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Investigation of the Possibility of Transformation of Heat Environmental Energy into Electric Energy by Means of a Vortex Process

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— ABSTRACT —

The object of the study in this paper is a method of conversion of dissipated environment heat energy. We plan to calculate parameters of an energy converter, operating according to this method. The objective of the work is determination of principles of conversion of environmental heat energy mechanically, by means of compression-decompression of an elastic working body, and to design an autonomous fuel-less power source.

The methodology of the project: Considering the main, known technical solutions in this field of research, the author offers a theoretical model of the calculation of the main parameters of the process. Then design documentation can be created to produce an experimental energy converter. Testing of this experimental model will allow adjustments of the theoretical model. The result of this work should be able to be developed up to a workable concept of energy conversion, which must be proved experimentally.

There is no open information about this object of research in Russia and abroad. Some analogues are discussed in this report.

Practical development of this research is an autonomous fuel-less source of mechanical energy and propulsion force. This machine can be used as an electric power source to provide electricity power in the 10 kW to 10 MW range.

The importance of this technology for industrial needs can be evaluated by analyzing the fuel component of any industrial production process. This fuel component reduces efficiency of all kinds of transport and increases production costs of any product, including agricultural products. The proposed technical solution eliminates this costly fuel component.

At this stage (R&D), the design documentation is developed to produce an experimental device only. Development of research to a future stage will allow us to build a prototype of the power converter and organize mass production of autonomous power sources.

Introduction

Let's describe the current state of the scientific and technical problem at hand. Power sources have various applications and we can determine two main areas: home or industrial power sources, and also transport power sources. Relevance of the present research is in great demand in power sources. Modern power engineering is based on hydro carbonic fuel, for example, gas-turbine power plants and internal combustion transport engines. It can't provide the growing need in high-quality development of civilization. Demand grows more quickly than supply. Fuel-based power engineering is not a unique solution in the modern world. It is necessary to change the fuel concept of the power engineering industry. Modern technologies must provide low cost and ecologically clean solutions. This process already is demonstrated in new transport technologies (hybrid and electric cars), wind, solar and heat pump power sources.

In Russia and abroad, some experiments were made to obtain additional kinetic energy from molecules of water flow or molecules of air (transformation of environment heat energy), but we do not know about organizing efforts to create production facilities and start manufacturing of autonomous energy converters. Experimental converters of centrifugal/vortex type are shown in Section 3 of this report.

The novelty of the technical idea presented here is the special part of the rotor, which plays a role in the centrifuge. Also novel is the explanation of the factor of elasticity. It is an important property of a working mix of gas and liquid in this technology of energy transformation. The purpose of the centrifuge is considered in Section 8, where you can see some power calculations of the energy converter.

The proposed technical solution allows self-acceleration of a rotor to apply this technology for wide range of power plants and transport propulsion units. This solution includes a method of creation of conditions of acceleration of motion of working liquid in the rotor, special elements of design to provide transfer of kinetic energy of liquid stream into kinetic momentum of the rotor that leads to increase of its torque, and also conditions of transfer of kinetic energy of liquid stream after exit from the nozzle of the rotor to the rotor, that allow an additional increase of torque to the rotor.

There are three types of turbines in the rotor: screw turbine, jet turbine and turbine with blades. There are no known analogs of this design of the device.

The basis of this scientific report is Contract No. 1 of January 11, 2011 between Faraday Ltd. (Tula, Russia) and Customer JSC "Vortex heat energy converters" (Kurgan, Russia). Several sketches of the design are part of this report, but a complete set of design documentation was provided to the customer separately.

Theoretical research on this topic can't give us a complete answer to all questions about transformation of environment thermal energy into useful mechanical work. Several factors in the theoretical model cannot be exactly calculated. It is necessary to organize a research project, to design,

DEFINITIONS

This report uses the following terms with corresponding definitions:

1. Converter: centrifugal vortex converter of environmental heat energy into electric power.
2. Low-potential heat: scattered thermal energy of environment, in particular, energy of air.
3. Heat pump: device to transfer heat energy from low-potential source of heat energy (with a low temperature) into energy of a hotter heat carrier. Thermodynamics describes a heat pump as a reversed refrigerator.
4. Working liquid, liquid working mass, working mass: water, oil or other liquid substance to be used in centrifugal vortex converter of energy. Important property of this "working liquid" is its inertial mass (rest mass). It is necessary to use it in inertial processes, for example, in rotation or accelerated movement.
5. Elastic working body: aerated working liquid, *i.e.* liquid mixed with some amount of air. Property of elasticity in this case is essential to accumulate potential energy in form of elastic deformations.
6. Working mix: elastic mix of liquid and gases.
7. Aerated mix or aerated liquid: stream (flow) of liquid, including air bubbles.
8. Coefficient of increase of power: ratio of kinetic energy of stream of working liquid at the outlet from nozzle of rotor pipe to kinetic energy, which was spent to create rotation of working liquid in the rotor.
9. Laminarization of a stream of air or liquid: reduction or full elimination of turbulence of this stream. Or, reduction of entropy of this stream, *i.e.* alignment of speed vectors of molecules in one direction.
10. Aether: universal gaseous environment media. It consists of particles. The particles have some mass, much less than the mass of a hydrogen atom. More detailed description and definition of aether is presented in an article by Prof. Mendeleev.[1] Aether is connected with particles of matter, and aether is the reason for its rest mass (inertial effects). This connection is demonstrated as inertial effect in case of accelerated motion of any massive body. Aether can be described with real physical properties, including elasticity of aether.

build and test the experimental model, then to organize measurements to modify the theoretical model, and then to get more detailed understanding of parameters of all processes. After this stage it will be possible to design a commercial level prototype of the energy converter.

This research project is planned only to calculate parameters of design of the experimental level model of the energy converter, and after its testing we can advance to a new level of research. It is necessary to check all parameters of the theoretical model by means of experiments.

The main technical characteristics of the offered experimental model are the following:

- The dimensions were set by the customer.
- The rotor of the converter has spiral pipes filled with moving liquid.
- In the centrifuge, by means of mixing of liquid and air, we can create cavitation effects, so this aerated gas-water mix will demonstrate required physical properties, especially the important property of elasticity of working body.
- Start (beginning of rotation of the rotor) is caused by moving liquid mass in the rotor. The external centrifugal pump is used for this purpose.
- The liquid outlet (exit from the rotor) is organized through tangential nozzles of rotor pipes, and this outlet of mass will provide torque of the rotor.
- After the rotor is accelerated up to nominal speed of rotation, the working difference of pressure will provide self-motion of the liquid to inlet (suction inflow). After this point, the start pump can be switched-off, and it will be possible to connect the electric generator to the shaft to get electrical output power.

The technological features of this experimental design are the following: main parts of the device are made of stainless steel, bronze and copper (pipes). There are no special materials here. Bearings are standard parts as well.

The main parameters of the experimental model are the following:

- Calculated output mechanical power is planned to be 10 kW, for speed of rotation n = 3000 rpm.
- Time of operation is unlimited (non-stop).
- It is planned to use water, but in some tests it is planned to try to investigate other types of working liquid, such as oil.

Patent information presented herein is primarily from Viktor Schauberger's patents.[2,3] The analysis of the patents allows for a real practical application of this research project.

Metrological equipment required: tachometer, manometer-vacuum gage, thermometer. Measurement of rotation speed is from 10 rpm up to 5000 rpm. Measurements of pressure in the pipeline are from 10^4 up to $5 \cdot 10^6$ N/sq.m. Temperature limits of liquid are from +10°C up to 180°C.

1. Description of Subject of Research

1.1 - Decision of direction of research

The general research problem is the technical solution of autonomous power sources. The project considers recommendations of the customer about possible methods of realization of transformation of environmental heat energy into electric power by means of creation of vortex processes in a centrifugal mechanical device. This choice of direction of research allows use of industrial facilities of the customer to organize innovation and the manufacturing process.

1.2 - Analysis of the problem

At the present time there are two main directions of practical application of low-potential environmental heat energy.

The first direction is widely known: heat pumps can provide transfer and concentration of heat energy. This technology uses classical compression-decompression cycles of working gas (the low-temperature boiling liquid). Modern heat pumps can spend 1 kW of electric power to transfer 4 kW of heat energy into the house. The primary source of heat energy is air, water or earth, *i.e.* we must provide heat exchange with environment media. For example, the American company Raser Technologies can create low-temperature geothermal power plants in places where there are no natural sources of hot water or steam. This technology includes drilling wells to 150 or 200 meters with circulating hydrochloric liquid. The temperature of this heat-carrier is about 75 to 80°C, enough to provide operation of a low-temperature turbine and to rotate an electric generator with this turbine. For example, this company built an 11 MW power plant in Alaska, where there are no natural geothermal

sources of water and steam.

Development of heat pumps will allow creation of self-running autonomous sources, but this technical solution is complicated by low-temperature turbine. These devices are high cost, stationary and cannot be designed for small power level.

We have to note advantages of environmental heat conversion method. A positive ecological result of innovation of this energy conversion technology was shown in 1954 by Russian Prof. K.A. Putilov in his physics textbook.[4] He wrote about innovation of technology of absorption of environment heat: "Simple calculations demonstrate that if we could use environmental energy conversion for all auto cars in all countries of the world then only after 1700 years we will notice decrease of water temperature of World Ocean by 1/100 of degree."

The second direction of development of technologies are devices of direct transformation of environment heat into electric power or into mechanical work. Let's consider the main methods of this direction of environmental heat conversion technologies.

1.2.1 - Photo inversion of energy.

We know the properties of some substances (luminophors) to re-radiate incoming photons. Re-radiated photons have increased wavelength ("Stokes luminescence"). There is also another process: reduction of wavelength of the re-radiated light (increase of energy of photons) in the case of reflection from a luminophor ("anti-Stokes luminescence"). The additional energy of the photon is a result of transformation of inner heat energy of the luminophor's matter into energy of luminescent radiation. Due to capture of heat energy of the luminophor's matter, the matter becomes more cold, and then decreases its temperature and is compensated by inflow of heat energy from the environment.

Therefore, there is a real increase of power of luminescent radiation due to concentration of environmental heat energy. This additional energy can be very significant. Theoretically, it can reach 160% efficiency, *i.e.* luminophor can give out 60% excess energy. There are several practical applications of this effect: cooling of objects, luminescent maser, luminescent photon power multiplication.

1.2.2 - Chemical inversion of energy.

Open energy systems of the catalytic process demonstrate properties that accumulate energy and exist in a non-equilibrium thermodynamic state. This process is possible due to the combination of an exothermic reaction with participation of some catalyst and endothermic reaction (cooling) of the catalyst. These chemical reactions are capable of self-running in the case of absorption of dissipated environment heat energy. It allow us to consider perspectives of new technological processes.

There are modern galvanic cells using endothermic reactions. Energy to provide the reactions is absorbed from the crystal lattice of atoms of matter of this device. During operation of this galvanic cell its case becomes more cold. Here is continuous inflow of environment heat energy to the surface of this device (we can say "energy is concentrating" in this case). Therefore, electric energy output of this chemical power source is partially provided by absorption of environment heat energy.

1.2.3 - Mechanical inversion of energy.

There are several ways to use kinetic energy of air molecules, heat energy of water or other source of low-potential heat. The devices can be passive or active. The devices using jet (stream) technologies are active devices. The object of research of this project is one of the methods of mechanical inversion of environmental heat energy by means of special stream of working liquid. We'll consider it later.

1.2.4 - Gravitational inversion of energy.

The gravitational field makes the environment non-uniform, *i.e.* it create some "distortions" in all thermodynamic processes. It leads to increase of entropy. This circumstance was noted by Maxwell and Russian Prof. Konstantin E. Tsiolkovsky. They proposed an idea about vertical gradient of temperatures in the atmosphere. This gradient must be the result of a gravitational field. Tsiolkovsky also assumed that this specified temperature gradient must depend on molecular composition of gas (air).

Modern theory of this process was developed by Prof. V.F. Yakovlev. He calculated dependence of gradient of temperatures on molecular composition of gas. E.G. Oparin and Yakovlev offered an idea of a new type of power source, which consists of two vertical pipes filled with different gases. The temperature of two different gases in the top part of the pipes must be significantly different due to a gravity field. This gradient of temperatures between two pipes can be used to generate electric power, for example, by means of thermocouples.

1.2.5 - Thermo-inversion of energy.

An example of this method is a piston engine using compressed gas. In this device there is injection of some non-flammable liquefied gas (nitrogen, helium) in the chamber. Pressure of this extending gas will move the piston, thus the cylinder of the engine will be cooled, and environmental heat energy will inflow into this device. Output power of this engine mainly is made by extending gases and some additional power will be provided due to absorption of environmental heat energy.

1.2.6 - Electro-inversion of energy.

One of the most prospective methods is solid state semiconductor converter of heat into electric power. There are also other methods besides semiconductors. N.E. Zayev patented several methods of concentration of environmental heat energy. He used properties of nonlinear electric capacitors and nonlinear ferromagnetic materials. He demonstrated the possibility of excess output energy in nonlinear cycles of charge—discharge of capacitors, or in non-linear cycles of magnetization, demagnetization of ferromagnetic materials. It is also direct transformation of environment heat energy into electric power.

2. Justification of Physical Principles of Energy Conversion

2.1 - Conception by Prof. Tsiolkovsky

Russian Prof. Konstantin E. Tsiolkovsky was interested in discovering principles of the Universe, and considered it to be some type of "heat transformation machine." He and other scientists assumed that the orthodox classical physics con-

cept of the Universal Law of dispersion of heat (ideas about unidirectional increase of entropy in the Universe) is a very strange and doubtful concept.

In the article "Second Beginning of Thermodynamics,"[5] Tsiolkovsky refers to Clausius' postulate[6] about heat, paraphrasing: "Heat can't be transferred itself from a cold body to a more warm body." Keyword here is "itself," *i.e.* without special conditions. From this remark, Tsiolkovsky draws a conclusion about the existence of the possibility of capturing environmental heat, but it is necessary to provide special conditions for this heat transfer from cold body to warm body.

This remark gives us some basis to look for ways to transform environmental heat in Nature, in particular, we must study special vortex processes in liquids and gases. In some case, conversion of environment heat energy can be discovered in natural processes.

Further, considering energy of gas molecules placed in the area of gravity field action,[5] Tsiolkovsky showed that this potential field is sufficient condition to create in vertical column of gas the special non-equilibrium conditions of pressure and temperature. So, useful work and power can be provided here without expense (for free). It is necessary to note: in the proposed project we plan to build a centrifugal converter of energy using a similar principle. The difference is the following: instead of gravitational field of the planet we will use a more powerful centrifugal force field.

Tsiolkovsky wrote: "…it is impossible to deny the possibility of a second type perpetual mobile since the Universe doesn't deny it." The "second type perpetual mobile" is a physical term introduced by Prof. Ostvald. This device is a machine which works due to a reduction of environment media entropy, *i.e.* due to absorption of environment heat energy.

We completely agree with Tsiolkovsky's ideas, and we offer here a real technical solution in this field of research.

2.2 - Theory by Gennady N. Buinov

Gennady N. Buinov in his scientific publications[7-11] showed analytical regularities of closed cycles of gases, for open physical systems (*i.e.* inflow of environmental heat energy is possible in open systems). He noted an important aspect of concept of "entropy": This notion is not something real with some physical sense, it is just a mathematical function that is useful for calculations. From this point of view, the function of entropy can be non-continuous, *i.e.* it can be broken and it can "have a gap." Buinov proved the possibility of self-organization of processes in open physical systems in the case of spontaneous reduction of entropy. So, there is a possibility of free increase of energy in real technical devices, if we will provide heat exchange with environment.

Buinov calculated and designed several types of industrial power stations: industrial concentrator of environmental heat energy using cyclic conversion of titan hydride, cyclic heat energy converter using water-ammonia mix with standard steam-turbine, heat turbine power plant working with closed-loop processes based on four-oxide of nitrogen.

Technical projects by Buinov use non-equilibrium conditions of gases and mixes of gases. This topic is out of the area of our present mechanical inversion project. Nevertheless, his theoretical conclusions are very useful to make analysis of processes of transformation of environment heat to provide useful work.

2.3 - Concept of conversion of energy by Oshchepkov

Conversion of environment heat energy was developed in Russia by scientists Pavel K. Oshchepkov, A.F. Okhatrin, E.G. Oparin and other researchers. Oshchepkov mainly was a top-level designer and expert in Russian radar systems. In 1967 Oshchepkov created the Public Institute of Energy Conversion (non-profit organization) to develop research on energy conversion in Moscow, with State Committee on rational use of material resources.

Oshchepkov wrote[12] : "The most attractive dream of mankind is mastering of processes of natural circulation of energy. Energy cannot be destroyed, as well as energy cannot be created…therefore there are two paired natural processes of dispersion of energy and natural processes of concentration of energy. There are people who claim that this idea contradicts with the Law of thermodynamics. It is incorrect. The second law of thermodynamics is correct law in closed system, and this second law is confirmed in thousands and thousands real examples, it is solution of many scientific and technical tasks. It is senseless to challenge justice of second law for these closed systems. But in reality there are no absolutely closed systems. The world is infinite in space-time, and interaction between material substances is described by more complex laws than second beginning of thermodynamics. Future science will discover these new laws. Use of process of natural circulation of energy in the nature will reduce threat of overheating to provide heat balance of our planet. Also conversion of environmental heat is not related with radioactive danger or atmosphere combustion products. It open for us abundance of energy, it create main basis of life...It is very timely to find solution for practical use of natural energy circulation."[12]

Oshchepkov introduced the notion of "cessor." This term means "concentrator of environment heat energy." In some Russian publications we see the term "C-cessor" for the case of electric capacitor. Converters of environment heat into electric power, for example, can be designed on the basis of properties of a non-linear electrical capacitor (technology by N.E. Zayev).

Scientific ideas by Oshchepkov are more interesting than the standard concept of heat pumps. He wrote: "The power sources in future times, to my opinion, will be special electronic devices. This electronic devices must take heat from surrounding space and transform it into electric power. In this technology I see greatest scientific and technical task. Scientific, engineering and designer experts must try to find ways to solve this problem."[12]

Oshchepkov's Public Institute of Energy Conversion created a theory, made calculations and designed several electronic devices to provide electric output power by means of transformation of environment heat energy.

Oshchepkov wrote[12] in 1967: "Today we see expensive economics…Many years it spends irreplaceable natural resources of coal, oil and gas. One problem is exhausting resources but also the resources are excellent valuable raw materials for chemical industry. They are burned in fire chambers of power plants, polluting the atmosphere and lead us to catastrophical 'greenhouse effect,' which is more dangerous than thermonuclear catastrophe. There is one more paradox of traditional power engineering: huge amount of energy is produced in one place to be transferred by expensive and not-reliable power lines in other place for

thousands of kilometers to the consumers of energy...for example in the apartment to electric bulb. Isn't this way too difficult and wasteful? Everything can be organized by different way, with more simple and cheap way, more reliable, with more efficiency. Let's allow standard powerful power engineering systems with power transmission lines to provide electric power for large industrial plants. But many small consumers, especially in rural areas of North of Russia and Siberia, can use small energy converters of environment heat (one or two kilowatt of electricity). It is enough to provide one apartment with energy for lighting, heating and other needs. The volume (size) of this power source is about standard desk lamp. If mankind wants live in harmony with environment, it is necessary to make everything to learn methods of receiving energy from environmental heat without breaking of ecological equilibrium of the Nature."

These words by Oshchepkov are very timely today.

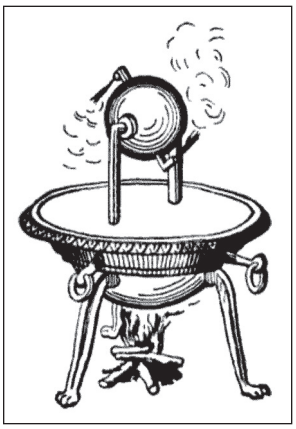

Figure 1. Steam turbine invented by Heron.

3. Analysis of Scientific and Theoretical Basis

3.1 - To the history of the problem

Considering centrifugal machines based on reactive jet effect, we have to note the ideas of famous inventor and scientist Heron from the ancient city-state Alexandria. In his treatise *Pneumatics* (about 120 years B.C.) Heron described various devices using compressed air or steam to move (rotate) due to reactive jet effect. Drawing is shown in Figure 1.

Heron's turbine uses vapor pressure received from burning fuel. All modern steam and gas-turbine machines work in the same ancient way today. The cycle of "burning–heating–pressure" is simple but this technology demands fuel consumption, *i.e.* it requires expense of resources. There is no novelty here if we replace one type of fuel with another, for example, we burn hydrogen instead of coal.

"Pressure of vapor" are the most important words for any power engineering expert. They know only one main law: it is necessary to spend fuel to heat water and to get high pressure steam, then a turbine can rotate the electric generator. The same idea was the main conception in the heads of drivers of old steam locomotives. There is no difference in this conception today.

Let me say some important news for these "experts": there is another method of creation of pressure. It is centrifugal pressure, and can be created without fuel. Some input power is necessary to start rotation of mass due to its inertial weight, but rotation can be organized in self-running mode. It was already known thousands of years ago, and periodically, this simple technology must be re-invented one more time for the benefit of humanity.

Let me note that approximately in 1760, Johann Andreas von Segner invented an engine based on reactive jet effect of out-coming stream of water. Segner didn't think about self-running autonomous operation of his device. He applied this method to apply centrifugal force for acceleration of water-mill rotor, which produces some useful work using water stream. In this machine it is possible to create big pressure of outgoing stream, since pressure is increasing due to action of centrifugal force. The pressure grows with increase of speed of rotation of the turbine. Many machines use the general principle of "Segner's wheel," presented in Figure 2.

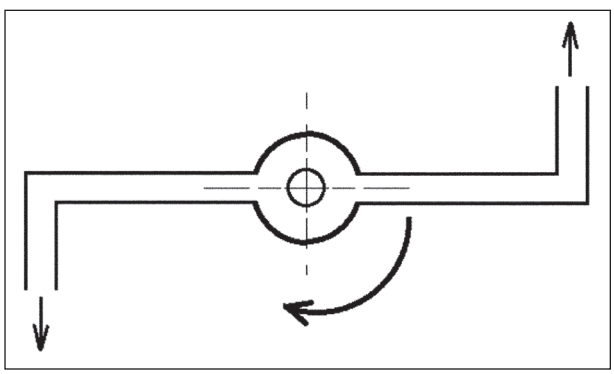

Figure 2. Segner rotor. Inlet of water is axial. Outlet is tangential.

If we can provide unlimited axial income of water, then this rotor will be rotating due to reactive jet effect. Also rotation must be accelerating rotation, if water is coming free of losses or losses are small. Let's note that the in center (along an axis) water flow moves with a small velocity, therefore this section of the axial pipe must be more than the total section of all tangential pipes. Also let's note that besides torque and rotation, in this design there is a paired force effect: inflow of water provide axial reactive propulsion force.

So, we have a new formulated task: it is necessary to create acceleration of water under action of centrifugal force. It allows the possibility of an increase in water kinetic energy and we can get additional kinetic energy for free. Then we can use blades of a turbine or some other method to use this additional kinetic energy for transformation into torque of the rotor.

For this purpose, it is necessary allow water to be accelerated during its motion under action of centrifugal forces. Thus, an optimum trajectory of its movement is logarithmic spiral of variable radius, shown in Figure 3.

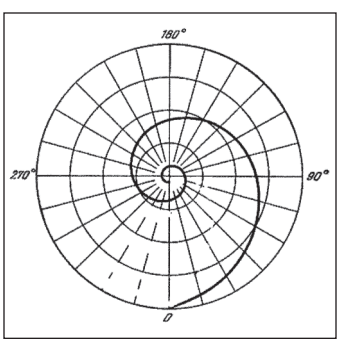

Figure 3. Logarithmic spiral of variable radius.

Some modern centrifugal water pumps and air fans already use similar design of blades to provide optimal trajectory of motion of liquid or air. In simple words, motion of water along any flat or conical spiral of increasing radius will allow water to be accelerated, that which create additional torque for this rotor. Use of air as working mass is also possible. It is much lighter than water, therefore speed of rotation of the air turbine must be much more than the speed of rotation of the water turbine to provide the same output power. It demands high-quality production facilities to manufacture some rotating parts and also to polish some parts of the casing.

3.2 - Viktor Schauberger

Let's consider an example of a self-rotating energy generator that was invented by Viktor Schauberger. This author also

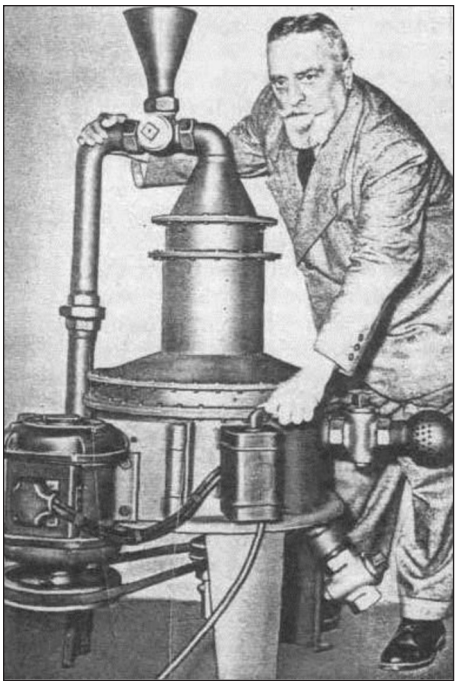

Figure 4. Viktor Schauberger and his "home generator."

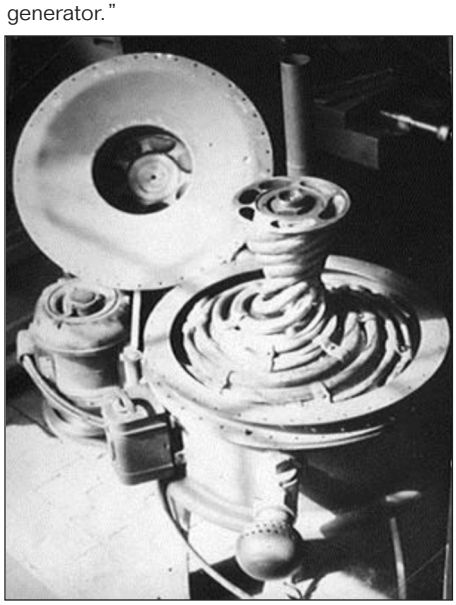

Figure 5. Design of the Schauberger rotor. Photo courtesy of the Austrian museum.

Figure 6. Schauberger device nozzle and micro-turbine.

developed a very interesting design of propulsion units for aerospace, but this report doesn't include consideration of new propulsion methods. Schauberger's inventions are practically very useful for development of new power engineering technologies. However, we note the following: all similar devices demonstrate both components of driving force—the axial propulsion force and the tangential force to get rotation. This aspect allows use of centrifugal machines both as power source and also as active (not reactive) propulsion unit, for example, for airspace craft, sea, river, auto or railway transport.

In Figure 4 one can see the original device made by Schauberger. This device provided his house with electric power and heat energy for several years.

Let's note, in Figure 4, in the right lower part of this machine, there is a spherical air filter connected with a crane. Let's assume it is necessary to adjust input of air into the system. At the left side, in lower part of the photo, you can see an electric generator connected by belt drive to the shaft of this centrifugal-vortex device. Above there is a funnel, used for filling the device with water. It is connected to a pipeline where water is circulated.

Some models of Schauberger's generators and original parts of his devices are stored in a museum in Austria. Figure 5 demonstrates an open view of the device.

The rotor includes several copper pipes which are bending around a cone. The input of water into the pipes occurs from the top (narrow part of the cone). Description of operation of this machine includes understanding of an important aspect: besides water, in the copper pipes there is alway some small amount of air. This condition is considered to be an important part of the design to provide successful operation of this device. Start of this machine requires some adjustment process: it is necessary to provide the correct ratio between the amount of water and amount of air in the mixture of water and gas in the pipes.

The second interesting feature of this device is the special design of the nozzle. In fact, it is a micro-turbine which doesn't rotate but creates rotation of the outgoing stream of water. Figure 6 demonstrates the design of the nozzle and Schauberger's micro-turbine. It is described in his patent.[3]

This technical solution has wide application in modern technical devices to increase the locity of motion of the jet stream at the exit from the nozzle.

There are some interesting facts: Schauberger's device demonstrated a self-rotation mode, but also it created a powerful axial (vertical) force. One of Schauberger's devices flew up and destroyed the roof of a building. [Schauberger's photo and photo of his devices in this report are published with permission of Schauberger's family (letter to Alexander Frolov dated January 2011)].

Viktor Schauberger solved the problem of hydrodynamic losses by means of his special micro-turbines; he also used an elastic working substance (air and water mix), which is an important aspect of this design. We will use it in our present project.

3.3 - Clem's experimental motor

We can consider one more interesting example of a technical device. It is Clem's motor. This machine also uses centrifugal force to create self-rotation mode. In 1972 Richard Clem worked as heavy road machinery operator in Dallas, Texas. He discovered that the rotating sprayer of hot asphalt can continue rotation after switch-off, and this rotation can be very continuous (about one hour). The design of this equipment is simple: the axis of this machine is vertical and its rotor has a conical form.

Clem did not know theory or Schauberger's results, but he empirically studied the problem to build a self-rotating "Clem's motor."

Figure 7 is a schematic diagram of Clem's generator.

This device also uses centrifugal force and motion of liquid in a special conical extending trajectory to increase torque of rotor. It is just an idea in general, according to general information, without real sizes and details; it wasn't tested experimentally. We will note here an important aspect: heat exchanger with environmental media (air or water) is presented in this case.

Figure 8 demonstrates the scheme of a similar device and pos-

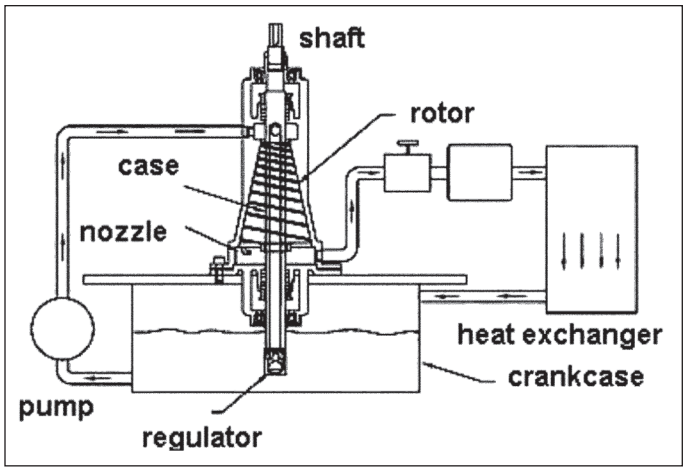

Figure 7. Principal scheme of Clem's device.

sible form of the rotor. The conical rotor is placed inside of a conical case. There are several spiral channels on the surface of the rotor. These channels must provide motion of liquid along the cone surface. The liquid comes to the end of the cone and moves out of the channels through several nozzles.

There is a recommendation for similar designs and we already reported about this aspect: it is necessary "to allow acceleration of moving liquid" since it is moving by action of centrifugal force. For this purpose, the spiral channels must have increase of step with increase of radius, and also it can be useful to provide variable cross-section of channels (it must be increasing as it approaches the nozzle).

There are several important aspects of this design of rotor. Segner's reactive effect produces torque and rotation but it is not the only reason for rotation. Acceleration of moving liquid along a spiral trajectory and interaction of this liquid with rotor must provide to this rotor additional torque. At the point of inlet (entrance to rotor) velocity of liquid is equal to speed of rotation of this rotor. In the last part of trajectory (near the nozzle) the liquid is moving quicker than the rotor. The increase of velocity of liquid is caused by centrifugal effect, it is a clear analogy of accelerated falling of a body in gravitational field. Thus, the rotor is accelerated by interaction with the liquid if it is moving more quickly than the rotor. At some speed of rotation, the external primary drive can be switched-off, and the device can be used in self-running mode of energy generator. It is possible also to use kinetic energy of stream after it will exit out of the nozzle. For this purpose it is necessary to apply inclined reflectors on the rotor, *i.e.* blades of turbine.

Thus, in this design there are three key aspects:

A. Acceleration of liquid is possible if we allow possibility of increase of its radius of motion. This motion is accelerated due to centrifugal force. If the liquid can move more fast than the rotor, some additional torque can be created.

B. The jet (reactive) Segner's effect provides acceleration of the rotor.

C. Additional torque can be provided by interaction of outgoing water stream and blades of the turbine, which is fixed on the rotor.

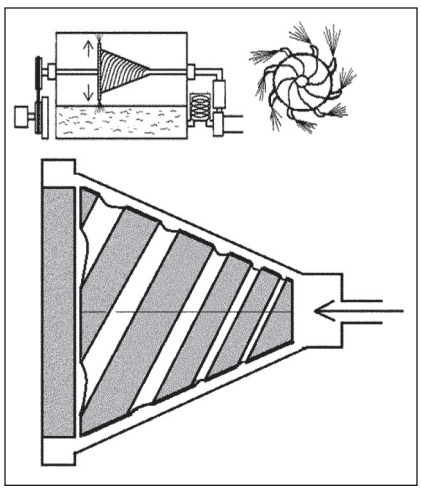

Figure 8. Version of Clem's device.

We have to note an important aspect: Richard Clem used Mazola food oil. The working liquid during operation was heated up to +150°C. Water in this case will boil, so oil is a better idea. Also we suppose the oil is more elastic than water.

There is little information about Clem's real device: liquid was forced in hollow shaft with pressure about $2 \cdot 10^6$ N/sq.m, then liquid moves across spiral canals of the cone and then it leaves the rotor through nozzles. It forced the cone rotor to rotate. Speed of rotation reached 2300 rpm. A heat exchanger (radiator) was used to cool the liquid (oil).

It is known that the first version of Clem's motor failed. Clem made a second version of the engine to be more strong. Some parts are shown in Figure 9, in the photo on the left. This version is a 250 kW motor, with a weight of about 90 kg. Clem installed this motor in a car and demonstrated its work on trips. The accumulator battery in the car was used only for start of Clem's motor and to provide lights for the car. A 1972 newspaper article[13] noted that Clem designed a "seven stage pump and a 'converter.'" The article noted that the pump "is used to move the oil, under pressure, from a storage area to the converter from where the energy is converted into enough power to turn the motor."

So, we can describe the main principles of operation of Clem's motor: working liquid (oil) passed across several canals in accelerated mode. This process provides increase of torque of the rotor. Then the liquid (oil) comes back to the collector tank, from the tank it goes to the heat exchanger and then the cycle of motion of liquid is started again. This energy converter operated like a turbine, but Clem said "it wasn't a turbine in usual sense of this word."

Clem's engine was tested by Bendix Corporation. The test consisted of dynamometer measurement of generated out-

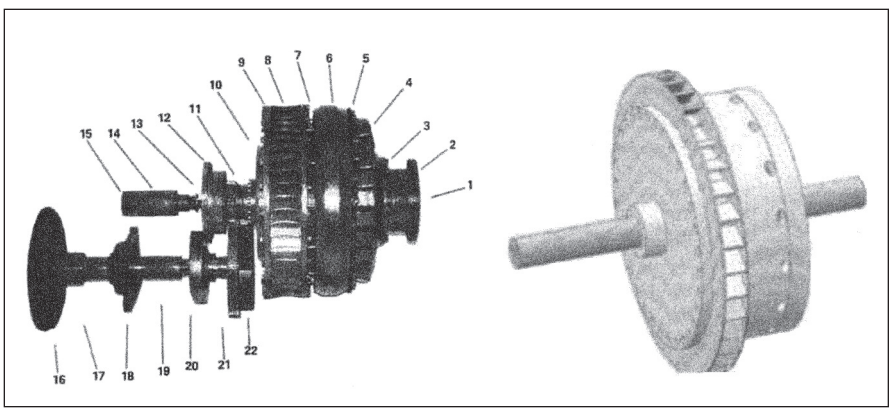

Figure 9. Left side: photo of original parts. Right side: 3D model.

put power in self-rotation mode. The engine was tested with 250 kW real load, continuously over nine days. It was a successful test, and Clem signed contracts to produce several generators for a coal company, but these production plans weren't realized.

The special features of Clem's device (what we know now) show an important role of a form of rotor. Also, a heat exchanger is important for a compact power unit of transport application.

3.4 - Scheme by Leopold Scherjau

One more attempt to create centrifugal-vortex converter of energy was made by Leopold Scherjau, his scheme is presented in Figure 10. This device wasn't successfully tested. There are significant problems with this design. This scheme is very similar to Schauberger's device, but here there is no conical rotor (there are rotor spiral pipes but radius of rotation of the liquid is very small and it is constant value). In my opinion, this aspect is important and a cone rotor is necessary in this device. We can see at the left part of Figure 10 an air inflow adjustment crane and also an air filter. Main part of rotor here has constant radius, therefore working liquid has no opportunity for accelerated motion (here is no increase of radius of rotation). In the lower part of this rotor, moving liquid leaves pipes in radial direction and comes to tangential nozzles. Small torque can be created but we cannot get additional torque since there is no conical rotor.

Optimization of design of this machine requires a special trajectory of movement of liquid. Radius of rotation must be gradually increased. Optimal form is trajectory of logarithmic spiral. It gives maximum freedom for moving liquid to increase its radial component of speed due to centrifugal force.

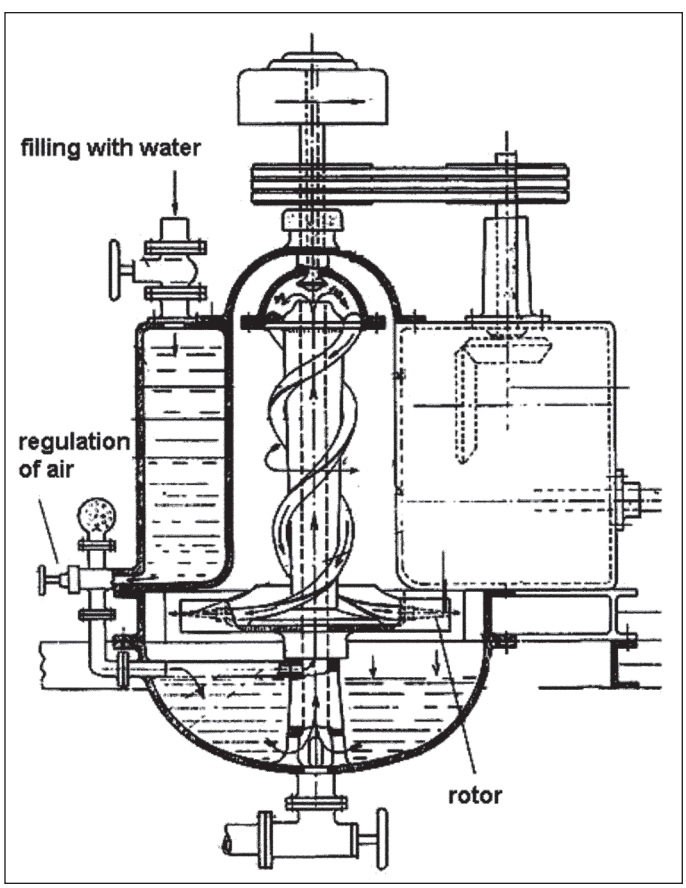

Figure 10. Scheme by Leopold Scherjau.

3.5 - Yuri S. Potapov's conception

We can consider practical achievements in the area of self-running devices, such as "quantum heat power plants" by Yuri S. Potapov. This power plant is shown in Figure 11. Here is heating of moving liquid. Electric power is generated for customer but part of this output power is necessary to use for pumps.

Principle of action of this power plant is the following: pump pushes water in special device to produce vortex turbulences (cyclone). After acceleration of water in cyclone it comes through nozzle to water-wheel (turbine). The turbine is connected to electric generator. In lower tank there is a second water-wheel turbine; this wheel is also connected with an electric generator. Temperature of working liquid is about 70 - 100°C, pressure is about 8 - 10 Atm in the area of the nozzle. This stream of water provides operation of the first turbine. The second turbine is placed in the lower tank. It works due to falling water stream. Thus, this device produce heat energy and electric energy without expense of fuel, and this technology is environmentally clean. We have no information about the manufacturer, test reports or operating experience of this equipment.

In Potapov's scheme we see both heat generation effect and excess kinetic energy produced by centrifugal machine. A special feature of this scheme is two-cascade transformation of kinetic energy of the water stream.

3.6 - Hardy's self-running water pump

Let's consider one more prospective direction of research in the area of autonomous power supply. Figure 12 is photo and scheme of an experimental turbine. James D. Hardy patented this idea.[14] The design is very simple; it is a "home

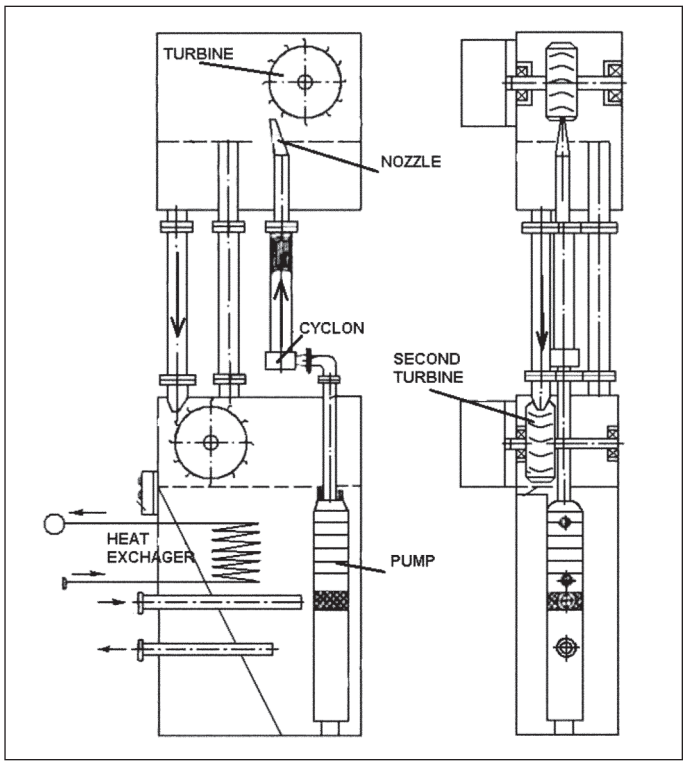

Figure 11. Scheme of two-stage electrical power plant by Yuri Potapov.

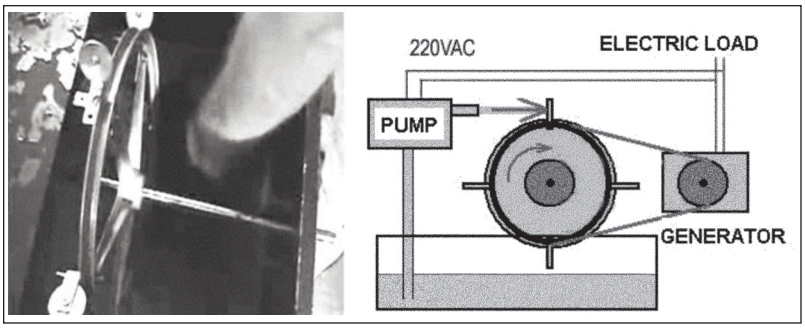

Figure 12. Hardy's experiment.

made" device.

There is some information about parameters of this pump: it is a high pressure pump, standard application is compact automobile high pressure sink, power input is 220VAC. Pressure of water stream is about 10^7 N/sq.m.

Productivity of the pump in Hardy's experiment was about 350 - 600 liters of water per hour. Consumption power was about 1 kW/hour. Output power provided by turbine is corresponding to kinetic energy of water flow and it is equal to about 25 kW. So, according to experimental data reported by Hardy, he succeeded in achieving autonomous mode (self-running process). In this mode the electric generator connected to the turbine must provide power for the pump and also extra-power for several lighting lamps (useful load).

We can note that speed of rotation is slow in the case of direct axial connection between generator shaft and turbine, *i.e.* it cannot provide correct speed of rotation of electric generator. To increase speed of rotation the shaft of the turbine uses a flywheel of large diameter and belt drive to provide connection to generator shaft of small diameter.

We can assume that Hardy's device proves the possibility of obtaining excess kinetic energy of stream of liquid in the case of centrifugal pump and very high pressure.

3.7 - Bogomolov's centrifugal energy converter

Vyacheslav I. Bogomolov invented a centrifugal converter of energy. The experimental device was created and tested at Faraday Ltd. in 2003. The scheme of this simple device is shown in Figure 13 (in this case the spring is free, *i.e.* it is non-compressed). In Figure 14 the energy converter is demonstrated in position of compressed spring.

Design is simple: during rotation two loads (inertial masses) are displaced on bigger radius of rotation and due to this motion of loads they compress the spring.

The essence of this invention is energy transformation method: during first stage, centrifugal forces compress the spring (or other elastic body), rotation can be provided by electric motor-generator. Then, in second stage the loads are rotating by inertia, and the spring is straightened. This process means transferring of the loads to smaller radius of rotation. Potential energy of compressed spring is converted into kinetic energy, which increases torque of shaft and electric motor-generator, which in this phase of cycle works in generator mode.

This device was tested experimentally, for the case of movement down and up, in gravity field (vertical direction). Figure 15 shows the scheme of this experiment.

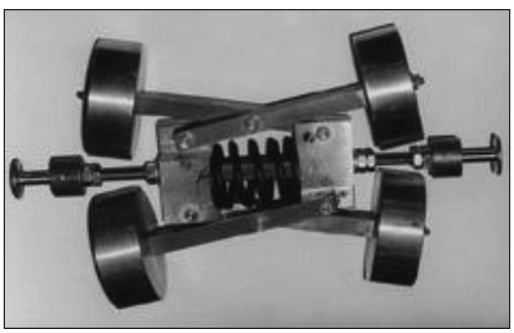

Figure 13. Bogomolov's converter of energy.

Figure 14. Bogomolov's energy converter in position of compression.

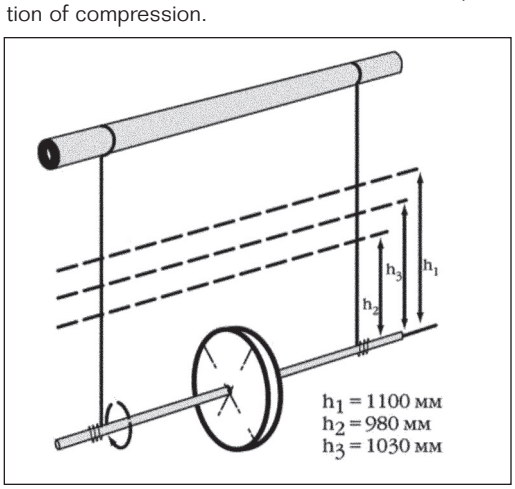

Figure 15. Bogomolov's experiment.

In initial state, two threads are wound on an axis of the device shown in Figure 15, and the device is placed at an initial height level h_1. After release, device moves down with acceleration, from initial height level h_1 to lower point. After it will be stopped, then due to inertia it will begin movement up. It cannot reach position of initial height h_1. There are some losses of energy. It can reach position on level h_2 or h_3.

During experiment, initial level and stop-point are the same, but levels h_1 and h_2 were measured and compared. We have to note that motion of the device up and down was organized with rotation, and centrifugal forces provided compression of the spring.

In the first version of this experiment the spring was fixed by strut. The device fell down from a height of 1100 mm; after passing the lower point, the device rises again up to height of 980 mm. The spring was fixed by strut, *i.e.* it was not compressed by centrifugal forces. In the second version of the experiment the spring was compressed by centrifugal forces in stage of falling, and the spring was straightened during motion up. In this part of the cycle, potential energy of compression was transformed to rotor torque (kinetic energy). In this case, after falling from the same height of 1100 mm, after passing the lower point, the device reached a level of 1030 mm. The difference between 1030 mm and 980 mm proves the existence of the effect of transformation of energy in the second version of the experiment (using the spring compression by centrifugal forces of rotation).

This experiment was repeated many times to collect statistical data. Accuracy of measurements was about 10 mm. Figure 16 shows the experiment. More details about Bogomolov's projects is in magazine *New Energy Technologies*.[15]

The method proposed by Bogomolov is very important for design of centrifugal and vortex energy converters. Elasticity is an important property of working matter of converter. Elasticity allows collection of potential energy of compression of elastic matter placed in area of centrifugal force field, and then to release it during de-compression of elastic matter. Gas or mix of gas and water can be used as elastic matter.

3.8 - Prof. Alexandrov's discovery

Prof. Alexandrov discovered (1957) the effect of transformation of potential energy to kinetic energy and it is interesting for us to consider application in the present research work. Alexandrov demonstrated a very simple experiment: a steel ball falls from some height, it falls with acceleration, and in the lower point of its trajectory the ball is reflected from a steel plate, then the ball moves up. Alexandrov demonstrated that after reflection the ball can rise above the position of its start, if it began the movement down with zero kinetic energy. This fact seems strange as this ball falling down, after collision with a plate, can get some additional energy to reach the point above the point of start.

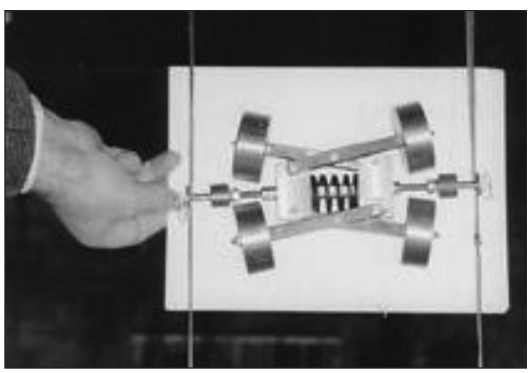

Figure 16. Bogomolov's experiment.

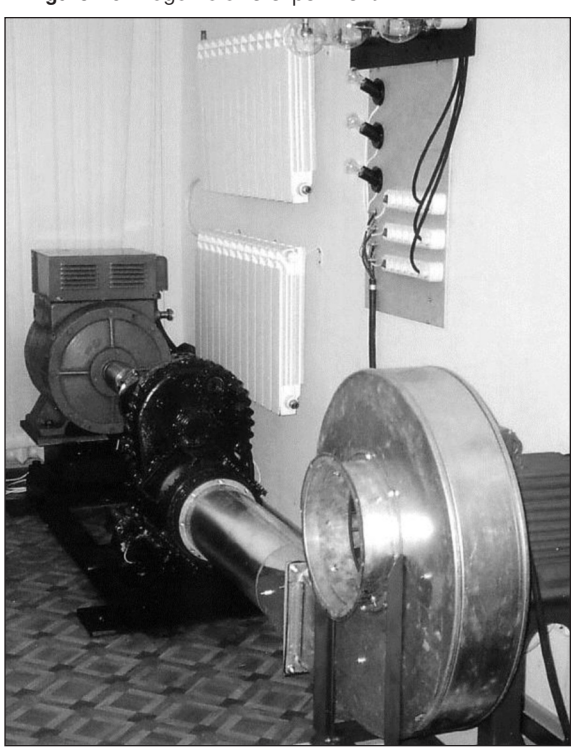

Figure 17. Experimental device in Faraday Lab Ltd, 2004.

Explanation of this effect wasn't made before and here we can offer some ideas. It is possible to assume that this effect is the result of elastic deformation of the ball in the process of collision. The reason for excess energy is some hidden energy in the form of compression of metal of the steel ball. Really, after several impacts, the ball partially loses elastic properties and the effect gradually decreases.

In this example, stages of accumulation and transformation of energy, are useful for us to design centrifugal-vortex converters. It is important to use the property of elasticity of matter to store energy and then to transform stored potential energy of compression into kinetic energy of motion.

3.9 - Experiments with air molecular motor

Let's consider a project from 2004-2005 by Faraday Lab Ltd. This project was named "molecular engine" by Yuri S. Potapov. The term "molecular" is related to kinetic energy of air molecules, which depends on temperature. We know that air molecules are chaotically moving but vector sum of all molecules in some volume of space is equal to zero. We can transform their energy into useful work, at least partially, if we create their directed movement (stream laminarization). In this case the vector sum of kinetic energy in volume of air will not be equal to zero.

Subcontractor in this research project was Degtyarev's factory (Kovrov, Russia). They designed, developed and produced the main part of the test bench for this experiment, named UKS-37. Theoretically, it was planned to produce excess electric power. A 37 kW electric generator was rotated by helicopter turbine. The turbine was powered by air stream from a fan. Power of air inflow (its kinetic energy) must be sufficient to provide functioning of the fan electromotor and also provide some power in useful electric load. There is a special cylinder-pipe between air fan and turbine. Some special conditions were created in this pipe to "take off" part of the kinetic energy of molecules of air and then to transfer this additional energy to the turbine. This device is shown in Figure 17.

We already considered a similar case in Section 3.6: excess kinetic energy is created already by centrifugal fan, due to elastic compression of air under the influence of centrifugal forces. The next stage is energy transformation of potential energy of compressed working body into its kinetic energy, then we must transfer this additional kinetic energy to the rotor. Also we must develop some method of reduction of losses, that can be experimentally investigated. These methods of optimization consist in installation of passive elements (reflectors) of air flow. These reflectors create vortex effect without energy consumption from an external source.

In other words, reflectors provide transformation of pressure of air stream into kinetic energy of rotation of molecules of air. This air flow makes the turbine rotate. The turbine is a helicopter gas-turbine GTD-350, with its standard gear box. Maximum electric power of electric generator GS-250 is 60 kW. Initially, source of air was centrifugal VPZ fan, diameter of its rotor was about 1 meter, consumption was about 7 kW, manufacturer is plant in Chudovo, Russia. Later, fan unit was replaced with another centrifugal fan: VDS-5 type, manufactured by LISSANT.

It was planned to reach autonomous mode of operation of the UKS-37 device and demonstrate about 37 kW of output electric power.

History of development of this project is the following: Potapov's concept was true, undoubtedly. There were orga-

nizational and technical difficulties to get autonomous mode of operation. Stage of production of experimental device was delayed by subcontractor. After production of this experimental setup, first tests in Kovrov city did not demonstrate autonomous self-running mode. After subcontractor reported to the customer (Faraday Lab Ltd.) about problems, we discussed possible development of the project. Customer did not receive workable device but subcontractor transferred to the customer the experimental test bench for further stage of experimental research. This work was organized at Faraday Lab Ltd. by myself and Igor Pogonyaylo.

The experimental device was received from subcontractor with broken fan. Due to this reason, the fan was replaced with new centrifugal VDS-5 fan; productivity is about 800 cubic meter per hour, electricity consumption is about 5 kW/hour (nominal).

Self-running autonomous mode in this design was impossible: VDS-5 fan cannot provide sufficient kinetic energy of air stream to overcome losses in low efficiency of turbine and electric generator. Consumption power of fan was about 5 kW/hour, so electric generator can provide about 3 kW/hour power. Attempts to increase electric load lead to decrease of quality of electric power: decrease of speed of rotation of electric generator and power voltage level. Technical solution was simple: we tried to increase volume and pressure of working air mass. For this purpose we planned to use a new AF53 compressor (air pressure was ten times more than pressure of VDS-5). Estimated results were about 30 kW/hour of output electric power, for input power about 10 kW/hour.

Due to lack of financing and also after technical problems with gear box of the turbine, this project was stopped in 2005. The experimental test bench was sold to another company, in Moscow. We do not know about results of experiments with this device after 2005.

During this experiment, some important aspects of optimization of this device were studied and proposed by Faraday Lab Ltd. At first, it had reflectors placed on the inner surface of the cylinder pipe. The cylinder had 400 mm diameter and 1000 mm length. This cylinder was installed between the centrifugal fan and the turbine. The reflectors on the inner surface of the pipe created vortex, *i.e.* "screw rotary process" of air motion. In this case output power in load of electric generator was increased by 5-7% in comparison with experiment without reflectors (rectilinear movement of air from the fan to the turbine).

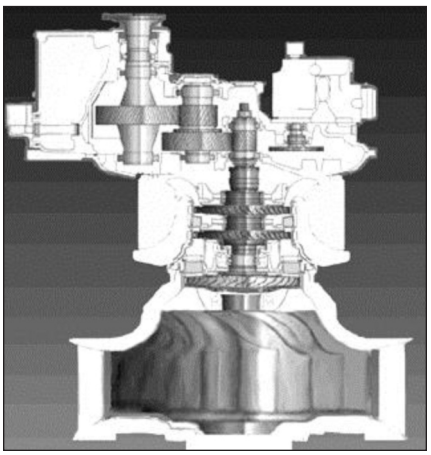

Figure 18. Scheme of EF9.

We can say it is free addition kinetic energy since rotation of air flow was provided by means of passive inclined reflectors. This increase in output power was created without increase of input power, due to change of a trajectory of the air flow in the pipe. By this way we can use part of potential energy of compressed air but main part of this free energy is transformed into kinetic energy after outlet from the device that is not useful for torque.

The concept of use of centrifugal machine is correct if we will use elastic working matter (for example, air) and we can hope to get self-running mode of operation in this case. It was possible to provide about 3 kW of output power (load was standard electric lamps with tungsten filament), and connection of this load to generator was not related to increase of consumption power.

It is especially important to note that it was possible to increase output power of electric generator exit by means of passive reflectors, *i.e.* with vortex motion of air. Also note: vortex motion is the sum of linear and rotation motion—there is centrifugal force, so there is additional compression of elastic matter.

3.10 - Air turbine designed by Haskell

There is some information about a self-running air turbine from the 1960s by Karl Haskell. Development of this project was organized by Ron Rockwell. There is no information about a patent but it is possible to note some parameters of this self-running turbine: speed of rotation is about 100,000 rotation per min. One more aspect: there is high electric potential due to air ionization.

We can assume that ionization of air will reduce friction in environment air, and in this way we can reduce losses. This method can be applied for design of a centrifugal-vortex machine using air as working body.

3.11 - Energy converter "EF9"

Another example of research a project in our area of interest is EF9 Energy Systems. They investigated technology of transformation of environment (air) heat energy into useful work. The scheme of this generator (3D model of 2011) is shown in Figure 18.

The authors didn't provide a description of principles of operation of this device. They believe that the main role in transformation of energy here is "Bernoulli's effect." The purpose of the EF9 Energy Systems is creation of a 50 kW generator for houses and also a compact energy generator (drive) for transport.

In analysis of processes of transformation of energy, for the cases of gases and liquids, we can use classical formulas and physical concepts, including Bernoulli's formula of calculation of total pressure of a stream.

4. Comparative Analysis, Advantages and Disadvantages of Methods

Let's consider advantages and disadvantages of several methods of creation of centrifugal-vortex converters of energy.

The advantages of Schauberger's device is its simplicity of manufacturing. From the other side, vertical axial arrangement of the rotor cannot be applied for some vehicles. An important feature of this technology is elastic working body (mix of liquid and air), and also special vortex micro-turbines to decrease hydraulic losses.[2,3] A useful aspect of this technology is "pair effect," *i.e.* axial propulsion force and torque force is created in pair.

Scherjau proposed a device without a conical rotor, therefore motion of water is organized here along the spiral of

constant radius. This motion doesn't provide transfer of its kinetic energy to the rotor. We can use this scheme for information about configuration of parts of centrifugal energy converter.

A simple experiment by Hardy demonstrated a possible technical solution of transformation of energy. It is a stationary device, therefore we must develop this design for other applications including transport. An advantage of this method is standard high pressure pump. Additionally it is necessary to design a turbine and general configuration of parts. A critical view of this device is that the pump can create high pressure but this pressure must be used to compress some elastic working body, according to the concept presented here. If so, the pump-turbine-generator setup can be a self-running power plant.

We considered air converters. It can also provide a self-running operating mode. Application of this technology can be more practical than liquid centrifugal-vortex energy converters. An advantage of this technology is working body (air). It has the important physical property of elasticity.

Clem's design is an optimal scheme for a converter. It uses liquid. Original schemes aren't available for open consideration, but basic principles can be reproduced according to available data. It will allow use of this scheme and design centrifugal-vortex converter of energy. It is especially important to note the fact that the working liquid in Clem's device is oil, *i.e.* elastic working body. The device creates torque of rotor and also heat energy. Oil technologies allow working with more high pressures and temperatures than water technologies. Also the oil is not a corrosive liquid, which is important for metal parts of the device.

5. Determination of Goals of Research Work

The purpose of the present research work is development of engineering approach to the idea of high efficient transformation of environment heat energy into electric power. It must be reliable, simple and low cost in manufacturing process.

In the theoretical part of this research work, we must consider a method of calculation of the main parameters of the process of transformation of energy, including calculation of losses of useful power and ways to minimize losses.

Calculation can be made by the dynamic method, considering accelerated motion of body in field of action of centrifugal force for the case of rotating liquid in the rotor. For this purpose, it is necessary to show conditions of this accelerated motion of the liquid, and then to calculate average normal acceleration for cases of several different angular speeds of rotation of the rotor.

Further, it is necessary to show efficiency of centrifugal-vortex converter of energy and make approximate calculation of hydraulic losses (losses of pressure on length of pipes). In addition, it is necessary to calculate losses in back-up pipeline (return of liquid to start point).

It is necessary to consider influence of difference of atmospheric pressure between area of rotation of the rotor and other parts of the hydraulic system. This device can work in hermetic or non-hermetic case.

To make verification of data that is calculated by dynamic method it is necessary to calculate value of power output by other methods, for example, by calculation of pressure difference in the system. Comparison of two results will allow us to see the value of error of the calculations.

6. Justification of Choice of Optimum Design

Considering several analogical designs in Section 3, it is possible to make a proposal about optimal design of a device to test the theoretical concept of centrifugal-vortex converter. The following parts must be provided: conical rotor, spiral channels (pipes) for motion of working liquid along trajectory of increasing radius, tangential outlet of working liquid and backup pipe to return liquid to the start point by external pipe. The form of pipes (channels of motion of liquid) has to provide optimal transfer of kinetic energy of liquid to rotor. This form is variable step and radius of the spiral pipes. In initial part of rotor, the step of spiral is maximum and radius is minimum. Near the nozzle, spiral step is minimum and radius is maximum.

It is planned to use water as working liquid, and, if necessary, to try with oil. In this regard, in a design it is expedient to apply oil-proof glands.

The most important is elasticity of the working body, in particular, air and liquid mix. This mix will provide accumulation of potential energy in form of elastic compression of the mix. Further it will be possible to transform this potential energy to kinetic energy of motion of liquid and to torque of the rotor, then the rotor will make the electric generator shaft rotate. Creation of air and liquid mix is planned in area of centrifuge. Here are conditions for cavitation of liquid and formation of bubbles. Also here is compression of elastic water-gas mix under influence of centrifugal forces.

7. Description of Principle of Operation of the Converter of Energy

The theory of mechanical centrifugal machines which can provide self-running mode demands serious study of concept of rest mass and inertial properties of matter bodies. In general, it is possible to say that centrifugal force and other inertial effects are aether-dynamics phenomenon. It is similar to aerodynamics in air environment: if we can create gradient of pressure in aether or in air then we will obtain lifting or propulsion force, and in some cases, both components of force. In simplified view, centrifugal force creates increase of potential energy of a body for free. This additional energy can exceed expenses of energy of primary source that is necessary to provide rotation of working liquid. Engineers and designers must "release" working liquid to allow it to move along the line of action of centrifugal force. In this way the liquid will get maximum acceleration and effectively use its kinetic energy. This engineering project is a very interesting commercial project also, since the level of mass production centrifugal-vortex converters of energy can become simple, reliable and inexpensive power sources for many practical applications (home, industrial, transport).

The design is shown in Figure 19. Let's consider principle of operation of this centrifugal-vortex converter of energy.

Water, or other working liquid, comes to branch pipe (on the right side of Figure 19). The pipe is fixed on flange of external case. It should be noted that working liquid has some rest inertial mass. This mass provides its inertial properties in rest and in motion. We cannot develop theory with-

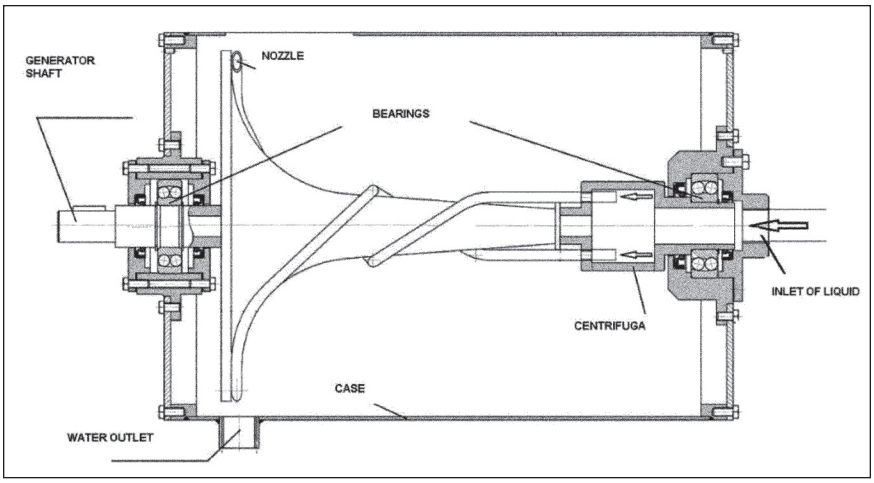

Figure 19. Sketch of centrifugal-vortex converter of energy.

out clarification of theory of matter and its physical properties. We need understanding of principles of operation of centrifugal-vortex converter of energy, since it uses inertial properties of liquid working body. We have to understand the following: aether is connected with matter particles of a body and it is the property of a physical system including a body and aether environment. This physical system is an open system and we can organize energy transformation in this system. We will especially note that aether is considered in the concept to be an elastic medium, on this level of energy. Russian Prof. Dmitry Mendeleev[1] explains the properties of matter in simple words: "...aether can be defined as weightless and elastic liquid, filling space and related with all bodies. Aether is recognized by physics as reason of light, heat, electricity and so on. It is possible to say that aether is similar to gas…Calling aether a gas, we must consider a fluid in the general sense, as elastic fluid which doesn't have coupling between its particles."

For understanding of the physics of the considered processes it is important to see the role of concept of mass of particles of matter, including aether. Faraday[16] wrote: "Matter is everywhere present...There is no intermediate space which isn't occupied with it...Hence, matter will be continuous throughout, and in considering a mass of it we have not to suppose a distinction between its atoms and any intervening space. The powers around the centers give these centers the properties of atoms."

So, inertial properties of mass are provided by aether, which is connected with particles and is placed between atoms. Therefore, accelerated motion and centrifugal force are effects of elastic interaction of a body with surrounding elastic aether environmental medium. From this point of view, additional energy and excess torque (kinetic momentum) can be obtained in technically closed physical system. In this case, it can be caused only by transformation of energy of environment, *i.e.* elastic deformations of the environment and thermodynamic changes in it. We can observe deformation of aether as absorption and emission of heat.

More deep consideration of the analysis of the physical mechanism of elastic interaction of bodies is out of the scope of the present research work. Let's note in short that the essence of the phenomena of elasticity is electromagnetic interaction of atoms; we can design and test some mechanical device but we have to remember about aether and electromagnetic nature of any matter.

Let's consider parts of the design of centrifugal-vortex converter. The so-called "centrifuge" provides rotation of liquid if the rotor is rotating. Later we'll calculate the value of input power to be spent for initial acceleration of working mass (to change its orbital velocity).

At the beginning of the cycle, working liquid arrives in branch pipe under pressure from pump, and then it passes area of centrifuge with rotation. It creates conditions of cavitation process and provides aeration of working liquid and its elastic properties. Further, working liquid is moving towards a nozzle inside of several pipes (fixed on the surface of the rotor). In this design it is planned to use eight identical pipes placed symmetrical. Figure 19 shows only two pipes of a total eight pipes.

At the beginning of work the rotor is motionless. Liquid comes in pipes at the centrifuge, then it passes into spiral-screwed pipes and it is moves to the wide part of the conical rotor, then leaves the pipes through nozzles. Velocity of motion of the liquid at the initial stage is dependent on the pressure of the pump; the pump is necessary to start. Increase of speed of rotation is result of reactive jet effect (Segner's effect).

Further, rotation leads to acceleration of orbital motion of the liquid in the centrifuge and also to acceleration of linear motion of liquid in pipes. The pipes are made in the form of a screw spiral of variable step and variable radius. At the start (on minimum radius of rotation of liquid) the spiral has a big step, meaning that the axes of the pipes are located at a small angle to the axis of rotation of a rotor; it is almost an axial position of the pipes. This part of the rotor creates a liquid condition of accumulation of additional potential energy (compression) without possibility of its transformation to kinetic energy. In the process of motion of liquid to the nozzles, the angle of spiral increases and this change of position means the possibility of accelerated motion of liquid in the field of centrifugal forces. There is a decrease of static pressure and expansion (increase in volume) of air bubbles of water-gas mix, which is the process of conversion of potential energy. As the velocity of the liquid increases, dynamic pressure also increases and static pressure in the pipes decreases.

Let's note that acceleration of liquid in the process of motion in pipes towards a nozzle creates vacuum (decompression) in area of centrifuge and inlet branch pipe. The pump can be switched-off if speed of rotation of the rotor reaches critical number of rpm, necessary to overcome hydraulic losses and power of initial acceleration of incoming liquid. Theoretically, it will be calculated in Section 8 that losses on friction are about 10% of total kinetic energy of flow of liquid. So, the device can be self-running.

Further, rotation of the rotor will be possible in autonomous self-running mode. Increase of speed of rotation of rotor depends on several aspects of transformation of kinetic energy of stream of liquid to the rotor torque. It will be considered in the following point of the report (calculations and results).

In the case shown on the left in Figure 19, you can see hatch to provide service access to elements of the rotor. It is possible to regulate angle and position of reflectors of third turbine. For sealing of the case, the hatch must be used with rubber laying on all perimeters of the hatch. A shaft to connect electric generator is provided in left part of the rotor. Electric load must be switched on after the rotor reaches nominal speed of rotation. Electric generator is standard and its nominal is 3000 rpm. Theoretically calculated power is 10 kW on nominal speed of rotation. The general scheme of circulation of liquid will be shown later, Figure 26. There is also a crankcase to collect liquid after exit from nozzles. In self-running mode (nominal speed of rotation) liquid will move from crankcase under influence of pressure difference (without pump).

8. Method of Calculation of Main Parameters of Energy Converter

8.1 - Conditions of accelerated motion of working liquid

There is a main condition of accelerated motion of the working body in this design: working liquid must have elastic properties. Incompressible liquid can't be accelerated as continuous stream and due to the incompressibility flow of this liquid will have gaps and strong turbulence.

The reason for movement of liquid in rotor pipes is gradient of pressure. The movement is directed towards smaller static pressure (maximum dynamic pressure) which is created in the wide part of the cone rotor. Thus, due to form of the rotor and its elements, in this device we can create reactive jet effect (outlet of liquid from nozzle), and also conditions of transformation of kinetic energy of stream to rotary motion of rotor. To provide this condition, pipes are made in form of screw spiral.

Description of principles of operation was made in Section 7, but now we consider detailed transformation of energy in the design.

Hydrostatic pressure in liquid is analog of potential energy, and it can be transformed into kinetic energy. An example of this case is a falling body. It is moving with acceleration of gravity "g." Similarly, we can consider potential energy of rotating liquid, which can't increase its rotation radius (for example this radius is limited by the rotor case). In our design of the rotor, there is part of a rotor with spiral pipes to collect liquid in some volume. This volume is area of centrifuge. Here is stored potential energy of working liquid.

Let's note the following: in this part of the device, due to rotation, exist conditions of increasing of potential energy of working water-gas mix. In this part, influence of centrifugal pressure creates elastic compression of working body. This process (starting rotation of incoming liquid into centrifuge) demands some expenses of energy (input power) to overcome inertia of body (liquid) and accelerate it. Ratio of expenses of power (input power) and output power allows calculation of efficiency of the converter.

In the process of rotation of liquid, there is a shift in radial direction if the radius of rotation increases. This shift is provided by gradient of centrifugal force. This motion of liquid in pipes is accelerated, *i.e.* there is increase of kinetic energy of liquid. Thus, total energy of unit of volume of working liquid in outlet (point of exit from nozzle) can be much more than total energy of the same unit of volume of working liquid in point of inlet to the rotor. This additional energy is provided for free due to centrifugal force.

Let's note again: additional energy in this physical system can be explained considering an open system. Inertia, in this case, is considered to be a property of environment media (aether), but it is not a property of the working body. Rotation of inertial mass body demonstrates centrifugal effect. This effect is caused by gradient of pressure of elastic medium (aether). Potential energy, in this case, can be transformed in kinetic energy in stage of relaxation (decompression) of working elastic body. Thus, in elastic environment (aether) there is some thermodynamic process. Value of this process is equivalent to output power and this process in aether manifest itself in changes in temperatures of the environment air.

Another useful effect is the possibility of receiving torque and axial propulsion force. Let's draw a mechanical analogy: Some massive load compresses a vertically installed spring. This spring is installed on some support. There is work to act against elastic forces of compressed spring and this work is performed by gravity (weight of the load). We can transform potential energy of this spring to kinetic energy if we will turn this spring in a horizontal direction. Decompression of spring will push away the load, and spring will receive opposite direction momentum of motion. The same process is observed in the device: centrifugal forces and elastic forces are counterbalanced in area of centrifuge. In process of motion of liquid, it moves to other physical conditions, which are determined by geometry of the case (radius and angle of spirals). These conditions are necessary for transformation of potential energy of compressed elastic working liquid to its kinetic energy, and, at the same time, this geometry creates in the case effect of axial propulsion force. In this physical system we can observe example of reactive effect: torque of rotor is corresponding to axial propulsion force.

8.2 - Calculation of acceleration and power

Let's consider accelerated motion of working liquid in rotor pipes. Similar case is process of falling of body (mass "m") from some height "h" in the field of gravity. For our case, instead of the acceleration of gravity "g" we use centrifugal acceleration "a" in formulas. Height "h," in this case, is equal to difference in radiuses of the cone rotor (one point is inlet of liquid in the pipe and other point is center of nozzle). Kinetic energy is increasing according to square of speed function. Static pressure also will be decreasing according to square of speed function. This dependence of pressure of liquid on the speed of its flow is described by Bernoulli's law. External atmospheric pressure is not a significant value here, therefore in our consideration there are only static and dynamic pressure.

Let's make some notes: at horizontal arrangement of an axis of the rotor, on small speed of rotation, normal acceleration of liquid in pipes is comparable with acceleration of gravity. So, it will be noticeable that each turn of the rotor has two half-periods: half of cycle of rotation "down" the liquid will receive more acceleration than in other half-period of "up." It is result of summation or subtraction of normal acceleration of rotation and acceleration of gravity. In this situation, there is non-compensated vertical mechanical

momentum in the device (vibrations). So, it is preferable to use vertical arrangement of an axis of rotor. However, for nominal speed of rotation the arrangement of rotor does not matter since normal acceleration will exceed acceleration of gravity.

Let's calculate normal acceleration for several values of speed of rotation):

$$a = V^2/R \quad (1)$$

where a is acceleration, V is linear velocity of motion and R is radius of trajectory.

The linear velocity of motion V along trajectory of radius R can be calculated as:

$$V = \omega R \quad (2)$$

where ω is angular velocity of rotation (Rad/sec):

$$\omega = \pi\, n/30 \quad (3)$$

where n is rotation speed (rpm).

The working liquid moves in the pipe. Its acceleration is variable and depends on the radius of rotation. Radius changes when the liquid approaches the nozzle. Let's use data on angular speed of rotation for five operating modes, and we will find normal acceleration in point of start, in radius of the centrifuge, (R=5·10^{-2} m), then we will find normal acceleration of liquid in central point of nozzle. This point is rotating on radius R=1.4·10^{-1} m. Then we will find their average value, for each mode. Results of calculations are shown in Table 1.

Work of centrifugal force to create accelerated motion of body depends on value of acceleration. Let's calculate value of work per unit of time to calculate power.

In the simple case, the motion of liquid in the pipe is started from the central point of axis towards the nozzle, in the radial direction of flat Segner's rotor, Figure 20.

Calculations in this case are similar to the example of a vertical falling body in a gravity field. In cone rotor screw spiral pipes there is also an axial shift of liquid due to influence of centrifugal force. Therefore, it is necessary instead of vertical falling body to consider an analogy with accelerated motion of body on an inclined plane surface. This physical task is classical and its solution is known; the scheme is shown in Figure 21.

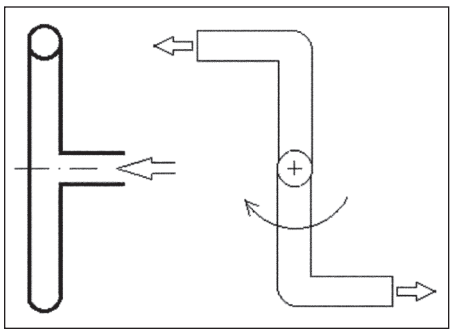

Figure 20. Scheme of motion of liquid in flat Segner's rotor.

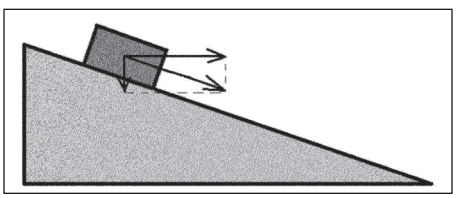

Figure 21. Accelerated motion of falling body on inclined plane surface.

Let's find final speed of motion of liquid in the pipe at point of nozzle. We can use:

$$V = (2\, a\ \mathrm{X}\ \sin\alpha)^{0.5} \quad (4)$$

where V is velocity of liquid in point of outlet, a is average acceleration, X is length of accelerated motion trajectory, α is angle of inclination of turn of spiral to axis of the spiral.

In present device, X is about 3·10^{-1} m, angle α is about 30 degrees in wide side of the cone rotor. Average acceleration for speed of rotation n = 3000 rpm according to Table 1 is equal to a = 9367 m/sec^2. Result: value of velocity of liquid in area of nozzle is about V = 53 m/sec.

Let's note: design requires optimization of parameters X and sinα in Formula 4. Value X depends on number of spiral turns. Angle α depends on form of rotor (inclination of spiral turns to axis of rotation).

Further, power is work per unit of time. Calculation of power requires setting the value of expense of liquid per second. Calculation of expense of liquid is possible by the following method: Let's find area of section of pipe (diameter is 10^{-2} m)

$$S = \pi D^2/4 \quad (5)$$

Result is S = 7.85·10^{-5} m^2. For velocity V = 53 m/sec there is flow of liquid through this section. Let's name this expense of liquid N and calculate it by

$$N_1 = VS \quad (6)$$

For speed of rotation n = 3000 rpm in one pipe we can estimate expense of liquid N_1 = 4·10^{-3} m^3/sec. This mass of water N_2 can be calculated by

$$N_2 = N_1\, \rho \quad (7)$$

where ρ is density of liquid (kg/m^3).

Table 1. Calculation of average normal acceleration for various speeds of rotation.

Speed of rotation n (rpm)	100	500	1000	1500	3000
Angular velocity ω (Rad/sec)	10.46	52.33	104.67	157	314
Linear velocity V (m/s) R=5·10^{-2} (m)	0.52	2.61	5.23	7.85	15.7
Acceleration a (m/sec^2) R=5·10^{-2} (m)	5.4	136.2	547	1232	4930
Linear velocity V (m/sec) R=1.4·10^{-1} (m)	1.46	7.32	14.65	21.98	43.96
Acceleration a (m/sec^2) nozzle R=1.4·10^{-1} (m)	15.2	382.7	1533	3451	13804
Average acceleration a (m/sec^2)	10	260	1040	2341	9367

In this case, N_2 = 4 kg/sec. For other type of liquid it is necessary to consider another density. We assumed here that cavitation will slightly decrease density and we do not take this decrease into account.

Expense of liquid for all eight pipes and nozzles equals 32 kg/sec, for speed of rotation 3000 rpm.

Kinetic energy of moving body can be calculated by:

$$E = 0.5\ (mV^2) \tag{8}$$

In our case we see flow of mass, *i.e.* we know expense of liquid N_2 "mass m per second" and we can calculate power. Let's use Formula 8 but replace "m" with N_2 to calculate power by:

$$P = 0.5\ N_2V^2 \tag{9}$$

where N_2 is expense of liquid (kg/sec), V is velocity (m/sec). Power P = 11 kW if speed of rotation n = 3000 rpm, N = 32 kg/sec, V = 53 m/sec.

Explanation of calculations: Speed of motion of liquid in the pipe, for purposes of this calculation, can be average value. This speed is variable during motion: after outlet from centrifuge, speed is increasing up to point of nozzle. Initial speed of stream in point of inlet to centrifuge is variable. It depends on speed of rotation of the rotor. For purposes of calculation we can accept it to be equal to zero, *i.e.* we will calculate minimum power. Real power can be higher since liquid is coming to the centrifuge with some nonzero speed. In a correctly designed return pipeline we can see significant axial component of speed of incoming liquid that will bring significant addition in creation of torque.

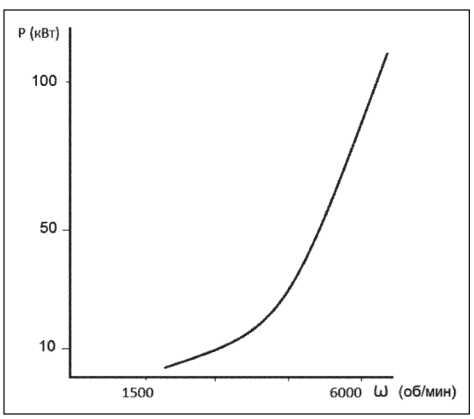

Figure 22. Function power of rotation speed.

So, considering zero speed of incoming liquid, average value velocity (half of maximum) equal to $V_{average}$ = 26.5 m/sec. Expense of liquid is N = 32 kg/sec, so by Formula 9 we can calculate power P = 11 kW. This power of flow of liquid was provided by rotation in the centrifuge. We can transform this energy to kinetic from the point of exit from the nozzle. Part of this power can be transformed into electro-energy, considering friction losses, hydrodynamic losses and efficiency of reactive jet turbine, efficiency of third turbine (reflector blades) and efficiency of electro-generator. We do not consider here the power of the pump, *i.e.* kinetic energy to start rotation in stage before self-running mode. This calculation was made for self-running more, and pump here is switched-off. In this mode liquid is circulated due to gradient of pressure between inlet and outlet.

Let's calculate power if speed of rotation is 1500 rpm. In this case, expense of liquid is reduced in half and equal to N_2 = 16 kg/sec. Average acceleration for this velocity of rotation is a = 2341 m/sec^2. According to Formula 4, we can calculate velocity in the end of trajectory of accelerated motion V = 26.5 m/sec, that is is reduced in half from the speed of rotation equal to 3000 rpm. So, velocity of outflow of liquid is linear function of speed of rotation. In the case of speed of rotation n = 1500 (rpm) we can calculate average velocity of motion of liquid in pipes. It is V_{cp} = 13.25 m/sec. According to Formula 9 we can calculate power of flow of liquid P = 1.4 kW.

Increase of speed of rotation two times, from n = 1500 rpm up to n = 3000 rpm, leads to increase of power eight times from 1.4 kW up to 11 kW. This factor is a product of two factors in Formula 9: expense of liquid is increased linearly two times and average acceleration is increased by square law, *i.e.* four times.

So, power depends on speed of rotation in cubic function. Increase of speed of rotation by three times will lead to increase of power by 27 times and so on. For example, let's calculate power for high speed of rotation. For speed n = 4500 rpm factor is three in comparison with n = 1500 rpm, so power will be increased 27 times to be about 37.8 kW. If we increase speed of rotation four times from n = 1500 rpm up to n = 6000 rpm, then power will be increase 64 times, from 1.4 kW up to 90 kW. Figure 22 demonstrates how power (kW) is a function of speed of rotation (rpm).

Let's note other factors: consumption of working liquid is dependent on diameter of pipes (section), diameter of centrifuge and diameter of rotor in the wide part of cone. Any change of proportions of sizes of rotor will lead to change of angle of inclination of spiral. It will change parameters of first (screw) turbine.

A power level about 10 kW can be theoretically obtained in the design proposed here.

Real results can be different from theoretical calculations of power. Increase of speed of motion of liquid in rotor pipes is related with large friction losses and hydrodynamic losses. Nevertheless, these problems can be solved by means of real technical methods. Creation of compact centrifugal converters of energy for transport, power industry and various equipment seems to be possible in range from 10 kW to 10 MW. It is a real engineering task.

8.3 - Efficiency of operation of centrifugal-vortex energy converter

Let's consider efficiency. It is an important question of theory of centrifugal-vortex converter. We will note existence of three reactive jet turbines in this design. The three turbines have different principle of operation, different efficiency and ways to increase efficiency.

8.3.1 - First turbine.

The first turbine consists of pipes placed on the rotor. Liquid is moving inside of the pipes. The pipes are bent in the form of a screw spiral. It creates conditions of transfer of kinetic energy of stream of liquid to rotor. Axial component of speed of movement of working liquid provides dynamic pressure of stream upon inner surface of the pipes, since they are placed at some angle to stream speed vector. So, by this some torque is created (analogy is any propeller). Average efficiency of modern screw turbines reaches 75% but we must take low efficiency to see low limit of power. Therefore we will set efficiency of transformation of kinetic energy of stream of working liquid to rotor torque at level of 50% that

corresponds to the law of conservation of momentum in this first turbine.

Calculation of heat friction losses in the pipe will be made in Section 8.4. of this report. It is about 10% of kinetic energy of liquid in the pipe length.

So, according to Formula 9, for speed n = 3000 rpm, power of flow of liquid is P = 11 kW, so 10% losses are about 1.1 kW. The value of heat loss and part of the energy will be transformed in the heating of the working liquid.

Taking into account heat losses, in our consideration there remains about 9.9 kW. We can assume 50% of this power will be transferred to the rotor shaft, *i.e.* according to the law of conservation of momentum P_1 = 4.9 kW.

8.3.2 - Second turbine.

The second turbine works due to reactive jet effect. It is similar to the principle of Segner's wheel. Kinetic energy of liquid stream (outgoing flow from the nozzle) is transferred to rotor, according to Newton's law. Therefore, power on the shaft is equal to half of power of the liquid stream in point of exit from the nozzle. In calculations we must use relative speed of movement between nozzle and liquid, for example, for n = 3000 rpm, velocity of liquid stream at point of exit from nozzle is equal to V = 53 m/s, and velocity of movement of the nozzle is V = 44 m/s. So, relative velocity is equal to $V_{relative}$ = 9 m/s. Thus, outgoing stream of working liquid provides rotor acceleration and the rotor can rotate with the increasing angular speed, if load is not connected to the shaft. Speed of rotation will increase until friction losses or temperature of working liquid reach critical value.

Let's calculate additive of power provided by second reactive jet turbine. This power can be calculated by Formula 9, taking into account the relative speed of liquid stream and speed of rotation of rotor. For n = 3000 rpm, N = 32 kg/s, $V_{relative}$ = 9 m/s, so power is equal to P_2 = 1.3 kW.

8.3.3 - Third turbine.

Further, there are blades on the rotor to transform kinetic energy of liquid stream into mechanical power on the shaft. We will consider its work and calculate estimated efficiency.

The third turbine here is eight separate reflectors of stream of working liquid. Reflectors are installed at angle about $\beta \approx 30$ degrees; all are placed near one nozzle. The turbine transfers about half of kinetic momentum of free stream of working liquid to the rotor, after this flow of liquid exits the nozzle. Contribution of the turbine to operation of the device is very significant. Considering the reflector is rotating together with the rotor, it is moving towards the free stream of liquid leaving the nozzle. Their vector speeds are shown in Figure 23.

Let's note, the result of action of radial centrifugal force is radial component of vector of stream υ_2 after exit of liquid from nozzle. So, vector υ_2 doesn't coincide with tangential vector υ_1. The optimal angle β is about 30 degrees. This angle can be established by adjustment of turn of reflector in relation to axis of stream.

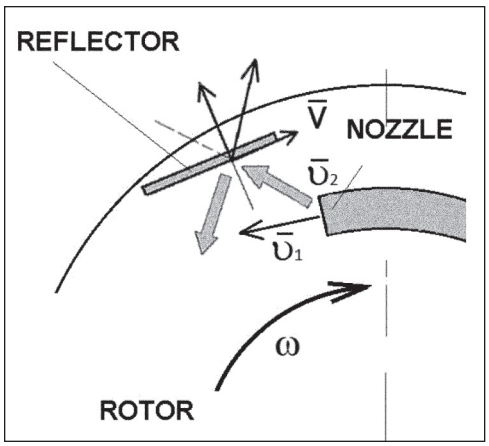

Figure 23. Vectors of forces in third turbine.

Calculation of power of the third turbine can be made by Formula 9, but it is necessary to use relative speed of interacting bodies (free moving liquid and moving reflector). This relative velocity is sum of speeds of stream and speed of rotor, but taking into account sinβ between them.

So, we can calculate power by

$$P_3 = 0.5 \sin\beta \, NV^2 \qquad (10)$$

where N is consumption of water (kg/s), V is relative speed (m/s), β is angle between vector of stream and the plane of reflector in point of their interaction.

According to calculation for n = 3000 rpm, N = 32 kg/s, V = 53 m/s, and $\beta \approx 30$ degrees, power of third turbine is P_3 = 22.4 kW.

8.3.4 - Total power.

Total power is sum of power of all three turbines by

$$P = P_1 + P_2 + P_3 \qquad (11)$$

For n = 3000 rpm, total power is P = 4.9 + 1.3 + 22.4 = 28.6 kW.

Let's consider efforts to make liquid rotate, *i.e.* we will find input power that is necessary to overcome inertia forces of liquid, which inflow into the rotor. We can use the law of energy conservation: to make liquid rotate with some speed, it is necessary to expend power which corresponds to the kinetic energy of liquid created.

In the initial part of the rotor, for these purposes there is a centrifuge. Radius is $5 \cdot 10^{-2}$ m. Kinetic energy of liquid in centrifuge can be calculated according to Formula 8. It is necessary to spend this amount of energy E_{input} to make liquid rotate. With Formula 9, taking into account value of speed of motion of rotating liquid in centrifuge, it is possible to find input power P_{in}.

Let's find value of input power P_{in} by Formula 9 for n = 3000 rpm, N = 32 kg/s and linear velocity of liquid in centrifuge on R radius = $5 \cdot 10^{-2}$ m V = 15.7 m/s.

Calculations show the following: initial acceleration of working liquid in centrifuge up to velocity V = 15.7 m/s requires power $P_{in} = 0.5\ NV^2$ = 4 kW.

Total power by Formula 10 is P = 28.6 kW and taking into account losses P_{in} = 4 kW of initial acceleration of incoming liquid we can estimate power on shaft about P = 24.6 kW. Electric generator will provide transformation of this mechanical power to electric power with efficiency about 85%.

We have to take into account total power of three turbines, friction losses and input power to start rotation of liquid in the centrifuge. Result is 20 kW of electric power at n = 3000 rpm.

8.4 - Calculation of hydraulic losses

Above calculations of maximum power were made without consideration of hydraulic losses, which depends on the material of pipes and mode of motion of liquid in the pipes.

Choice of material of pipes require comparative analysis of resistance coefficient C_d. If pipe is made by drawn (brass, lead and copper) this coefficient is about $C_d = 2 \cdot 10^{-3}$. For high-quality seamless steel pipes, it is equal to $C_d = 2 \cdot 10^{-1}$. For pig-iron pipes, this coefficient is approximately equal to $C_d = 1.0$.

It is a good idea to use copper or brass drawn pipes.

Let's consider briefly the theory of streams of liquid to find ways to decrease hydrodynamic losses of working liquid stream kinetic energy.

There are two types of hydraulic losses of energy: friction losses on length of pipelines and local losses caused by elements of pipelines. In this element due to change of size or configuration, there is change of stream speed. The stream becomes separated from the inner surface of the pipe and vortex is created. In the present design of the device there is not this element of pipes. The beginning of the pipe is connected to the centrifuge without joints and transitions, then the pipe comes to the end with nozzle. There are no sharp bends and soldering; it isn't required here.

Sudden expansion or narrowing of stream creates losses of pressure (kinetic energy). In these places there are vortex formations, *i.e.* separation of stream from inner surface of the pipe with organization of continuous rotary motion of liquid. In the present design of the device (on all length of rotor pipes) there is no expansion or narrowing of stream diameter. It must reduce hydrodynamic losses significantly.

Hydrodynamic resistance depends on mode of motion of liquid. Fundamental experiments in this field of research were made by Reynolds in 1883. He considered two modes of motion of liquid: laminar mode and turbulent mode.

Laminar mode of liquid flow is layered current without hashing of particles of liquid, without pulsation of speed and pressure. In a laminar current of liquid in a direct pipe of constant section we can observe that all lines of current are directed parallel to the pipe axis, thus there are no cross movements of liquid particles. Turbulent mode of liquid flow is current with intensive hashing of liquid, with pulsations of speeds and pressure. In this turbulent flow there is main longitudinal movement of liquid, cross-motion and rotary motions of separate volumes of liquid. Intensive turbulence considerably increases friction coefficient.

Transition from laminar mode to turbulent mode is observed at critical speed of motion. Value of this speed in function of kinematic viscosity of liquid and diameter of pipe:

$$(V_{av})_{\text{critical}} = (Re_{\text{critical}}\upsilon) \,/\, D \tag{12}$$

where Re_{critical} is Reynolds critical number, D is pipe diameter, υ is kinematic viscosity of water.

Let's calculate average critical velocity $(V_{av})_{\text{critical}}$. Kinematic viscosity of water $\upsilon = 1.007 \cdot 10^{-6}$ m^2/s for $t = 20$°C temperature, diameter of pipe is $D = 10^{-2}$ m. Let's take into account lower critical number of Reynolds $Re_{\text{critical}} = 2300$. Calculation shows that in this case $(V_{ave})_{\text{critical}} = 2.3 \cdot 10^{-1}$ m/s.

In calculations of velocity of motion of liquid in rotating rotor pipes by Formula 4 we see values of velocity 100 to 200 times more than critical velocity. For example, maximum velocity for speed $n = 3000$ rpm is equal to $V = 53$ m/s, that is 200 times more than $(V_{ave})_{\text{critical}} = 2.3\ 10^{-1}$ m/s.

Obviously, without special technical adaptations, the mode of motion of liquid will be very turbulent, *i.e.* there are big losses here.

The coefficient of hydraulic friction by Blasius' formula

$$\lambda = 0.316/Re_{\text{critical}}^{0.25} \tag{13}$$

where λ is hydraulic friction coefficient on the length.

On low limit $Re_{\text{critical}} = 2300$ hydraulic friction coefficient is $\lambda = 4.5 \cdot 10^{-2}$.

It is necessary to remember the difference between hydraulic system pressure caused by acceleration of gravity "g" and acceleration of motion of liquid in rotating rotor pipes. Value of average acceleration "a" for various speed of rotation was already calculated (Table 1). Darci-Weisbach Formula 14 lets us find friction losses of pressure p on length of L. In our case $L = 3 \cdot 10^{-1}$ m.

$$\Delta p = \lambda(L/D)(V^2/2)\rho \tag{14}$$

where L is length of pipe, D is diameter of pipe, V is velocity of stream, ρ is density of liquid.

Result of calculation: for speed of rotation $n = 3000$ rpm, density of liquid is about 10^3 kg/m^3, and average velocity of stream $V = 22$ m/sec, losses of pressure of pipe length is about $3.2 \cdot 10^5$ N/sq.m.

Hydraulic friction losses considerably affect efficiency. In Section 8.6 we'll calculate working pressure difference. After this step we'll see percentage ratio value of reduction of working pressure difference due to friction losses. This reduction corresponds to losses of power on the shaft. Once again, let's note that these losses correspond to heat power; it is necessary to remove this heat from working liquid by means of a heat exchanger.

8.5 - Calculation of static pressure difference

Let's calculate difference of static pressure in air that is created by the process of rotation of the rotor. We can consider movement of the nozzle in environment as a relative movement. This motion creates changes in balance of static and dynamic pressure of air on open end of the nozzle. Bernoulli's law is:

$$p_{\text{atm}} + p_{\text{stat}} + 0.5\rho V^2 = \text{const} \tag{15}$$

where p_{stat} is statical pressure of air on nozzle, p_{atm} is atmosphere pressure, ρ is density of air, V is relative velocity on the nozzle in the environment.

We know the value of atmosphere pressure, so Formula 15 can be presented as

$$p_{\text{stat}} = 1.01 \cdot 10^5 - 0.5\rho V^2 \ (N/m^2) \tag{16}$$

Atmosphere pressure of air is the same for both ends of the pipe for a motionless rotor, but in the case of rotation, it decreases by value of dynamic pressure.

In a rotating pipe, there is pressure difference between the nozzle and other end of the pipe. We can calculate this difference by

$$\Delta p = 0.5\rho V^2 \ (N/m^2) \tag{17}$$

where Δp is pressure difference in pipe, ρ is density of air, V

is relative velocity of the nozzle in environmental (air).

For n = 3000 rpm, relative velocity is V = 44 m/sec. Density of air is about ρ = 1.2 kg/m^3. Pressure difference is $\Delta p_{stat} = 1.1 \cdot 10^3$ N/m^2, for this speed of rotation.

Further, considering this energy converter, we have to take into account the closed cycle of liquid motion (Figure 24). So, there is gradient of atmospheric pressure for working liquid. In crankcase of device (if device is not sealed hermetically) there is atmospheric pressure on surface of liquid but for rotating nozzle there is reduced static pressure of air. Difference is about $\Delta p_{stat} = 1.1 \cdot 10^3$ N/m^2.

Thus, due to existence of atmospheric pressure, there is some additional power. The working liquid will get additional acceleration by difference of static pressure of environment.

Let's calculate this additional power. Surface of the nozzle can be calculated by Formula 5. It is equal to $S = 7.85 \cdot 10^{-5}$ m^2. Surface of all eight nozzles is $S_8 = 6.2 \cdot 10^{-4}$ m^2.

On this surface acts force F, for pressure difference $\Delta p = 1.1 \cdot 10^3$ N/m^2 (Formula 17). The force F can be calculated by

$$F = \Delta p \, S_8 \tag{18}$$

From our calculation $F = 7 \cdot 10^{-1}$ N.

Let's calculate the torque of the rotor, considering force F acts in the point place on radius $R = 1.4 \cdot 10^{-1}$ m. Torque can be calculated by

$$M_{torque} = F \cdot R \tag{19}$$

Result of calculation is $M_{torq} = 10^{-1}$ Nm.

For n = 3000 rpm, *i.e.* angular velocity ω = 314 Rad/sec, we can calculate power by

$$P = M_{torque} \, \omega \tag{20}$$

This value is the additional power on the shaft of the rotor. It is the result of air pressure difference P = 31 W.

This additional power is not significant, therefore, hermetical sealing of the device isn't a necessary condition. Let's note that this method of calculation of power of working liquid stream uses a method based on pressure difference, and it can be useful in other cases.

8.6 - Calculation of power based on pressure difference

To check calculations and possible value of error, there is a known technique of double solution of the same task by various methods. In Section 8.3, value of power was found in dynamics, by determination of kinetic energy of stream. This energy is the result of accelerated movement in pipes from centrifuge to nozzle. Let's find power on the shaft in a different way, considering liquid movement as a result of pressure difference in tubes that is created by rotation of rotor. From value of pressure difference, we will find force, torque and power. After that, we will estimate friction losses.

Let's find the difference of full pressure in the beginning and at the end of trajectory of movement of liquid in the pipe. There is Bernoulli's formula:

$$0.5 \, \rho V^2 + \rho g h + P_{atm} = \text{Const} \tag{21}$$

where ρ is density of liquid, V is velocity of stream of liquid, g is acceleration of free falling in gravity field, h is height.

In the case of accelerated movement of liquid in the pipes of the rotor, the formula is:

$$0.5 \, \rho V^2 + \rho a R + P_{atm} = \text{Const} \tag{22}$$

where ρ is density of liquid, a is normal acceleration, R is radius of rotation, V is velocity of liquid stream.

To calculate pressure difference we can use:

$$\Delta p = (0.5 \, \rho V_2^2 + \rho a_2 R_2) - (0.5 \, \rho V_1^2 + \rho a_1 R_1) \tag{23}$$

where V_1 = 15.7 m/s, a_1 = 4930 m/s^2, $R_1 = 5 \cdot 10^{-2}$ m are velocity, acceleration and radius, V_2 = 53 m/s, a_2 = 13804 m/s^2, $R_2 = 1.4 \cdot 10^{-1}$ m are velocity, acceleration and radius at the end of the pipe (at nozzle). The values were calculated and presented in Table 1.

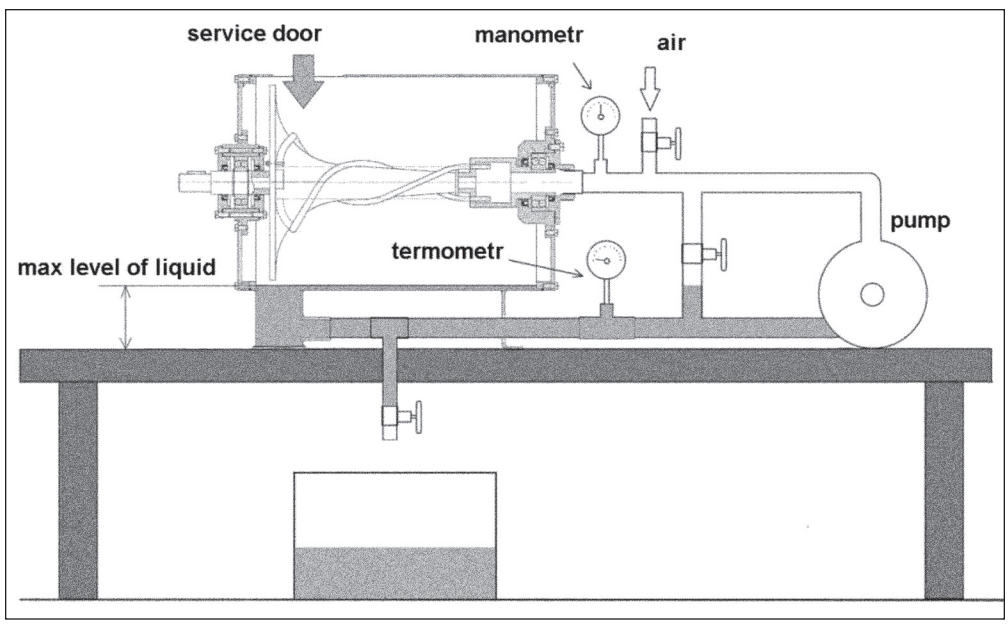

Figure 24. Scheme of liquid circulation.

Value of working pressure difference is calculated by Formula 23 as $\Delta p = 2.93 \cdot 10^6$ N/m^2.

Let's compare this value with the data in Section 8.4 about hydrodynamical friction losses in pressure: $\Delta p = 3.2 \cdot 10^5$ N/m^2. Hydrodynamical losses are about 11% of working pressure difference. This was mentioned in Section 8.3.

So, taking into account hydrodynamic friction losses we can estimate the value of working pressure difference $\Delta p_{work} = 2.6 \cdot 10^6$ N/m^2. We can note that a similar value of pressure was used in Clem's device.

Atmosphere pressure difference was considered in Section 8.5. It is not a significant value $\Delta p_{stat} = 10^3$ N/m^2, so we do not

take it into account for calculations.

Let's note that an increase of working pressure difference can be created by means of reduction of radius of rotation of liquid in the centrifuge, and also by increase of radius of rotation of nozzle. We cannot reduce radius of centrifuge since centrifugal pressure is created in this part of the device and it is a useful effect to provide compression of elastic working body. So, to increase power we must increase radius of the wide part of the conical rotor.

We know the pressure difference $\Delta p_{work} = 2.6 \cdot 10^6$ N/m^2, so we can calculate force F as:

$$F = \Delta p_{work} S_8 \quad (24)$$

Square of eight nozzles is $S_8 = 6.2 \cdot 10^{-4}$ m^2, so force is $F = 1.61 \cdot 10^3$ N.

This force of total stream from eight nozzles is due to the pressure difference. Let's assume we make this stream work in a turbine with 50% efficiency—that is Newton's law of transfer of kinetic momentum between stream and blades of turbine. Radius of turbine is $R = 1.4 \cdot 10^{-1}$ m, so we can calculate torque on shaft according to

$$M_{torque} = F \cdot R \quad (25)$$

Result of calculations is $M_{torque} = 2.25 \cdot 10^2$ (Nm).

For $n = 3000$ rpm, angular speed is $\omega = 314$ Rad/sec and we can calculate power by

$$P = M_{torque}\, \omega \quad (26)$$

Power is $P = 70$ kW. Considering efficiency is 50%, power is about $P = 35$ kW.

Also we have to take into account 11% friction losses, so power is $P = 31$ kW.

We already made calculations of power according to the dynamic model of Formula 11; it was $P = 28$ kW.

Calculations of value of power of centrifugal energy converter were made by two different methods and both results are very close, with accuracy about 10%.

8.7 - Proposals on reduction of losses

In this device it is planned to operate with over-critical velocity, so it is necessary to use special methods of reduction of losses. The size of the device and diameter of pipes cannot be increased and must correspond to planned values.

The first idea for reduction of hydrodynamical losses is decrease of viscosity of working liquid. We will use aerated liquid, *i.e.* it is not a continuous flow of liquid but water-gas mixture. Viscosity of this mixture is less than viscosity of water. It is necessary to use special methods to provide aeration of liquid, in opposite case cavitation will change continuous state of liquid flow to change it in vapor-gas mixture (gas and vapor bubbles inside of liquid flow). In standard equipment, the cavitation is a negative effect and designers try to avoid cavitation in pipes of water systems. In our case, the cavitation can be useful to decrease viscosity of liquid and also to provide elastic properties to working liquid (it is necessary to collect potential energy in state of elastic compression). In the proposed device, the cavitation is organized in the area of the centrifuge. The ends of the pipes are inserted into the area of the centrifuge (30 mm part of pipes).

One more proposal is a special helical mode of motion of liquid in the pipes (laminar-vortex trajectory of motion of liquid), therefore we can name this device a "vortex" energy converter.

Vortex motion can be a self-organizing process by means of rotation of flow around its axis. It is possible the flow of liquid can move with acceleration, but friction forces on surfaces try to stop this accelerated motion. In reality, any stream of liquid moving down with acceleration will start rotation. The central part of the stream is moving with higher velocity than the periphery of the stream. Friction creates micro-vortexes in the peripheral part of the stream since there is maximum of friction. The micro-vortexes provide minimum of friction and allow acceleration of the stream. So, this self-created vortex process reduces resistance to motion of the stream in periphery area of the stream. So, motion of liquid is a helical vortex trajectory.

The physical basis of this effect is simple: rotation of liquid around axis creates centrifugal force, and this force pushes liquid to the walls of the pipe. Due to this force, transverse oscillations of particles (*i.e.* turbulence) in the liquid flow is reduced or totally eliminated.

It is necessary to provide vortex rotation of liquid around axis of motion, by means of special elements of design. We offer several technical solutions: helical relief on inner surface of the pipes, and also micro-turbine at the end of the pipe. Experimental testing of this method was made with air and described in Section 3.9. Viktor Schauberger described this method in his patents.[2,3] Figure 25 demonstrates Schauberger's technical idea for the special pipe.

Acceleration of liquid is provided by twisting of mainstream flow of water inside the pipe by means of special blades. In area of low pressure (along axis of rotation) there is a main stream of liquid, a main mass transfer of working body. Velocity of motion along axis of the pipe is increased in area of low pressure. Area of high pressure is peripheral of the flow; there are micro-vortexes in this area of the flow. This area of high pressure plays a role in "ball bearings."

We can see analysis of helical (vortex) liquid flows in publications by Milovich[17]: "Helical motion of liquid is special motion. In this motion each particle of liquid is moving linear along its trajectory and also it is rotating around axis of this trajectory. Result of this rotation is shift of layers in normal direction (perpendicular) in relation to linear velocity. This shift creates motion of all mass of the flat liquid layers in normal (perpendicular) direction to the main axial direction of motion. It creates rotation of flow around axis of motion. Kinetic energy of this motion is equal to kinetic energy of linear stream."

There is an important conclusion: increase of kinetic energy of the main stream by means of reduction of hydrodynamical losses is possible only in the case of technical possibility of increase of kinetic energy of rotation, *i.e.* design of rotor of the device must allow this increase of kinetic energy of rotation.

So, we offer to use in this research project copper pipes, that allow rotation. Rectangular (square) channels cannot provide rotation of the liquid flow.

An additional element of design is helical relief (groove) on inner surface of the pipes, where a big step (3-7 times the radius) in the beginning of the trajectory of liquid will provide conditions of rotation of liquid.

In the next stage of research it can be useful to calculate and design micro-turbines by Schauberger's method.[3] This design is demonstrated in Figure 26.

Figure 26 shows that the micro-turbine is placed at the end of the pipe, in the nozzle. Please note diameter of section of nozzle is decreased with micro-turbine. So, this part of the device will provide an increase of pressure in liquid, which is moving in the pipes. Pressure is important to provide compression.

Also it can be interesting to install the micro-turbine in the beginning of the pipe. From the other side, this additional dynamical element of design will reduce its reliability and increase its cost. Passive elements of design, *i.e.* helical relief (grooves) on inner surface of the pipes, allow reduction of hydrodynamical losses in the device.

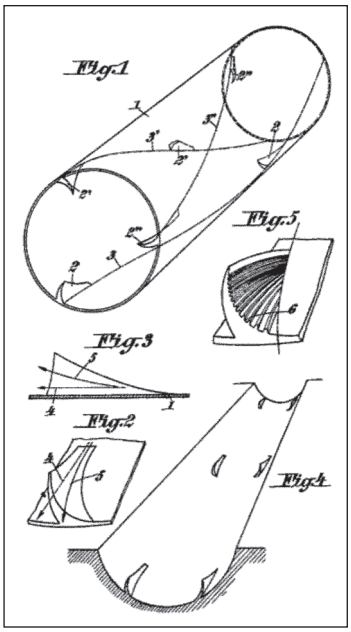

Figure 25. Schauberger's idea of special pipe to create vortex.

Let's note importance of section size and length of the back-way pipeline. Value of losses depends on the section diameter and length. Increase of section of the pipeline will reduce velocity of motion of liquid and losses. Calculation of losses of pressure for n = 3000 rpm, by Formula 14 in backway pipeline of two-inch diameter $D = 5 \cdot 10^{-2}$ m, with length L = 1.2 m, for velocity of motion V = 18 m/s let us value the loss of pressure about $\Delta p = 1.7 \cdot 10^5$ N/m^2, that is about 7% of working difference of pressure. So, it is recommended to make back-way pipeline as short as possible, and it is necessary to use gradual (not rectangular) changes of trajectory of liquid. It is not recommended to use corrugated hosepipes.

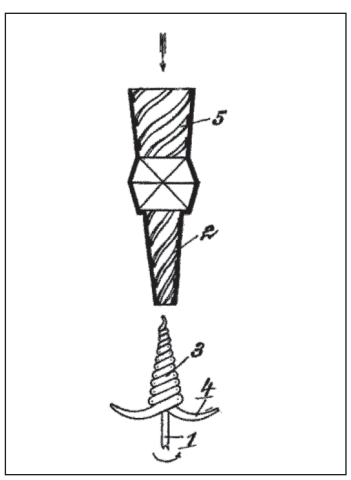

Figure 26. Schauberger's micro-turbine.

Total loss in this hydraulic system is about 18% for n = 3000 rpm. This energy is heat and it is necessary to remove this heat energy by means of an external heat exchanger.

9. About Necessity in Experimental Research

In Section 8 it we noted experimental proof of the theory and calculations. The main aim of the experimental work is proof of concept, method of calculation of power and losses. The third turbine provides the main part of total power and torque on the shaft of the electro-generator, so the main experimental task is obtaining real experimental data about optimal parameters of the third turbine. It is planned to investigate efficiency of different forms of blades of the turbine, and also to find optimal angle of the blades. Possibility of regulation of this angle is provided in the design of experimental device.

Also in experiments it is planned to obtain experimental data about the real efficiency of Schauberger's method of reduction of hydraulic losses.

Also in experiments it is planned to investigate operation of the device with helical relief (grooves) on inner surface of the pipes and compare results with a device where standard pipes are used. Different value of step of helical grooves can be tested (from 3 up to 10 diameters of the pipe) to get experimental data about most efficient value of the step.

10. Estimated Results

The main planned result of this research work is proof of possibility to build a workable centrifugal-vortex energy converter. Theoretically, after start with external motor or pump, the rotor must rotate with acceleration up to nominal speed of rotation and it must provide power (torque) on the shaft. This power must be sufficient to get 10 kW electro-energy for n = 3000 rpm. Also it is planned to detect some axial propulsion force.

Conclusion

Calculation of design of experimental energy converter was presented in this research work. This converter transforms environmental heat energy into mechanical work. This research work will be completed after experiments prove the possibility of self-running mode of operation and theoretical data about power are confirmed. Power must be a function of speed of rotation. After this stage of research it will be possible to design powerful fuel-less machines for industrial application. Accuracy of calculation is about 10%, that is related with average value of acceleration of moving liquid. This method reduces result of calculation, *i.e.* real power must be more than theoretical value of power. Reliability of theory will be proved by experiments.

Conclusions are the following: it is doubtful that reactive effects (Segner's type rotor) will provide torque of the rotor. We can conclude that it is possible to provide self-running mode of rotation of the rotor if we make the correct design of the machine. Important conditions are: collection of potential energy in compressed working body, and then transformation of this potential energy into kinetic energy, and then to transfer this kinetic energy to rotor and provide torque. Special vortex mode of motion (laminar-vortex mode) of the liquid in the pipes will provide reduction of hydrodynamical losses.

It is necessary to note: this mechanical machine is an open physical system and it can operate in self-running mode only if we provide transformation of environmental heat energy into kinetic energy of the rotor. From this point of view, this machine is analogous to a heat pump.

Development of the project requires teamwork. Designers and engineers can develop an experimental device to provide a new level of power engineering with a wide range of industrial and commercial applications. Innovation of this new technology will reduce the cost of energy.

This research work is a rare project in the field of advanced power engineering.

Addendum

The device presented herein was built and tested in Ural, Russia per the calculations discussed. It was difficult to reach 3000 rpm for this type of rotor. In the future, calculations should be made for 1000 rpm, and it is also necessary to double the diameter of the spiral pipes used.

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