DISCOVERY OF "QUANTUM NUMBERS" IN THE CARDIO-PULMONARY INTERACTION STUDIED IN THERMODYNAMICS WITH FINITE SPEED

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Abstract: The paper proposes an extension of Thermodynamics with Finite Speed (TFS) to Biological Systems, with Cardio-Pulmonary System study as the first objective. It is an extremely important system in the functioning of any blood beings (including humans). For stationary states, three fundamental *state parameters* were introduced: *Heart frequency*, F_i, *Lung frequency*, F_p, and *their ratio*, R_f, in order to describe the *self-organized interaction* between them. With these new parameters of state one could also describe Processes "between" stationary states, as it was already done for several Thermal Machines by using TVF and *instantaneous average parameters* such as *instantaneous average internal energy*, U_{mi}, *instantaneous average entropy*, S_{mi}. Since the *heart* and *lungs frequencies* are proportional to the energy consumed by each of them, these two quantities „are similar" to U_{mi}. Their ratio, R_f, is also proportional to the ratio of these energies and will characterize the *interaction of the two subsystems*. Using these new parameters, an analytical formula linking the two properties was sought, by studying the experimental behavior of R_f in time. Numerous experiments have led to a very interesting and important conclusion, stating that R_f is a function of a "quantum number" N (integer). Based on the experimental findings, a new formula correlating the *Speed of Lungs*, F_p, with the *Speed of Heart*, F_i, in their *continue interaction* was "invented". This formula is absolutely essential for TFS extension to Biological Systems. It will alow to find *analytical expressions for Power and Efficiency of Heart and Lungs* as a function of a *single speed*, *Fi,* as it was previously done for a wide range of Thermal Machines (as a function of the piston speed that is the main parameter in TFS). Designers can now use these analytical formulas for more efficient and optimized design of artificial hearts and lungs customized for each patient.

Keywords: "Quantum Numbers" in the Heart-Lungs Interaction, Thermodynamics with Finite Speed, Cardio-Respiratory System, Self-organization of Heart-Lung Interaction, Quantum Formula of the correlation between Heart and Lung Frequencies, Stationary States and Processes with quantum jump in the Cardio-Respiratory System.

1. INTRODUCTION

Once *Finite Speed Thermodynamics* (FST) [15] *and the Direct Method* (DM) [15, 17] *validated* for Classical Stirling Engines and Solar Stirling Engines [7-15, 26-28], its extension to refrigerating machines study [17, 29] provided an analytical formula for the *isentropic efficiency of a compressor working with vapor* [17, 29]. As Stirling machines are *closed systems*, and compressors and internal combustion engines are Closed / Open / Closed systems, this achievement is part of the trend of extending FST to *Open Systems*. The present work tries to extend FST and DM to other open systems, this time apparently to a completely different domain, namely to biological systems.

Thus, optimizing the cost of transport facilities tree [1, 2], it was found that *blood vessels are naturally optimized* in animals, birds, fish and humans in the Cardio - Respiratory - Internal Organs - Brain - Muscle. Then, the question raised was whether one can extend Finite Speed Thermodynamics (FST) or / and Finite Time Thermodynamics (FTT), or both of them unified [4, 41-43, 54-56, 60] to the study of Cardio Respiratory system [3, 5, 6]. The analogy with Thermal Machines consists of considering the heart as a "*liquid pump with valves*" (Open / Closed / Open System) and *lungs as an "air compressor"*, so *two "thermal-biological machines" in continuous interaction*.

2. USE OF CONCEPTS FROM FINITE SPEED THERMODYNAMICS (FST) IN EXPERIMENTAL STUDY OF HEART-LUNG INTERACTION

Similar concepts to those used in Finite Speed Thermodynamics were introduced in the study of Cardio Respiratory system. Thus, corresponding *instantaneous mean state parameters*, namely F_i = *frequency of* Heart and F_p = *frequency of Lung* will characterize the stationary (or quasi-stationary) states of the heart and lungs, subsystems in continuous interaction in the Cardio-Respiratory System. Then the *ratio of these frequencies*, $R_f = F_i / F_p$, is introduced to characterize the *interactional state* between these *two oscillating subsystems*, heart - lung. These "instantaneous mean state parameters" adapted from the analogy with Finite Speed Thermodynamics [12-16, 21, 23-40], were further used in thousands of experiments that involved their measuring in different regimes (steady state regimes) corresponding to various positions of the body: horizontal (in bed), on chair, vertical (standing), moving horizontally, moving up and down stairs. The aim of these experiments were to find a formula for the frequencies ratio, R_f, depending on various parameters (position as steady state, or before/after the position change).

Firstly, it was found that R_f is an integer in many stationary states (and quasi-stationary) equal to 3, 4, 5, 6, 7, 8 ... or half-integer, such as 2.5; 3.5; 4.5; 5.5; 6.5; 7.5; 8.5, ... Based on these results, "first quantum formula" for heart-lung interaction was proposed as:

$$F_i = F_p \cdot (3 + N/2);\ N = 0, 1, 2, 3, 4, 5, 6, 7, 8, \tag{1}$$

where $3 = R_{fo} = F_i/F_p$ = *frequency ratio at the awakening of SP every morning*, (based on thousands of experiments / measurements for the last three years). Thus, R_{fo} is for SP "fundamental steady state after night sleep". Note that for particular conditions, i.e. during summer, near a swimming pool with thermal water, the ratio $R_f = F_i/F_p$ can be even less than 3 (ground state ratio), i.e. it can be 2.5. Therefore relation (1) was corrected as follows:

$$F_i = F_p \cdot (3 \pm N/2);\ N = 0, 1, 2, 3, 4, 5, 6, 7, 8 \tag{2}$$

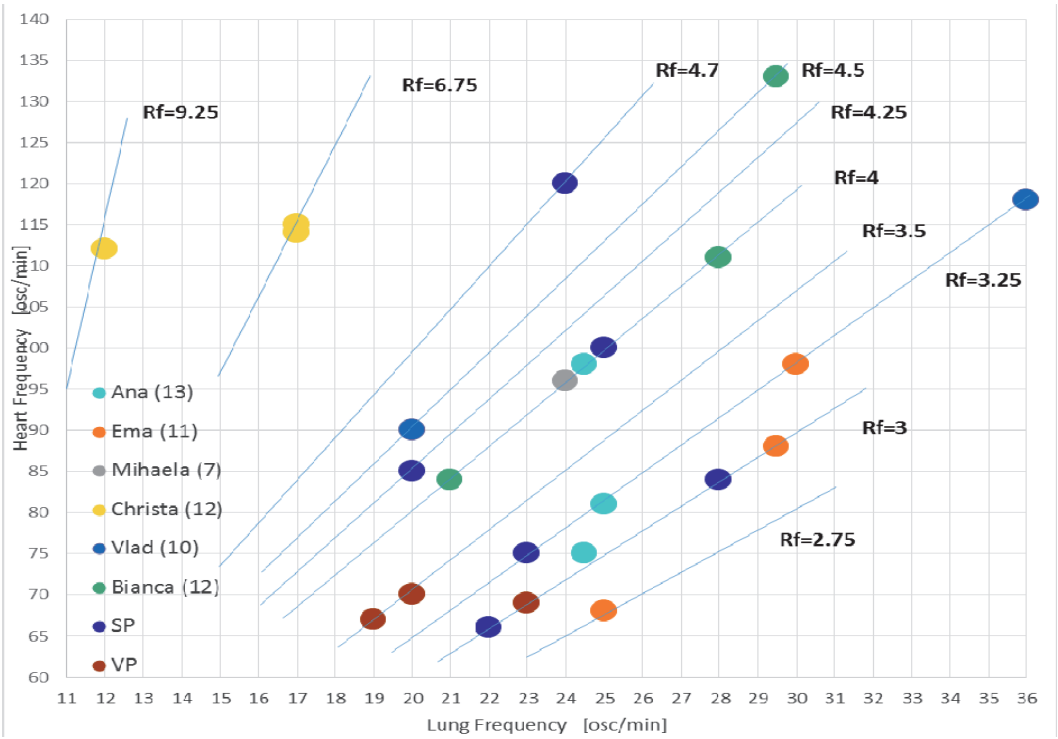

Fig. 1. Correlation between heart and lung frequency, with highlighting of R_f lines.

One can see that for $N = 1$ and sign (-) in front of $N/2$, interactional heart–lung condition is characterized by $R_f = 2.5$. It results that this interactional state is strongly influenced by thermal regime (ambient air temperature and exposure to direct sunlight). It was supposed that same thing

could also happen to others, so on the basis of experiments performed on dozens of people, it was found that the following formula is better and simpler than relations (1) or (2), and also *general for any person* (as verified on children aged between 7 and 13 years and adults):

$$F_i = F_p \cdot (2 + N/2);\ N = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 \quad (3)$$

Then a scheme of operation of cardio-respiratory system was developed, inspired by the Finite Speed Thermodynamics applied to Thermal Machines [17]. Also previous work providing the PV/Px diagram, that led to the validation of this scheme for 13 Stirling machines (and 17 operating regimes) [7, 15, 27, 53, 57, 59] inspired us to develop such a diagram for the cardio-respiratory system [18]. Based on this diagram, a qualitatively and quantitative description of heart-lung functioning became possible, with the aim of finding analytical formulas for the power consumption of the system and its performance as a function of its "operation speed". Unlike thermal machines, there are now two different operating speeds, one for each subsystems, heart and lungs, so an analytical relationship between them had to be found.

After several attempts, the finding (very daunting at first) that the points in a chart $F_i = f(F_p)$ or vice versa $F_p = f'(F_i)$ *cannot be statistically processed* pushed further the experimental research on hundreds of states and dozens of subjects. Systematic experimental measurements protocol aiming to emphasize the emergence of stationary and quasi-stationary states suggested by Prof. Dr. Eng. Florin Danes was prepared. Also, measurement accuracy was improved by doubling the time measurement of F_p (for a more precise value).

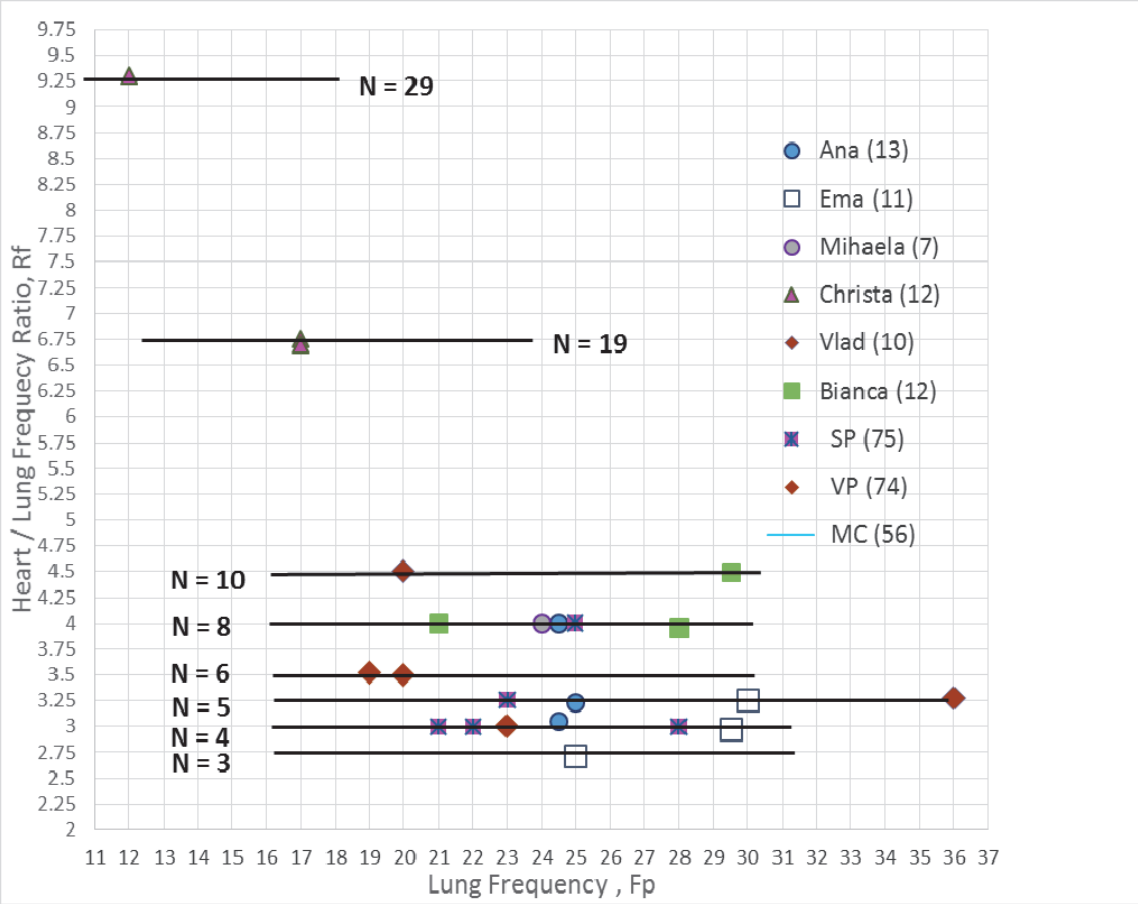

Fig. 2. Heart/Lungs Frequency Ratio and quantum numbers .

The occurrence of the "*quantum numbers*" in these experiments, that have integer and semi-integer values, and also numbers (Integer + N/4) type for R_f, raised the idea of similarity to the interaction between the electron and proton [51] in the hydrogen atom. Then, this interaction was studied in [61], where the "quantum leap" of the electron after interaction with a photon (either

received or released by the hydrogen atom) by exposure to sunlight was examined. Based on this "analogy" a more general and precise formula is proposed by the following expression:

$$F_i = F_p \cdot (2 + N/4);\ N = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 \qquad (4)$$

The results obtained by applying relation (4) are shown in Figures 1 and 2.

Any *process with change* of F_i, F_p or both *of them during the passage between two stationary states* occurs with quantum leap. It is expressed by the passage from an *integer value of number* $N = N_1$ to *another integer value* $N = N_2$ either by increase of N in *processes with physical or mental effort* (which requires more *power consumption* of the heart and lungs) or by decrease of N, when effort reduction or rest are involved (sitting, lying in bed, etc.).

These processes with quantum leap between different energy levels are graphically illustrated in a new type of diagram $R_f = f(F_p)$. It shows that in any *process with quantum leap* between two stationary states *the quantum number will change its value, namely* $N_1 \rightarrow N_2$. *This variation of the quantum number N describes the passage of the Heart-Lungs System from an interacting state with specific order and energy level to another interacting state with another order and energy level.*

A diagram $R_f = f(F_p)$ is shown in [18] where by using one of the previous relations (1) - (4), the total power consumption of the cardio-respiratory system of a person was expressed as a function of a single speed, just as it was previously done for Stirling machines, where are actually 3 speeds (the speed of a working piston w_p, the speed of the moving piston w_d, and the gas velocity through the Regenerator w_R), all expressed according to just one speed, namely the working piston speed, w_p.

There are also 3 speeds for the cardio-respiratory system, namely (1) heart speed, F_i, (2) lungs speed. F_p and (3) the speed of the blood, which is the "working medium" between them. The blood acts as a carrier of O_2 during the inhalation phase and then of CO_2 and H_2O (metabolism products) during the exhalation phase.

3. CONCLUSION AND PERSPECTIVE

The formulas (1)-(4) represent a very important discovery related to the interaction between heart and lungs, two oscillating biological subsystems that are self-organizing ones in the stationary states for optimum operation. This optimum is most probably assured by minimal source of entropy, namely by generating the minimum supplementary irreversibility necessary of that operating mode. Optimum operation also involves a high degree of order, for the physical and spiritual "comfort" of the human body not only in sleep, when the system is resting and recovering, but also in stationary states associated to stable position (in bed, on chair, standing, constant walking, uniform work (repetitive). Music and dancing are activities in which heart, lung and movements rates harmonize producing a feeling of comfort, pleasure, relaxation, in which all frequencies of movements of the various subsystems are harmonizing.

Formula (1) is approximate but formulas (2)-(4) are more accurate. Virtually all stationary states have complied with formula (4). Approx. 50% of stationary and quasi-stationary states respected formula (1), where systematic measurements (after experimental protocol) made by Prof. Dr. Eng. Silvia Danes and Research Chem. Georgeta Botez. Formula (4) has been 100% verified by double accuracy experiments in F_p measurement on several subjects.

By applying and using the formulas (1-4) for determining the Power [18] and Efficiency of the heart and lungs, it will be possible to study and optimize various activities, such as work, sport, recreational gymnastics, fitness, jogging, alternative therapies of body maintenance and "repair", relaxation, fun, music, dance, Bowen, Reiki, Reflexotherapy, Physiotherapy, thermal baths, Yoga, meditation, prayers.

REFERENCES

[1] Enache, V., Petrescu, S., *„Algoritm local pentru optimizarea costului rețelelor arborescente de conducte”*, Proceedings of the VII-th Edition of The International Conference of Academic Days of the Academy of Technical Science în Romania, Bucharest, pag. 236, AGIR Publisher, Bucharest, 2012.

[2] Enache, V., Petrescu, S., *„Optimizarea costului instalațiilor arborescente de transport”*, Revista Termotehnica, Anul XVI, nr. 2/2012, p. 4, AGIR Publisher, Bucharest, 2012.

[3] Petrescu, S., Enache, V., *„Applying the Finite Speed Thermodynamics (FST) to the Human Cardiovascular System”*, Nat. Conf. of Thermod. (NACOT), Constanta, Romania, 2013.

[4] Petrescu, S., Feidt, M., Costea, M., Enache, V., Petre, C., Boriaru, N., „*Perspective d'unification de la Thermodynamique en Dimensions Physiques Finies avec la Thermodynamique à Vitesse Finie"*, COFRET'14, Paris, CNAM, 23-25 Avril 2014.

[5] Petrescu, S., Enache, V, Bolohan, R., „*Condiții de optim în sistemul Cardio-Vascular-Pulmonar obținute în cadrul Termodinamicii Ireversibile cu Viteză Finită, I. Debitul de oxigen în funcție de viteza sângelui"*, Revista de Chimie, Bucharest. 2014, (In Press)

[6] Enache, V, Petrescu, S., Bolohan, R., „*Condiții de optim în sistemul Cardio-Vascular-Pulmonar obținute în cadrul Termodinamicii Ireversibile cu Viteză Finită, II. Optimizarea puterii utile furnizate de organism"*, Revista de Chimie, Bucharest, 2014, (In Press).

[7] Petrescu, S., Costea, M., Harman, C., Florea, T., "*Application of the Direct Method to Irreversible Stirling Cycles with Finite Speed"*, International Journal of Energy Research, Vol. 26, pp.589-609, 2002. USA.

[8] Petrescu, S., Harman, C., Costea, M., Popescu, G., Petre, C., Florea, T., "*Analysis and Optimisation of Solar/Dish Stirling Engines*", Proceedings of the 31st American Solar Energy Society Annual Conference, Solar 2002, "Sunrise on the Reliable Energy Economy", Reno, Nevada, vol.CD, ISBN: 0-89553-174-7, Editor: R. Campbell-Howe, June 15-20, 2002, USA.

[9] Petrescu, S., Petre, C., Costea, M., Boriaru, N., Dobrovicescu, A., Feidt, M., Harman, C., "*A Methodology of Computation, Design and Optimization of Solar Stirling Power Plant using Hydrogen/Oxygen Fuel Cells*", *Energy*, 35, 729–739. 2010.

[10] Costea, M., Petrescu, S., Harman, C., „*The Effect of Irreversibility on Solar Stirling Engine Cycle Performance*", *Energy Conversion & Management*, Vol. 40, pp. 1723-1731, 1999, USA.

[11] Costea, M., Petrescu, S., Feidt, M., „*Synthesis on Stirling Engine Optimization"*, *Thermodynamics Optimization of Complex Energy Systems*", Edited by A. Bejan and E. Mamut, Kluwer Academic Publishers, pp. 403-410, 1999, USA.

[12] Petrescu, S. "*Lectures on New Sources of Energy*", Helsinki University of Technology, Otaniemi, Finland, p.320, Lectures în October 1991.

[13] Petrescu, S., Zaiser, J., Petrescu, V. „*Lectures on Advanced Energy Conversion*", Bucknell University, Lewisburg, PA, USA, 1996.

[14] Petrescu, S., Harman, C., Costea, M., Florea, T., Petre, C., „*Advanced Energy Conversion - Vol I*", pentru cursul: *MECH- 422/622* , Bucknell University, Lewisburg, PA -17837, January, 2006, USA

[15] Petrescu, S., Costea, M., et. al., "*Development of Thermodynamics with Finite Speed and Direct Method*", AGIR Publisher, Bucharest, 2011.

[16] Petrescu, S., Harman, C., „*The Connection Between the First Law and Second Law of Thermodynamics for Processes with Finite Speed - A Direct Method for Approaching and Optimization of Irreversible Processes*", Journal of The Heat Transfer Society of Japan, Vol. 33, No. 128, pp. 60-67, Jan, 1994.

[17] Petrescu, S., Harman, C., Costea, M., Florea, T., "*A Method For Determining the Performance of Stirling Machines based on the First Law for Processes with Finite Speed and Using a PV / Px Diagram*", Proceedings Fifth World Conference on Integrated Design & Process Technology, Dallas, USA, 2000.

[18] Petrescu, S., Costea, M., Timofan, L., Petrescu, V., "*Means for qualitative and quantitative description of the Cardio-Pulmonary System Operation within Irreversible Thermodynamics with Finite Speed*", ASTR Conference, Sibiu, Romania, 6-7 November, 2014.

[19] Chen, L. G., Feng, H. J., Sun, F. R., "*Optimal piston speed ratio analyses for irreversible Carnot refrigerator and heat pump using finite time thermodynamics, Finite Speed Thermodynamics and Direct Method"*, Int. J. of Energy Institute, 2011.

[20] Feng Huijun, Chen Lingen and Sun Fengrui, "*Optimal ratio of the piston for Finite Speed irreversible Carnot Heat Engine Cycle"*, Int. Journal of Sustainable Energy, 30: 6, 321, Dec. 2011, 321-335, First published on: 23 September 2010.

[21] Carvajal, I., Polupan, G., Jarquin, G., Vázquez, J.*, "Optimization of the Thermal Efficiency of a Robinson Engine Applying the Senft-Schmidt-Petrescu Model",* Información Tecnológica Vol. 24 (3), 85-94 (2013), *On-line version* ISSN 0718-0764, Inf. Tecnol. vol.24 no.3 La Serena, MEXIC, 2013, http://dx.doi.org/10.4067/S0718-07642013000300010.

[22] Cullen, B., McGovern, J., Petrescu, S., Feidt, M., *„Preliminary Modelling Results for Otto-Stirling Cycle",* Proc. ECOS -2009, Foz de Iguasu, Parana, Brazil, p. 2091-2100, Aug. 31 - Sept. 3, 2009.

[23] McGovern, J., Cullen, B., Feidt, M., Petrescu, S., *"Validation of a Simulation Model for a Combined Otto and Stirling Cycle Power Plant"*, Proc. of ASME 2010, 4th International Conference on Energy Sustainability, ES-2010, May 17-22, Phoenix, Arizona, USA 2010.

[24] Feidt, M., Cullen, B., McGovern, J., Petrescu, S., "*Thermodynamics Optimization of the Endoreversible Otto / Stirling Combined Cycle"*, ECOS-2010, 15-17 June, Lausanne, Switzerland, 2010.

[25] Stanescu, G., „*The study of the mechanism of irreversibility generation în order to improve the performances of thermal machines and devices"*, Ph. D. Thesis, U.P.B., Bucharest, 1993.

[26] Costea, M., „*Improvement of heat exchangers performance în view of the thermod. optimization of Stirling Machine; Unsteady-state heat transfer în porous media", Ph.D. Thesis*, UPB & U.H.P. Nancy 1, 1997.

[27] Florea, T., *„Grapho-Analytical Method for the study of the operating processes irreversibility în Stirling Engines”*, Ph.D. Thesis, UPB, 1999.
[28] Petre, C., „*Utilizarea Termodinamicii cu Viteză Finită în Studiul şi Optimizarea ciclului Carnot şi a Maşinilor Stirling”*, U. P. Bucuresti, Teza de Doctorat, 2007.
[29] Dobre, C., intitulată *"Contribution to the Development of Irreversible Engineering Thermodynamics Methods, applied to analytical and experimental study of Stirling and quasi-Carnot Machines"* Ph.D. Thesis, UPB, 2012.
[30] Stoicescu, L., Petrescu, S. *„The First Law of Thermodynamics for Processes with Finite Speed în Closed Systems”, Bulletin I.P.B.*, Bucharest, Romania, Vol. XXVI, No. 5, pp. 87-108, 1964.
[31] Petrescu, S., (Adviser: L. Stoicescu), „*Contribution to the study of thermodynamically non-equilibrium interactions and processes în thermal machines”*, Ph.D. Thesis, I.P.B., Bucarest, Romania, 1969.
[32] Stoicescu, L., Petrescu, S. „*Thermodynamic Processes Developing with Constant Finite Speed”,* Bull. I.P.B. Romania, Vol. XXVI, No. 6, pp. 79-119, 1964.
[33] Stoicescu, L., Petrescu, S. „*Thermodynamic Processes with Variable Finite Speed”*, Bull I.P.B., Bucharest, Vol. XXVII, No. 1, pp. 65-96, 1965.
[34] Stoicescu, L., Petrescu, S. „*Thermodynamic Cycles with Finite Speed”*, Bull. I.P.B., Bucharest, Vol. XXVII, No. 2, pp. 82-95, 1965.
[35] Stoicescu, L., Petrescu, S. „*The Experimental Verification of The New Expression of the First Law for Thermodynamic Processes with Finite Speed”,* Bull. I.P.B., Bucharest, Vol. XXVII, No. 2, pp. 97-106, 1965.
[36] Petrescu, S. „*An Expression for Work în Processes with Finite Speed based on Linear Irreversible Thermodynamics”,* Rev. Rom. Sci. Techn. - Electrotech. and Energ., Romanian Academy, Tom.19, No.2, pp. 249-254, 1969.
[37] Petrescu, S. „*Kinetically Consideration Regarding the Pressure on a Movable Piston”,* Rev. Rom. Sci. Techn. - Electrotech. and Energ., Romanian Academy, Tom 21, No.1, pp. 93-107, 1971.
[38] Petrescu, S., „*Study of the Gas - Gas Interaction with Finite Velocity for Flow Processes”*, Rev. Rom. Sci. Techn. - Electrotech. and Energ., Romanian Academy, Tomul 23, No.2, pp. 299-312, 1973.
[39] Petrescu, S. „*Experimental Study of the Gas - Piston Interaction with Finite Speed în the Case of an Open System”,* Rev. Rom. Sci. Techn. - Electrotech. and Energ., Romanian Academy, Tom 31, No.5, pp. 1081-1086, 1974.
[40] Petrescu, S. „*An Expression for Work în Processes with Finite Speed based on Linear Irreversible Thermodynamics”*, Rev. Rom. Sci. Techn. - Electrotech. and Energ., Romanian Academy, Tom.19, No.2, pp. 249-254, 1969.
[41] Petrescu, V., Petrescu, S. “*A Treatment of the Concentration Overpotential Using the Thermodynamics of Irreversible Processes”,* Revue Roumaine de Chimie, Romanian Academy, 16, 9, pp. 1291-1296, 1971.
[42] Moran, M. J., *“A Critique of Finite Time Thermodynamics”*, Proc of ECOS' 98, Nancy, France, Ed: A. Bejan, M. J. Moran, G. Tsatsaronis, Nancy, France, pp. 1147-1150, 1998.
[43] Moran, M. J., “*On Second Law Analysis and the failed Promises of Finite Time Thermodynamics*”, Energy, vol. 23, pp. 517-519, 1998.
[44] Gyftopulous, E. P., *”Fundamentals of Analysis of Processes”,* Energy Conversion & Management, vol. 38, pp. 1525-1533, 1997.
[45] Petrescu, V., *„Electrode Processes and Transport Phenomenon at the Interface of Chlorine-Carbon Electrode-Molten Salt”*, PhD Thesis, Polytechnic Institute of Bucharest, 1974.
[46] Petrescu, S., Petrescu, V., Stanescu, G., Costea, M. “*A Comparison between Optimization of Thermal Machines and Fuel Cells based on New Expression of the First Law of Thermodynamics for Processes with Finite Speed”*, Proc. First International Thermal Energy Congress, ITEC - 93, Marrakech, Morocco, 1993.
[47] Petrescu, S., Stanescu, G., Petrescu, V., Costea, M. „*A Direct Method for Optimization of Irreversible Cycles Using a New Expression for the First Law of Thermodynamics, for Processes with Finite Speed*”, Proceedings of The First International Thermal Energy Congress ITEC- 93, Marrakech, Morocco, 1993
[48] Petrescu, S., V., Maris, Costea, M., Boriaru, N., Stanciu, C., Dura I. „*Comparison between the Fuel Cells and Heat Engines. I. A Similar Approach în the Framework of Thermodynamics with Finite Speed*”. Journal of Chemistry, Bucharest, Vol. 64, No. 7, 739-746, 2013.
[49] Petrescu, S., V., Maris, Costea, M., Boriaru, N., Stanciu, C., Dura I. „*Comparison between the Fuel Cells and Heat Engines. II. Operation and Performances*”, Journal of Chemistry, Bucharest, Vol. 64, No. 10, 1187-1193, 2013.
[50] Petrescu, S., Stanescu, G., Iordache, R., Dobrovicescu, A. „*The First Law of Thermodynamics for Closed Systems, Considering the Irreversibilities Generated by the Friction Piston-Cylinder, the Throttling of the Working Medium and Finite Speed of the Mechanical Interaction*”, Proc. ECOS'92, Zaragoza, Spain, Ed. A. Valero, G. Tsatsaronis, ASME, 33-39, 1992.
[51] Petrescu, S., Stanescu, G. „*The Direct Method for studding the irreversible processes undergoing with finite speed în closed systems”*, Termotehnica, No.1, Technic Publisher, 1993.
[52] Petrescu, S. „*Tratat de Inginerie Termica. Principiile Termodinamicii” (Treatise on Engineering Therodynamics. The Principles of Thermodynamics).* AGIR Publisher, Bucharest, Romania, 2007.

[53] Petrescu, S., Harman, C., Costea, M., Feidt, M. „*Thermodynamics with Finite Speed versus Thermodynamics în Finite Time în the Optimization of Carnot Cycle"* Proc. of the 6-th ASME-JSME Thermal Engineering Joint Conference, Hawaii, USA, March 16-20, 2003.
[54] Florea, T., Petrescu, S., Florea, E. „*Schemes for Computation and Otimization of the Irreversible Processes în Stirling Machines"*, (RL), Leda & Muntenia Publisher, Constanta, Romania, 2000.
[55] Petrescu, S., Harman, C., Bejan, A. „*The Carnot Cycle with External and Internal Irreversibility"*, Proc. Florence World Energy Research Symposium, Energy for 21st Century: Conversion, Utilization and Environmental Quality, Firenze, Italy, 1994.
[56] Petrescu S., Harman C., Costea M., Petre C., Dobre C. „*Irreversible Finite Speed Thermodynamics (FST) in Simple Closed Sistems. I. Fundamental Concepts"*, Termotehnica, AGIR Publisher, Bucharest, Romania, No. 1, 2010.
[57] Petrescu, S. „*The Development of Thermodynamics with Finite Speed and the Direct Method",* Tomul LVI, Fasc 3a, COFRET 2010, 5-7 mai, Iași, Romania, 2010.
[58] Petrescu, S., Costea, M., Tirca-Dragomirescu, G., Dobre, C. „*Validation of the Direct Method and its applications în the optimized design of the Thermal Machines for the increase of the Efficiency",* 28-29 Aug, Conf. ASTR, Craiova, Romania, 2010.
[59] Petrescu, S., Petrescu, V., „*Thermodynamics Laws. Evolution, Fundamentals, Applications"*, (RL), Tehnic Publisher, Bucharest, Romania, pp. 294, 1983.
[60] Petrescu, S., Zaiser, J., Harman, C., Petrescu, V., Costea, M., Florea, T., Petre, C., Florea, T.V., Florea, E., „*Advanced Energy Conversion - Vol II", MECH- 422/622*, Bucknell University, Lewisburg, PA, USA, February, 2006.
[61] Petrescu, S., Harman, C., *"The Jump of an Electron in a Hydrogen Atom using a Semi-classical Model"*, Journal of Chemistry, Bucharest, English Edition, 2, N2.1-2, pp.3-10, 2001.

DESCOPERIREA "NUMERELOR CUANTICE" ÎN INTERACŢIUNEA CARDIO-PULMONARĂ STUDIATĂ ÎN TERMODINAMICA CU VITEZĂ FINITĂ

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Rezumat: Lucrarea propune o extindere a Termodinamicii cu Viteză Finită (TVF) la Sistemele Biologice, având ca prim obiectiv studiul Sistemului Cardio-Pulmonar, extrem de important în funcţionarea oricărei fiinţe cu sânge (incluzând oamenii). Pentru stările staţionare, au fost introduşi 3 parametri de stare fundamentali: frecvenţa Inimii, F_i ; frecvenţa Plămânilor, F_p si Raportul lor, R_f, în vederea descrierii interacţiunii auto-organizate dintre ele. Cu aceşti noi parametri de stare pot fi descrise şi Procese "între" Stări Staţionare, aspect tratat deja pentru multe Maşini Termice, folosind TVF şi cu parametrii medii instantanei, precum Energia internă medie instantanee, U_{mi}, Entropia medie instantanee, S_{mi}. Deoarece frecvenţa Inimii şi cea a Plămânilor sunt proporţionale cu Energia consumată de Inimă, respectiv de Plămâni, aceste doua cantităţi "sunt similare" cu U_{mi}. Raportul R_f va fi, de asemenea, proporţional cu Raportul acestor Energii şi va caracteriza interacţiunea celor două subsisteme. Folosind aceşti noi parametri, s-a căutat o formula analitică pentru corelarea celor doua proprietăţi, pe baza studiului experimental al comportării lui R_f în timp. Numeroasele experimente realizate au condus la ceva extrem de interesant şi important, anume : R_f este un "Număr Cuantic". Pe baza acestei descoperiri experimentale s-a "inventat" formula care corelează Viteza plămânului, F_p, cu Viteza Inimii F_i, în interacţiunea lor continuă. Această formulă este absolut esenţială pentru extinderea TVF la Sistemele Biologice. Ea va face posibilă găsirea unor expresii analitice pentru Puterea şi Randamentul Inimii şi al Plaminilor, ca funcţie doar de o singura viteză, F_i , aşa cum s-a făcut anterior pentru o gama largă de Maşini Termice, ca funcţie de viteza pistonului (parametrul principal în întreaga TVF). Proiectanţii vor putea folosi de acum înainte astfel de formule analitice pentru o proiectare mai eficientă şi pentru un design optimizat al inimilor artificiale şi ai plămânilor artificiali, personalizate pentru fiecare pacient.