Issue of maintenance of energy converter factor of the cavitation heat generator at constant level

E G Porsev¹, B V Malozyomov¹

¹ Novosibirsk State Technical University, 20, Karl Marx Av., Novosibirsk, 630073, Russia

Email: mbv5@mail.ru

Abstract. The problems of converting mechanical energy into heat, which involves the use of cavitation phenomena in a moving fluid to obtain heat in an amount exceeding the electrical energy at the entrance to the system, are considered. Recommendations are given for production to generate heat for the heating buildings and hot water to reduce primary energy consumption and increase the level of environmental safety.

1. Introduction

The hydrodynamic conversion of mechanical energy into heat involves the use of cavitation phenomena in a moving fluid to produce heat in excess of electrical energy at the entrance to the system. A similar formulation of the problem is possible if the hypothesis of cold nuclear fusion in the volume of a cavitation cavity or the hypothesis of the release of energy of cluster bonds of natural water is working [1, 2]. Knowledge of this area of physical phenomena will solve a number of scientific problems and applied problems. The prospects and fundamental feasibility of such phenomena are proved by a number of successful experimental works that have found practical application. Qualitative leaps may appear in the development of branches of science and technology related to the use of physical energy of water and the production of energy devices that exclude the burning of hydrocarbon fuel or the use of other energy carriers external to the system [3, 4].

The authors found that using this effect in production to generate heat for heating buildings and hot water will dramatically reduce the consumption of primary energy and increase the level of environmental safety [9].

2. Problem of Maintenance

The problems, difficulties that have existed so far and which are solved by the proposed development are given below. Anomalous heat generation has been known in several technologies since the 80s of the 20th century. First of all, this is the cavitational flow of a liquid, an electric arc, sorption processes, and others. For us, it makes sense to talk about the problems and difficulties in the field of mastering the production of heat production technology using cavitation [5].

In this area, despite a rather large list of inventions and studies, the problem is not solved radically for several reasons:

1. Most inventors evaluate the effectiveness of their designs based on the results of heating the air in heated rooms, and this is incorrect since the efficiency of the room replaces the effectiveness of the apparatus;
2. The effectiveness of structures, measured by the calorimetric method, is achieved no higher than 1.6-1.8;

3. The tariff for electric energy per 1 kWh exceeds the tariff for thermal energy per 1 kWh by 3.0-3.5 times. This makes it unprofitable to use a hydrodynamic heat generator for heating buildings if the conversion coefficient does not exceed a value of 3.5.

4. As the heat generator works, the conversion coefficient changes very significantly, most researchers take into account the integral value of the coefficient, thus refusing to optimize the process.

The assumptions to explain the nature of the phenomenon of superunit energy release during cavitation fluid flow are generally recognized that in all apparatuses and technologies, cavitation is the active principle giving a superunit effect. According to modern concepts, cavitation is a discontinuity in the continuity of a fluid flow, or according to another hypothesis, local boiling of a fluid due to a drop in pressure in the flow, followed by condensation of vapors in the high-pressure region, accompanied by local hydraulic shock. The temperature during the collapse of cavitation cavities is from 5000 to 10000 °K, and the pressure is from 40 to 1000 MPa.

Classical physics can not yet give an explanation of the phenomenon of heat release during cavitation fluid flow, but there are a number of hypotheses. There are more than a dozen, including the following:
- hypothesis of microdischarges proposed by Y.I. Frenkel in 1940, according to which the energy phenomena observed during ultrasonic irradiation of liquids are explained by microdischarges in cavitation bubbles;
- the balloelectric hypothesis proposed by Harvey N.A., according to which the ultrasonic glow is explained by an electric discharge between the bubbles, when compressed, the potentials increase due to a decrease in the electric capacity, which leads to a breakdown of the liquid;
- mechanical hypothesis proposed by Vale V.A. in 1951, it consists in the fact that in the field of ultrasonic there is ultrasonic luminescence due to the redistribution of ions at the water-air interface and their polarization due to chemisorption of extraneous molecules;
- the hot zone hypothesis, first expressed by Nolting B.E., is that when ultrasonic vibrations occur in a liquid medium, they lead to the appearance of cavitation and cavitation bubbles, the radius of which slowly increases in time and then decreases sharply. The collapse process is characterized by high radial velocities (greater than the speed of sound) and large pressure values in the final stage of collapse, and a rapid reduction in the volume of the bubble leads to adiabatic compression of the gas in the bubble with a significant increase in temperature at which thermonuclear reactions are possible;
- the thermochemical hypothesis proposed by Griffing W. in 1952 and consists in the fact that an increase in temperature inside the bubble due to adiabatic compression can cause the dissociation of gas or vapor molecules contained in the bubble, and subsequent recombination of these ions on the surface of the bubble causes ultrasonic luminescence and energy effect. Upon closer examination, the thermochemical hypothesis turns out to be a variant of the “hot zone” hypothesis;
- shock wave hypothesis proposed by Müller H.G. and Shock A. in 1941, it follows that the radial velocity of the collapse of the bubble can exceed the speed of sound and with adiabatic compression on the surface of the bubble should arise shock waves that go into the gas phase, compress and heat the gas, causing it to glow;
- structural hypothesis proposed by Obraztsov V.I. in 1978, it is based on the dependence of the ultrasonic luminescence on the structure of molecular associates and the properties of the gas-water transition layer, and when the cavitation bubbles collapse, the collapse energy is transferred to the associate molecules, transferring them to an excited state, which then leads to the destruction of associates and the release of binding energy (cluster hypothesis);
- thermonuclear hypothesis proposed by A. Kladov. and lies in the fact that when a cavitation bubble collapses, the radius of the bubble at the final moment of the collapse stage should decrease to an atom of average size, and the collapsing cavitation bubble is an energy transformer that converts energy with low parameters (sound energy) into energy with high parameters;
- the hypothesis of cold nuclear fusion proposed by Potapov Yu.S. and Fominsky L.P. and lies in the fact that the cause of energy release is the presence of the phenomenon of internal electron conversion in an atom. It consists in the fact that when the selection rules prohibit the emission of a gamma quantum by an excited atomic nucleus (excitation by an external action, for example, during the collapse of cavitation bubbles), the excitation is removed due to the transfer of the excitation energy of the nucleus to the atomic shell electron. In this case, the electron is knocked out of the atom with the release of energy;

- the hypothesis of phase transitions of the second row was proposed by Landau L.D., is that water molecules, interacting, form a cluster - a bunch of random shape, composition and size. Changes in the external parameters of the system: temperature, pressure, strength of power energy fields, etc., lead to a change in its thermodynamic state;

- the hypothesis of a change in the electronic configuration of a substance with increasing external pressure was proposed by P. Melnikov and Makarenko V.G. with employees, it consists in the fact that, as the distance between the atoms of a solid decreases, it is possible to form new stable electronic configurations that fix a reduced distance, changing the volume of matter and the energy state (a phenomenon is also possible in diatomic molecules). A close examination of the hypothesis can be considered a kind of hypothesis of phase transitions of the second kind.

Obviously, these hypotheses have their advantages and disadvantages. The only thing that unites them is the inability to predict the result with high reliability in all cases. Nevertheless, in each case, the increment in the energy of the system goes to the increment of the Gibbs energy and, in relation to the purpose of this study, to increase the energy yield when converting the kinetic energy of a moving fluid flow into heat during its cavitation flow.

Despite the lack of a reliable theory, searches are ongoing, the flow of applications for inventions is increasing, annual international scientific conferences are being held, and journals devoted to this subject are being published. From our point of view, it makes sense not to wait for the appearance of a rigorous theory, but to use the effect existing today in life.

3. Test procedures

3.1. Test Scheme 1

We have conducted experimental studies of the process of converting the mechanical energy of a moving fluid stream into heat during its cavitation flow in a rotary pulsation apparatus (RPA), as the most efficient equipment. RPA Kladova A.F. was taken as a prototype [6, 7]. The difference was that the RPA was driven by a direct current electric motor - this made it possible to optimize the process by the frequency of pulsation of the fluid flow. The energy at the entrance to the system was measured by a DC energy meter, the rotor speed with a strobe-tachometer. The output energy was measured by the calorimetric method: by accurately weighing the water and heated parts poured into the circuit, calculating the total amount of heat taking into account the radiation. To increase the accuracy of measurements of the energy conversion coefficient, physical (non-technical), no-load experiments were conducted for the drive electric motor. This made it possible to subtract the intrinsic losses of the electric motor when determining the physical conversion coefficient.

The development of this technique was the improvement of the laboratory bench, on which dynamometric motor scales were installed to directly measure the torque on the RPA shaft and accurately calculate the physical energy consumption for creating a cavitating fluid flow.

The next step was the creation of a stand with an asynchronous AC drive, an electric energy meter at the entrance to the system and an electronic heat meter (including thermometers and a flow meter) of heat removed from the heater. Obviously, according to this scheme, the technical conversion coefficient (CC) was measured. It is possible to evaluate the physical CC according to this scheme only with large errors.

The working hypothesis was that the CC depends on a number of process parameters:
\[ CC = f(T, \eta_0, F, V_1, \delta, V_2, V, \Delta P, \tau), \]  

where \( T \) - is the temperature of the water at the inlet of the activator, \(^\circ\)C;
\( \eta_0 \) - is viscosity of water, MPa\( \cdot \)s;
\( F \) - is the acoustic frequency of the first harmonic, Hz;
\( V_1 \) - is linear radial velocity of water in the gap, m/s;
\( \delta \) - is surface tension of the liquid, N\( \cdot \)m;
\( V_2 \) - is the rotational linear velocity of the water in the gap, m/s;
\( V \) - is the total water velocity, m/s;
\( \Delta P \) - is the pressure drop across the activator, MPa;
\( \tau \) - is processing time, hour.

3.2 Test Scheme 1

The consumption of electrical energy at the entrance to the system was determined by the electric energy meter CA4-1674M (accuracy class is 2.5), included at the input of the electric drive motor of the rotary-pulsation activator of the heat generator. The amount of thermal energy released from the heating battery was measured with a heat meter SPT942.03 (accuracy class is 1.0). The flow rate of the coolant through the system was determined by an ETWI-15 water meter (accuracy class is 1.5). The temperature of the coolant at the inlet - outlet of the heating battery was measured by a set of thermometers KTPTR-01-60 (accuracy class is 1.0). The rotational speed of the rotor shaft of the hydrodynamic activator was measured with a St-5 strobe tachometer.

The conversion coefficient of the kinetic energy of a moving fluid flow into heat (technical) during its cavitation flow was calculated through the ratio of the energy emitted by the heating battery to the energy consumed from the electrical network. Losses from technological equipment to control thermometers and own losses of the electric motor were not taken into account; therefore, the CC by this method is underestimated by the value of the above losses.

The study of frequency dependence. The search for the optimal pulsation frequency of the fluid flow gave a frequency range in the range of 3.8-4.8 kHz, in which the maximum heat release is observed [8, 9].

Correlation analysis was carried out on a PC using the standard SNEDECOR program. The correlation matrix in coded variables is given in the Table 1.

The analysis of the correlation matrix showed that a strong correlation exists between the following factors (Table 1):

| No. of factor | Factor                           | Mach pair correlation | Correlation Between \( Y_i \) and \( X_j \) |
|--------------|----------------------------------|-----------------------|---------------------------------------------|
| \( X_1 \)    | Water temperature                | -0.9771               | -0.3079                                    | -0.1631                                    |
| \( X_2 \)    | Viscosity                        | -0.9771               | 0.2701                                     | -0.1080                                    |
| \( X_3 \)    | Ripple frequency                 | 0.7082                | 0.1764                                     | 0.3354                                     |
| \( X_4 \)    | Radial water velocity in the gap | -0.4528               | 0.0424                                     | 0.0592                                     |
| \( X_5 \)    | Liquid surface tension           | 0.0909                | -0.0491                                    | -0.1026                                    |
| \( X_6 \)    | Tangential fluid velocity        | 0.7082                | -0.1550                                    | -0.2107                                    |
| \( X_7 \)    | Activator differential pressure  | 0.1759                | 0.5235                                     | 0.3672                                     |
| \( X_8 \)    | Time of processing               | 0.8244                | -0.0909                                    | 0.0522                                     |

Obviously, for the subsequent analysis, it is advisable to remove duplicating factors from the model in order to obtain a more adequate model [10].
The analysis of the influence of the studied factors on the energy conversion coefficient was carried out according to the results of experiments on a PC using the standard SNEDECOR program and allows obtaining the coefficients of the regression equation, to evaluate the adequacy of the equation to the process under study and the standard calculation error [11].

Regression analysis showed that some of the factors are practically insignificant (significance was determined in accordance with the principle of significance of the angular coefficient according to the standard error). The exclusion of insignificant factors and the addition of factors not included in the primary analysis, a regression model was obtained [12]:

\[ CC = -7.13 + 0.056T + 130.48\eta + 0.0000955F - 4.13V - 0.015V^2 - 569.47\eta^2 + 426.96F^2 \pm 4.403 \]  

(2)

Obviously, the greatest contribution to the positive effect is made by factors \( F \) and \( \eta \), other factors insignificantly affect the energy output of the process.

Checking the adequacy of the equation to the process under study was carried out according to Student's criterion and indicates a good fit of the model to the process under study.

| Date | Time   | \( W \) | \( T_1 \) | \( T_2 \) | \( \Delta T \) | \( Q \) | \( M_1 \) | CC  |
|------|--------|--------|--------|--------|--------|--------|--------|-----|
|      | hr min | kW·h   | °C     | °C     | °C     | Gcal   | T      | about.ed. |
| 09/11 | 18-00  | 28.2   | 43.48  | 39.10  | 4.40   | 71.14  | 3.18   |
|      | 18-30  | 29.2   | 43.80  | 41.29  | 4.89   | 71.76  | 3.47   |
|      | 19-00  | 30.2   | 47.74  | 41.35  | 6.41   | 72.30  | 4.03   |
|      | 19-30  | 31.2   | 48.57  | 38.32  | 10.26  | 72.84  | 6.42   |
| 09/14 | 10-30  | 36.0   | 38.20  | 35.89  | 2.32   | 74.96  |        |
|      | 11-30  | 38.2   | 42.73  | 39.51  | 3.24   | 75.29  | 2.12   |
|      | 11-45  | 38.6   | 42.21  | 39.82  | 2.39   | 76.20  | 1.50   |
|      | 13-00  | 40.02  | 29.93  | 28.76  | 1.20   | 77.18  |        |
|      | 14-00  | 42.4   | 36.74  | 35.03  | 1.69   | 78.52  | 1.11   |
|      | 14-20  | 42.5   | 37.76  | 35.22  | 2.55   | 78.87  | 10.40  |
|      | 15-20  | 43.4   | 39.20  | 35.73  | 3.47   | 79.73  | 3.66   |

4. Conclusion

1. Analysis of the data obtained and the data of previous studies allows choosing the dominant hypothesis about the origin of the supertotal effect of the conversion of the kinetic energy of a moving fluid flow into heat during its cavitation flow, in our opinion this is a second-order phase transition.

2. The second-order phase transition has not yet been quantitatively taken into account in theoretical works on this type of energy conversion and, therefore, the third law of thermodynamics is not taken into account in assessing the energy balance of the process.

3. The production of the aforementioned heat generators is relevant, since they can be used for heating cottages, other types of individual housing, industrial premises, and livestock farms and everywhere where the supply of centralized heating mains is expensive and environmentally friendly.

4. A special aspect is the use of cavitation heat generators of our design in the structure of the Ministry of Emergency Situations, when it is necessary to provide emergency heat supply to the house in case of damage to the heating main, on sea and river vessels, for heat supply of temporary housing in case of natural disasters, since these units are compact and can be mobile.
References

[1] Strizhenok A V, Korelskiy D S 2016 Assessment of the state of soil-vegetation complexes exposed to powder-gas emissions of nonferrous metallurgy enterprises Journal of Ecological Engineering 17(4) 25-29

[2] Strizhenok A V, Korelskiy D S 2015 Assessment of the anthropogenic impact in the area of tailings storage of the apatite-nepheline ores Pollution Research 34(4) 809-811

[3] Filyushov Yu P, Zonov P V, Malozemov B V and Wilberger M E 2011 Energy efficient control of an alternating current machine. The Polzunovsky Herald. 2011 2 45-51

[4] Bykadorov A L, Zarutskaya T A and Muratova-Milekhina A S 2015 Increase of efficiency of short-circuits fault location in traction networks of alternating current on the basis of information technologies. Bulletin of transport of the Volga region 6(54) 15-19

[5] Kuznetsov S M 2005 Traction network protection of SC current. (Novosibirsk: NSTU) p. 352

[6] Kuznetsov S M 2011 Setting of electronic security with simulation model corrected. Transport Science, Technology, Management. VINITY 12 30-34

[7] Kuznetsov S M, Demidenko I S, Yaroslavtsev M V and Krivova A O 2009 Mathematical model study of traction network dynamics of direct-current railway with train starting. / Scientific transport problems of Siberia and Far East. NSAWT 2 324-327

[8] Malozyomov B V, Vorfolomeyev G N and Schurov N I 2005 Reliability and diagnosing electrotechnical systems. In the collection: Proceedings - 9th Russian-Korean International Symposium on Science and Technology, KORUS-2005 347-350

[9] Bykadorov A L, Zarutskaya T A and Muratova-Milekhina A S 2015 Increase of efficiency of short-circuits fault location in traction networks of alternating current on the basis of information technologies. Bulletin of transport of the Volga region 6(54) 15-19

[10] Ivanov G Ja and Malozyomov B V 2005 Reliable power saving electric drive of wide application. In the collection: Proceedings - 9th Russian-Korean International Symposium on Science and Technology, KORUS-2005 330-332

[11] Anurov V I 2008 Modeling of transient processes in case of short circuit in the traction network and the presence of electric locomotives on the feeder zone. Electro. Electrical engineering, electric power industry, electrotechnical industry 2 16-18

[12] Kazanin O I, Sidorenko A A, Vinogradov E A 2017 Choosing and substantiating the methods of managing gas emission in the conditions of the Kotinskaya mine of JSC Suek-Kuzbass. ARPN Journal of Engineering and Applied Sciences 12 (6) 1822-1827