ENGINEERING SCIENCES

ATMOSPHERIC GRAVITATIONAL ENERGY CONVERTER: CONCEPT AND OPERATING PRINCIPLE

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ARTICLE INFO	ABSTRACT
	The article presents the operating principle of atmospheric gravitational converter (hereinafter referred to as AGT) with an external supply of non-thermal clean energy. The operating principle is based on using the existing potential energy of the atmosphere in the gravitational field of the Earth. AGK is characterized by unique capabilities to generate by implosion useful clean energy without harmful emissions, such as NO_x and CO_2. Its main advantage is that the supply of external non-thermal energy for the operation of AGK is carried out steadily in any required quantity and is not dependent on the time of day, weather or location.

Introduction. Modern civilization has faced with a serious challenge of providing mankind with energy based on clean technologies that ensure environmental protection. It is evident that the further use of energy sources based on the explosive process of converting thermal energy into mechanical work in engines and turbines of internal combustion has become a dead end and is harmful to the ecology of the Earth in XXI century.

The objective of our research was to develop a method and a device using the gravity in more general form than in hydroelectric power stations where only a partial water vapour component of the atmosphere is mostly used. However, the energy of the atmosphere is huge. The internal energy of the atmosphere is estimated as $8.6 \cdot 10^{23}$ J, the potential energy — as $3.6 \cdot 10^{23}$ J, and the kinetic energy is smaller by two orders of magnitude: 10^{21} J, i. e. it constitutes less than 1% of the potential energy [1, 2].

Gravity and inexhaustible potential energy of the atmosphere, which is the natural accumulator of solar energy, are the key to all that is necessary to create AGK, vacuum atmospheric power amplifiers (hereinafter referred to as VAPA) and clean energy generators.

A clean energy generator working on the basis of AGT with an external supply of non-thermal energy provides unique possibilities of generation of useful energy with virtually no harmful emissions. The main advantage of the developed device is that the supply of external non-thermal energy for the drive mechanism is provided steadily in any required quantity and is not dependent on the time of day, weather or location (except for the elevation). In the context of the external energy use, the most similar device is the classic Stirling engine which can operate only in conditions when the direct sunlight or other external heating source is available. AGT can operate with minimal use of any type of fuel, it has a virtually unlimited service life due to the use of gravity and potential energy of the atmosphere, and at the same time, it can be designed for specific tasks with little or no specified

power limitation. Combined with industrial or individual electric power generators, AGT can reduce the consumption of fossil fuels by up to 90%.

II. Theoretical justification. The air density is $1.29*10^{-3}$ g/cm^3, the lifting force acting on the 1 m^3 balloon with hydrogen of $9*10^{-5}$ density is equal to approximately 12 N. With a vacuum inside the balloon, the lifting force of the balloon with a minimum weight of the shell will be almost maximum, amounting to approximately 13 N.

As a particular case of the Archimedes' principle, the option can be considered when the lifting force acting on the moving surface of the shell, which is on the boundary between two media (the atmosphere and the vacuum), is increased by several orders of magnitude and can be up to 101,300 N/m^2 at the sea level.

Let's assume that the atmosphere at the Earth's surface is uniform and the density is constant($\rho = const$) and the condition of continuity is met ($\frac{\partial \rho}{\partial t} = 0$). Then atmospheric pressure (hereinafter referred to as AP) acts on the object as a three-dimensional mass force F for the hydrostatic pressure in accordance with the Euler equations. In our case, the atmospheric pressure p_a can be expressed for as follows:

$$\rho F_x = \frac{\partial p_a}{\partial x}; \ \rho F_y = \frac{\partial p_a}{\partial y}; \ \rho F_z = \frac{\partial p_a}{\partial z}. \tag{1}$$

Or in a vector format:

$$\rho F = \mathrm{grad} p_a \tag{2}$$

When $\rho = const$ and volumes forces $\mathrm{grad} p_a = 0$ are absent, the atmospheric pressure on the object is the same from all sides (Pascal's law). The only mass load (the force of gravity $F_t = mg$) is acting in the field of gravitational forces. F_t should be compensated by the opposite vertical component of AP to suspend the object in the atmosphere. This task can be realized under certain conditions.

Let's review these conditions. Being a natural accumulator of solar energy, the atmosphere is an open system where this process is realized. The potential energy of the atmosphere column with height h attributable to S_{eff} area equals to:

$$E_p = S_{eff} \, g \int_0^h \rho(h) h dh = S_{tff} \, g \rho_9 \frac{1}{\mu^2}[1 - \exp(-\mu h)(\mu h + 1)] \tag{3}$$

in this case, the following barometric formula of air density in the atmosphere is used $\rho(h) = \rho_0 \exp(-\mu h)$, $\mu = Mg/RT$, where M is the molecular weight of the gas, R is the gas constant, ρ_0 is the air density at the height $h = 0$, and T is the absolute temperature.

Assuming that the atmosphere is uniform at the Earth's surface and the density is constant $\rho_0 = const$, then the potential energy of the atmosphere can be expressed as follows:

$$E_p = S_{eff} \, g \rho_0 h^2 / 2 \ [\text{J}] \tag{4}$$

This formula is the expression for the potential energy of the atmosphere in the gravitational field of the Earth.

As a particular case, let's consider the compensation of the gravitational force with the help of atmospheric pressure and the use of a vertical AP to perform mechanical work or to suspend the object in the atmosphere (Fig. 1).

The atmospheric pressure on the surface with the area of $S = 1$ m^2 equals 101,300 Pa or 101KN/m^2. Thus, the force F_a of atmospheric pressure p_a acting on the surface with the area of 1 m^2 equals:

$$F_a = p_a S = 101,300 \text{ Pa} * 1 \text{ m}^2 = 101,300 \ [\text{N}] \tag{5}$$

The compensating vertical component of AP (hereinafter referred to as CCAP) also equals to 101,300 N. CCAP can be formed under certain conditions when other volumetric mass loads F are redistributed to the support (4, 5). CCAP can lift a load (7) with the mass of 10,000 kg in a suspended state relative to the support, if the load is attached to the movable end/platform (2) (hereinafter referred to as MP) of the separating elastic membrane (3).

In this case, CCAP is always normal to any point of the separating membrane between the two media and is proportional to the effective area of MP S_{eff}. Atmospheric column rests on the effective area, which is limited by the perimeter of the barrier between two media — vacuum and atmosphere — and is

independent of the shape of the membrane surface which may be convex or concave. In general terms, CCAP is opposing gravitational force F_t, which can be expressed as follows:

$$-F_a = F_{CCAP} = p_a S_{eff} \qquad (6)$$

The following is the condition of the object's suspension in the atmosphere, when between the object and the fixed support surface (5) there is a vacuum environment (1) separated from the atmosphere by an elastic separating membrane (3):

$$F_t = -F_{CCAP} = mg - p_a S_{eff} = 0 \qquad (7)$$

where: m is mass of the suspended object.

F_{CCAP} is actually the potential power of atmospheric pressure, which can act in any direction in the atmosphere, where there is an elastic separating membrane between the two environments – air and vacuum or liquid and vacuum.
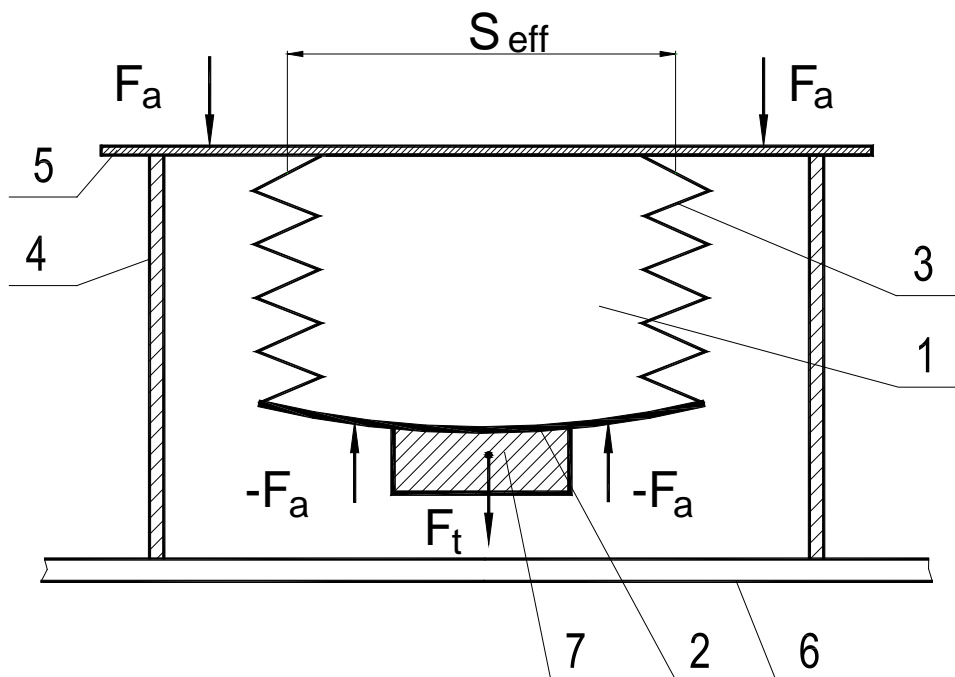

Fig. 1

Atmospheric pressure can be used to lift the load. For this purpose the atmosphere should be exhausted from the vacuum chamber (1) and a vacuum environment (subsystem 1) should be created. The work A_1 should be performed, it is determined by the power consumption of the vacuum pump N_p [W], the volume of the vacuum chamber V_0 [m^3] and its speed of exhaust v_1 [m^3/s], and will be expressed by the following formula:

$$A_1 = N_p V_0 \quad [J] \qquad (8)$$

It is obvious that the creation of a vacuum environment in the subsystem 1 considers only the energy required for the operation of selected vacuum pump.

As mentioned above, the load can be lifted using the atmospheric pressure (subsystem 2), which is almost always at sea level. The load in the subsystem 2 is lifted by CCAP acting on the outside of the platform. At the same time, the work A_2 applied to lift the load in the gravitational field is performed by the potential energy of the atmosphere. Its value is determined by the area MP S_{eff}, the height h_1 of load relative to the support, and the atmospheric pressure P_a:

$$A_2 = -F_a h_1 = P_a S_{eff} h_1 = P_a V_0 \geq mgh_1 \qquad (9)$$

It is obvious that the maximum weight of the load is directly proportional to the effective area S_{eff} of the platform at P_a = const, and the produced work is proportional to the volume of the vacuum chamber.

If the chamber is in the atmosphere at sea level and has a volume V_0 in the form of a cube with a face $h_1 = 1m$, then CCAP F_2 of atmospheric pressure P_a for the effective flat area of the cube's platform $S_{eff} = 1$ m^2 will be as follows:

$$F_2 = P_a S_{eff} = P_a 1 \ m^2 = 101{,}300 \ \text{N} = 101 \ [\text{kN}] \tag{10}$$

Then, considering the Formula 9, the work performed by the platform when lifting the load to a height $h_1 = 1$ m under the action of CCAP will be as follows:

$$A_2 = P_a S_{eff} h_1 = P_a V_0 = 101 \ [\text{kJ}] \tag{11}$$

If the platform moves at a speed of 1 *m/s*, the power output N_p of the system 2 will be as follows:

$$N_p = P_a V_0 / s = 101 \ [\text{kW}] \tag{12}$$

The atmosphere's potential force CCAP acting on the platform is virtually unchanged in absolute terms, as the atmosphere pressure at sea level can be considered constant and $P_a = $ const, thus, the performed work and the useful power of the system 2 will always be determined by the volume of the vacuum chamber and the speed of the platform's movement. Thus, the potential energy of the external environment (in this case, the potential energy of the atmosphere) is used to perform the work by the system 2. The external environment can be an environment, which is not the atmosphere, for example, water. In this case, the system's capacity increases proportionally to the internal pressure of the environment (water) at the location (immersion depth) of the vacuum chamber.

The system 2 is brought to its initial state by pressurizing the chamber with the natural air up to the pressure P_a, at the same time the forces acting on the platform are being equalized and the platform is lowered, in this case — under the force of gravity. No additional power inputs are required to bring the system 2 to its initial state.

In addition, the pressure at the pump's inlet can be lowered due to the initially exhausted receiver with the volume $V_p \gg V$. According to the Boyle–Mariotte law, this will allow to exhaust in optimum conditions with minimum energy consumption.

Thus, the potential energy of the atmosphere can be used as a source of useful non-thermal energy to produce mechanical work and generate energy without explosive thermodynamic cycle with the use of fossil fuels. The continuity of this process can be ensured if the movable platform periodically returns by a closed cycle to its initial state, and the pressure in the chamber returns to its initial state through exhaust and the natural inlet of the atmosphere to the vacuum chamber. In this case the value of the energy expended to obtain a vacuum in the chamber can be much smaller than the value of the potential energy of the atmosphere used for the work produced by MP, for example, for generation of electrical energy using classical implosion process.

This method can be applied to create devices where the work is performed continuously by a closed vacuum-atmospheric cycle with an external supply of non-thermal energy without thermodynamic expansion of the working body. The method, which involves the potential energy of the atmosphere, can be considered another theoretically justified way of use of gravitation and solar energy to produce useful work. [3]

III. Atmospheric gravitational energy converter

A long-term positive mechanical work of the device using external non-thermal energy can be ensured by the cyclical movement of MP relative to the support.

As shown previously, when the platform with area $S_{eff} = 1$ m² passes the distance $l = 1$ m under the CCAP force F_a of the air column exerting the pressure on the effective area of the platform's outside, the following work will be produced:

$$A = F_a \, l = 101 \ \text{kN} * 1 \ \text{m} = 101 \ [\text{kJ}] \tag{13}$$

101 kW of useful power per second can be obtained.

$$N = F_a l / t = 101 \ [\text{kW}], \tag{14}$$

Based on the formulas 13 and 14, the power is obviously determined by the speed of exhaust from the vacuum chamber with a maximum volume $V = S_{eff}$. The platform returns to its initial position by natural pressurizing of the vacuum chamber with atmospheric air in order to compensate the action of CCAP on the platform's outside. Thus, the system can operate as a two-stroke vacuum-atmospheric mechanical power unit with a preset adjustable frequency and the vacuum-atmospheric closed cycle of "exhaust-pressurization" for the atmospheric gravitational energy converter (AGT).

In case of a real device of the mechanical unit of AGK, the vacuum chamber with a variable volume can be a working chamber (hereinafter referred to as WCH) in the form of bellows, which movable end serves as a platform (MP) under tension and compression. The inner cavity of the

cylinder movable relative to the permanently fixed pistoncan serve as a working chamber with variable volume. [4,5]

Considering the formulas 13 and 14, if $P_a = const$, the power of such generating unit is 100 W with a one-litre WCH.

If a standard conversion of the platform's translational motion into the crankshaft rotation is applied and the frequency of the vacuum-atmospheric cycle (at the mentioned parameters) is 10 Hz (600 rpm), 1 MW of power can be obtained using the atmosphere potential energy in the working chamber to produce the mechanical work.

On the other hand, according to the formula 13, when the translational motion of the platform is converted to the crankshaft rotation, the torque is as follows:

$$\tau = F_a r = P_a S_{eff} l / 2 \text{ [Nm]} \tag{15}$$

and the power of such device, using the crank gear mechanism, can be expressed as follows:

$$N = n P_a S_{eff} r \text{ [W]} \tag{16}$$

where: n is the number of revolutions of the power shaft; P_a is the atmospheric pressure; S_{eff} is the effective area of the platform's outer surface; r is radius of the point of force application.

This formula defines the basic parameters of the power implosive unit, which operates by the vacuum-atmospheric cycle with the conversion of the shuttle movement of the platform into the rotation of the crankshaft and uses the potential energy of the external environment (atmosphere) as a source of external non-thermal energy.

For example, torque for this case at normal atmospheric pressure $P_a = 1.013*10^5$ Pa is the following:

$$\tau = 1.013*10^5 S_{eff} l / 2 = 50{,}650 \text{ [Nm]} \tag{17}$$

the output power, when n = 10, is the following:

$$N_{out} = 1.013*10^5 n S_{eff} r = 506 \text{ [kW]} \tag{18}$$

In this case, the output power is two times less than the power produced by a mechanical unit of power-producing facility. According to formula 14, the power generated by the device is 1 MW at a frequency of 10 Hz, but according to formula 18, the output power on the output power shaft is 0.5 MW. Force F_a does not change its value during the working stroke and if there are two WCH of the mechanical unit, force F_a will be constant during the entire two-stroke cycle, as each stroke is a working one. Therefore, 50% power loss is not expedient, and it's advisable not to use the crank gear mechanism. This can be done using the direct conversion of the potential energy of the atmosphere into usable electrical energy of the solenoid in a magnetic field.

The vacuum atmospheric gravitational converter AGK allows to carry out the direct conversion of energy of the atmosphere in a gravitational field which is proportional to the maximum volume of WCH, into useful electrical energy of the solenoid in a magnetic field.

Let's consider this possibility. As shown above, we use the energy of the atmosphere in a gravitational field through the creation of a vacuum chamber. In our case, it is presented as a working chamber (WCH) with a variable volume and the movable end surface (MP) (see Fig. 1.). The energy of the atmosphere can be expressed by the following formula:

$$W_{WCH} = P_a S_{eff} l = P_a V_{WCH} \tag{19}$$

where l is the length of the platform stroke when the volume of WCH is being reduced from maximum to minimum, which determines its working volume V_{WCH}.

It is known that the energy of the magnetic field of the solenoid is as follows:

$$W_s = \mu \mu_0 H^2 S_s L / 2 = B H V_s / 2 \tag{20}$$

where S_s is sectional area of the solenoid,

L is length of the solenoid,

V_s is volume of the solenoid,

H is magnetic field strength,

B is magnetic induction,

μ_0 is magnetic permeability.

The formulas 19 and 20 show that the energy obtained through working chamber is directly proportional to its volume and the atmospheric pressure, and the power of solenoid is directly proportional to its volume, magnetic induction and strength of magnetic field, in which it is located.

In general terms, if WCH is in a different environment, such as water, it is necessary to take into account the density of the environment ρ, which in this case is a complete analogy of magnetic permeability μ_0.

If the movable end surface (MP) is rigidly connected to the solenoid in the magnetic field, they will move under the action of CCAP with the same speed by a shuttle atmospheric vacuum cycle. The work produced by MP will be converted in the solenoid in the work done by the magnetic (Lorentz) force. At the same time, the induction electromotive force (proportional to the MP's work) will be produced. The solenoid moves under the action of CCAP, which in this case may be called "the power of conversion" F_c and is directly proportional to the effective area of MP. And the Ampere force F_{amp}, which creates the resistance (magnetic braking) to the movement of solenoid, is directly proportional to the strength of current generated by the solenoid to perform the work on the load and also directly proportional to the cross-sectional area of the solenoid. Thus, the maximum efficiency of the converter can be obtained, if the effective area of MP and cross-sectional area of the solenoid are equal. If the area of the movable surface exceeds the cross-sectional area of the solenoid, the F_c will exceed F_{amp}, and in such case the amount of energy required to exhaust WCH will exceed the capacity of the solenoid. If the cross-sectional area of the solenoid exceeds the area of MP, it will be impossible to get the maximum strength of current required according to the parameters of the solenoid. Only equal areas will ensure the optimal conversion of the potential energy of the atmosphere into usable electrical energy.

Conclusions. The developed experimental models of AGT and VAPA show their real functional capability with the preset parameters. [6]

Currently, we are working on the practical implementation of clean energy generation technologies on the basis of AGT in order to ensure their competitiveness on the market of new generation of autonomous power generating devices in a wide range of output power from 3–5 kW to 2–4 MW. The second promising application of AGT is energy-efficient power units of electric vehicles with a high service life.

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