality between the experiments.

Fourth, we have discussed in detail [1-6] the reasons for the shapes of these curves, both at low and high electrical power (or current) inputs, along with the nature of the boundary conditions. These reasons, and planning based upon them, may help understanding of the nuclear and continuum electromechanical nature of these processes. Attention to, and use of, optimal operating point curves is reasonable because impedance matching is fundamental. As electrical engineering, power engineering, antenna theory, and mechanical engineering have demonstrated, impedance matching can not only be critical but power (and its time-integrated form as energy) is the variable which should be used to follow coupled energetic systems. Therefore optimal operating points in general, and the non-dimensional power gain factor in particular, may prove quite useful in this field.

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