ISSN 2518-170X (Online)
ISSN 2224-5278 (Print)

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ
«ХАЛЫҚ» ЖҚ

ХАБАРЛАРЫ

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»
ЧФ «Халық»

N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF
KAZAKHSTAN
«Halyk» Private Foundation

SERIES

OF GEOLOGY AND TECHNICAL SCIENCES

6 (468)

NOVEMBER – DECEMBER 2024

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

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«ҚР ҰҒА» РҚБ Хабарлары. Геология және техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Меншіктеуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).

Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: *геология, мұнай және газды өңдеудің химиялық технологиялары, мұнай химиясы, металдарды алу және олардың қосындыларының технологиясы.*

Мерзімділігі: жылына 6 рет.

Тиражы: 300 дана.

Редакцияның мекен-жайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

«Известия РОО «НАН РК». Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420,** выданное 29.07.2020 г.

Тематическая направленность: *геология, химические технологии переработки нефти и газа, нефтехимия, технологии извлечения металлов и их соеденений.*

Периодичность: 6 раз в год.

Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, оф. 219, тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.

ISSN 2518-170X (Online),

ISSN 2224-5278 (Print)

Owner: RPA «National Academy of Sciences of the Republic of Kazakhstan» (Almaty).

The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420,** issued 29.07.2020.

Thematic scope: *geology, chemical technologies for oil and gas processing, petrochemistry, technologies for extracting metals and their connections.*

Periodicity: 6 times a year.

Circulation: 300 copies.

Editorial address: 28, Shevchenko str., of. 219, Almaty, 050010, tel. 272-13-19

http://www.geolog-technical.kz/index.php/en/

NEWS of the National Academy of Sciences of the Republic of Kazakhstan
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224–5278
Volume 6. Number 468 (2024), 167–181
https://doi.org/10.32014/2024.2518-170X.468

UDC 620

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DEVELOPMENT OF AN ECOLOGICALLY CLEAN TECHNOLOGICAL UNIT FOR HEAT AND ELECTRIC POWER GENERATION

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Abstract. Existing installations for generation of thermal and electric energy have a number of disadvantages. These include low efficiency from 40%, high energy losses, dependence on weather conditions, high indicators of pollution emissions, significant energy losses during its transportation, significant financial costs for the purchase and delivery of fossil fuels.

Alternative, so-called 'green' sources of energy generation are also not as cheap and safe as many people believe. The search for new and innovative ways of production and transmission of electrical energy, which will combine high efficiency, low cost and minimal environmental damage is an urgent task.

The technological unit presented in the article is an innovative solution for the production of thermal and electrical energy. The peculiarity is the possibility of using both specially prepared working water and water from various natural sources or centralised water supply systems, which makes it universal and applicable in various conditions.

The described installation has a number of advantages. Firstly, its versatility and flexibility, the possibility of using different water sources, making it suitable for different locations. Secondly, energy efficiency, the possibility of producing heat and electricity, which allows optimising the use of resources. Thirdly, environmental friendliness: the use of renewable energy sources reduces the negative impact on the environment. Fourthly, cost-effectiveness, providing reduced energy costs and the possibility of operation in conditions of rising electricity tariffs, making the installation economically attractive for businesses and end users.

Keywords: thermal power generator, technology, hot water, thermal energy, electric energy, temperature, ecology, pump.

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ЖЫЛУ ЖӘНЕ ЭЛЕКТР ЭНЕРГИЯСЫН АЛУ ҮШІН ЭКОЛОГИЯЛЫҚ ТАЗА ТЕХНОЛОГИЯЛЫҚ ҚОНДЫРҒЫНЫ ӘЗІРЛЕУ

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Аннотация. Жылу және электр энергиясын өндіруге арналған қолданыстағы қондырғылардың бірқатар кемшіліктері бар. Оларға 40% төмен тиімділік, жоғары энергия шығыны, ауа райы жағдайына тәуелділік, ластаушы заттардың шығарындыларының жоғары деңгейі, тасымалдау кезіндегі энергияның айтарлықтай жоғалуы, органикалық отынды сатып алу мен жеткізуге айтарлықтай қаржылық шығындар жатады.

Энергия өндірудің «жасыл» деп аталатын балама көздері де көпшілік ойлағандай арзан әрі қауіпсіз емес. Жоғары тиімділікті, төмен шығындарды және қоршаған ортаға ең аз зиян келтіретін электр энергиясын өндіру мен берудің жаңа және инновациялық әдістерін іздеу кезек күттірмейтін міндет болып табылады.

Мақалада ұсынылған технологиялық қондырғы жылу және электр энергиясын өндіруге арналған инновациялық шешім болып табылады. Ерекшелігі - арнайы дайындалған жұмыс суын да, әртүрлі табиғи көздерден немесе орталықтандырылған сумен жабдықтау жүйелерінен суды да пайдалану мүмкіндігі, оны әмбебап және әртүрлі жағдайларда қолдануға мүмкіндік береді.

Сипатталған қондырғының бірқатар артықшылықтары бар. Біріншісі – оның әмбебаптығы мен икемділігі, әртүрлі су көздерін пайдалану мүмкіндігі, оны әртүрлі орындарға қолайлы етеді. Екіншіден, энергия тиімділігі, ресурстарды пайдалануды оңтайландыруға мүмкіндік беретін жылу және электр энергиясын өндіру мүмкіндігі. Үшіншіден, экологиялық тазалық: жаңартылатын энергия көздерін пайдалану қоршаған ортаға кері әсерін азайтады. Төртіншіден, энергия шығындарын азайтуды және электр энергиясы тарифтерінің көтерілуі жағдайында жұмыс істеу мүмкіндігін қамтамасыз ететін экономикалық тиімділік қондырғыны кәсіпорындар мен түпкілікті тұтынушылар үшін экономикалық жағынан тартымды етеді.

Түйін сөздер: жылу электр генераторы, технология, ыстық су, жылу энергиясы, электр энергиясы, температура, экология, сорғы.

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РАЗРАБОТКА ЭКОЛОГИЧЕСКИ ЧИСТОЙ ТЕХНОЛОГИЧЕСКОЙ УСТАНОВКИ ДЛЯ ПОЛУЧЕНИЯ ТЕПЛОВОЙ И ЭЛЕКТРИЧЕСКОЙ ЭНЕРГИИ

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Аннотация. Существующие установки для генерации тепловой и электрической энергии имеют ряд недостатков. Это и невысокий КПД от 40%, высокие энергопотери, зависимость от погодных условий, высокие показатели по выбросам загрязнений, значительные потери энергии при ее транспортировке, значительные финансовые расходы на приобретение и доставку органического топлива.

Альтернативные, так называемые «зеленые» источники энергогенерации тоже не так дешевы и безопасны, как полагают многие. Поиск новых и инновационных способов производства и передачи электрической энергии, которые будут сочетать в себе высокую эффективность, низкую стоимость и минимальный экологический ущерб является актуальной задачей.

Технологическая установка, представленная в статье, представляет собой инновационное решение для получения тепловой и электрической энергии. Особенностью является возможность использования как специально подготовленной рабочей воды, так и воды из различных природных источников или централизованных систем водоснабжения, что делает её универсальной и применимой в различных условиях.

Описанная установка имеет ряд преимуществ. Во-первых, это ее универсальность и гибкость, возможность использования различных источников воды, что делает ее подходящей для разных мест. Во-вторых, энергоэффективность, возможность производства тепла и электричества, что позволяет оптимизировать использование ресурсов. В-третьих, экологичность: использование возобновляемых источников энергии снижает негативное воздействие на окружающую среду. В-четвертых, экономическая эффективность, обеспечивающая снижение затрат на электроэнергию и

возможность эксплуатации в условиях роста тарифов на электричество, делает установку экономически привлекательной для предприятий и конечных потребителей.

Ключевые слова: теплоэлектрогенератор, технология, горячая вода, тепловая энергия, электрическая энергия, температура, экология, насос.

Introduction

Seeking new methods of energy generation to meet the requirements of the "green economy" is one of the key challenges of the 21st century. The green economy strives for sustainable development, minimization of negative environmental impacts and efficient use of resources. Therefore, it is necessary to look for energy solutions that reduce greenhouse gas emissions, do not use depleted resources and maximize the use of renewable energy sources.

Thermal power plants currently in use have a number of disadvantages, which include:

1) High greenhouse gas emissions and air pollution: units powered by fossil fuels such as coal, oil and natural gas contribute to significant emissions of greenhouse gases such as carbon dioxide and nitrogen oxides, thus leading to climate change and air pollution.

2) Depletion of natural resources: the extraction and use of fossil fuels lead to the depletion of natural resources such as oil, coal and natural gas, which are limited and do not satisfy the growing global demand for energy.

3) Accident risks and environmental pollution: thermal power plants, such as nuclear power plants and thermal power plants, pose a risk of accidents including radiation emissions and leakage of toxic substances that can lead to serious consequences for the environment and human health.

4) Inefficient use of resources: traditional thermal power plants often have a low efficiency coefficient, which means that a significant part of the energy obtained from the fuel is lost as heat, or is not used efficiently.

5) Dependence on energy imports: many countries depend on energy import, which makes them vulnerable to market price changes and geopolitical conflicts.

6) Potential threats to public health: emissions and waste from thermal power plants may pose a threat to public health due to air and water pollution.

7) Fuel price volatility: market volatility and changes in fossil fuel prices can have a negative impact on the economy and energy consumers.

Therefore the development and implementation of new, more efficient and environmentally friendly methods of energy generation is critically important to ensure sustainable development and reduce negative environmental impacts.

The developed technological plant is designed to produce hot water, heat and electricity/ It also allows solving problems in energy conservation, energy, industry, agriculture, civil engineering, environmental and other areas.

The technological plant will allow:

- producing hot water, heat and electricity without the use of classical, traditional combustible hydrocarbon (solid, liquid, gaseous) fuels that cause irreparable environmental damage to ecology, flora, fauna, etc.;

- delivering hot water, thermal and electric energy to any detached administrative, residential buildings, cottage complexes, preschool and school buildings educational institutions, hospitals, industrial, agricultural and military facilities located far from central sources of heating;
- supplying consumers with an autonomous source of hot water, heat and electric energy at minimal costs.

Materials and main methods

The principle of operation of the described technological plant presents a challenging approach to the generation of thermal and electrical energy. It includes an asymmetric annular condensation collapse that causes the phenomenon of the "cavitation effect". (Vivek, at all, 2022). However, it should be noted that the cavitation effect can cause undesirable consequences for the operation of the plant (Arzumanov, 1978).

The cavitation effect occurs when bubbles are formed in a liquid due to pressure changes. In this case, if the cavitation effect takes place inside the process plant, this can lead to intense erosion and wear of the working surfaces, as well as to the destruction and failure of the equipment (Pearsall, 1972).

The negative effects of cavitation in practice can be minimized by a number of measures. These may include the use of special structural elements, the addition of dopants to the working fluid, the control of pressure and temperature, as well as the development of more durable materials for plant parts (Arzumanov, 1985).

In the result of the destruction of the boundary layer due to the use of special technologies, scientific and technical developments, and proprietary design solutions, the destructive effect of cavitation on the working surfaces of the box and rotor blades of the generator of the plant is completely excluded, which ensures stable operation, efficient production of thermal and electrical energy (Brennen, 2014).

The principle of operation of the technological plant is as follows:

In high-pressure pumps, there is an increase in the temperature of the liquid. The temperature of the liquid in the pressure pipe is 2-3° C, which is on average 2.5° C higher than in the suction pipe.

The total length of the circulation line pipes is 5 meters. The actual overall dimensions of the process plant are shown in Figure 1. The high-pressure pump is integrated into the circulation circuit. The markings on the diagram are as follows: Item 1 - circulation pump, Item 2 - heat exchangers, Item 3 - mixing tank. Considering that the distance from the mixing tank to the pump is 0.5 m, the water velocity in the line from the pump to the expansion tank is 30 m/sec, and from the expansion tank to the pump it makes 5 m/sec., the water makes one circulation along the entire length of the circuit in 0.4 seconds.

Since the circulation pump in the heat generator is completely protected from cavitation, at the pump suction site such a high water velocity is allowed at any water temperature. The design of the heat exchangers and the method of organizing the flow of water make it possible to achieve a set level of speeds in the heat generator itself.

The water makes 150 circulations a minute, and each time it heats up to 2.5 ^{o}C, which means that the water should heat up to 375 ^{o}C. This water passes through the heat exchanger through which system water is supplied. The pump capacity is 120 m^3/hour per circulation, i.e. 0.4 seconds. In one circulation the system lets pass 0.0133 m^3 of water or 13.3 kg, and each time it is heated to 2.5 ^{o}C. At 150 circulations per minute, 4987.5 Kcal of heat can be produced, which is 299250 Kcal/hour or 347 kW/hour.

According to the existing concepts of thermodynamics, the electric motor of the pump should consume the same or slightly more power. Otherwise, the law of conservation of energy is violated. If the amount of energy entering the system is known, then it must coincide with the amount of thermal energy entering from the system, taking into account losses.

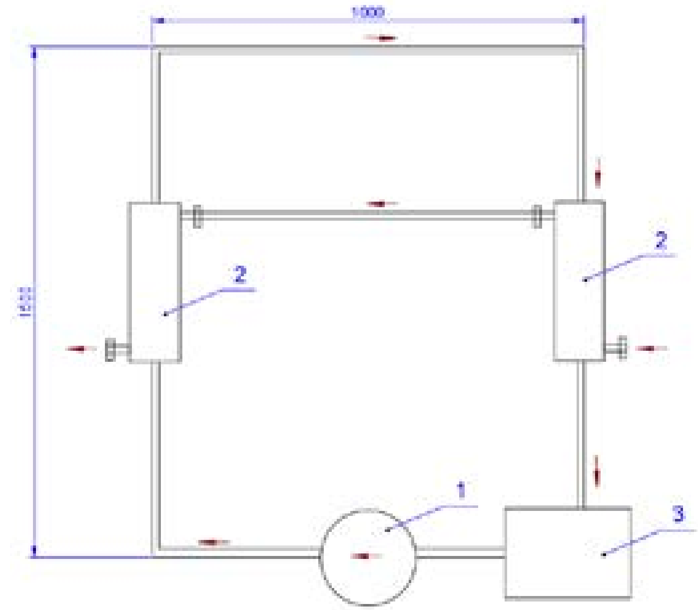

Figure 1 - High pressure pump for pumping liquid

When the pump is in operation, the pumped liquid starts releasing energy, which was not previously taken into account; and this energy is also spent on heating the liquid. Thus the amount of thermal energy obtained during the operation of the pump will be greater than the amount of electrical energy consumed by the electric motor. Therefore, it makes sense to talk not about the efficiency of the pump, but about the multiplicity of energy conversion in the engine-pump system.

The energy conversion factor - *k* (ECF) (multiplicity or ratio of power conversion

- PCR) should be understood as the ratio of the amount of heat generated in the system to the amount of electrical energy consumed in the system, that is, $k = Q_p / Q_{z.}$.

where: Qp is the thermal energy generated in the system (measured in joules or watts),

Qz is the electrical energy consumed by the pump (measured in joules or watts).

The multiplicity of energy conversion (multiplicity or power conversion ratio ECF or PCR) can be significantly greater than one.

Additional energy will be generated when pumping the liquid.

Firstly, the liquid in the pump can heat up due to friction both between the liquid and the elements of the pump structure, and between the elements of the liquid itself.

Secondly, purely thermodynamic heating takes place: a change in pressure in the liquid leads to its heating.

These two types of liquid heating consume external energy, that is, the energy of an electric motor. There is another type of heating called cavitation energy, when external energy is not used. It occurs due to the redistribution of thermodynamic parameters in the liquid itself during pumping, the conversion factor is greater than one.

Cavitation protection is important when designing pumps for pumping liquids at high temperatures. The energy consumed is not taken from the power of the drive motor, but from the liquid itself, or enters the liquid from the outside when the cavitation process takes place. The main purpose of the development of a technological plant is to make this energy heat water.

In the developed thermal power generator, the energy release process is dramatically enhanced, which made it possible to obtain increased water heating. However this, in turn, additionally required designing a pump completely protected from cavitation. The pump was made and named a hydraulic roller pump. In the rotor of this pump, hydraulic rollers rotating with a very high number of revolutions are used as blades, the rotation speed of which is 20-40 thousand revolutions per minute. Such an intensity of water circulation can be obtained only when water is in a negatively stressed state, that is, in a stretched state. The experiment on the development of a fine water purification system has shown that water does not compress well, but stretches perfectly. Figure 2a shows a diagram using a 1.5 m high water differential pressure gauge. The outer diameter of the tube was 10 mm, the inner diameter was 8 mm. Water was poured into the diffmanometer at zero, and a Kamovsky pump was used; it creates air discharge and pressure equally well and has a small, well-controlled air flow rate. When connecting the diffmanometer hose to the pump discharge nozzle, the water level in the diffmanometer in its left branch rose, and in the right branch it fell and the heights h_1 and h_2 were completely equal.

When connecting the diffmanometer hose to the discharge nozzle, the level in the right branch rose as in Fig. 2b, and in the left it fell, and the height h_1 was

10÷30% higher than the height h_2. Since the inner diameter of the diffmanometer tube did not change, in this case we can talk about an increase in the volume of liquid in the right branch of the diffmanometer only due to the stretching of the liquid. There were no air bubbles coming out of the water. At very small values of compressibility of the liquid, it stretches well, that is, it can be in a negatively stressed state.

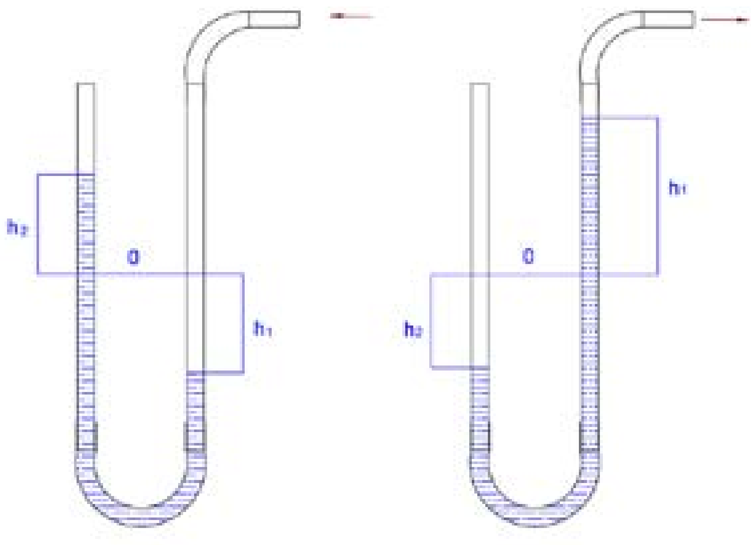

Figure 2 - The scheme of the experiment on water stretching

A specially conducted experiment specified that in a negatively stressed state water has a pronounced viscosity anisotropy. When the hydraulic roller rotates, there is no friction in the tangential direction between the water layers. That is why in a negatively stressed state, water can be twisted to very high values of the twisting intensity. This fact made it possible to develop a hydro roller pump. This also led to the birth of a hydraulic roller bearing, which can operate at any number of shaft revolutions, under any loads, with a shaft diameter from 0.2 to 4 meters. It is a self-centering, non-friction bearing that is practically not subject to wear and does not require lubrication.

At the specified speed of the hydraulic roller, water acquires the properties of a solid-state body. Under the action of gravitational forces, 1 liter of water weighs 1 kg or 9.81 N, and since the weight of the body:

$$P_i = V \cdot \rho w \cdot g \qquad (1)$$

where V is the volume of the body, ρ_w is the density of water, g is the acceleration of gravity or the force intensity value. For the gravitational field $g = 9.81$ m/sec^2.

In a centrifugal field, the magnitude of the tension is the centrifugal acceleration:

$$g = C2\varphi / R \qquad (2)$$

Where: C_{φ} – circumferential or tangential velocity, R – the rotation circle radius. For a hydro roller pump of a technological plant with a roller diameter of D=0.028m, so the radius R=0.028/2=0.014 m. and a hydraulic roller speed of N=40.000 rpm, the circumferential speed is

$$C\varphi = \frac{\pi \cdot 0.028m \cdot 40.000}{60} = 58.6 \text{ m/sec}$$

and the centrifugal acceleration is 245’282 m/sec^2, which is 25’000 times greater than the gravitational acceleration; and the weight of such a hydraulic roller, with its diameter 0.028 m and length ℓ = 0.4 m in the field of centrifugal forces, will make:

$$g = \frac{58.6^2}{0.028} = 245.285 \text{ m/s}^2$$

$$V = \pi \frac{Dr^2}{4} \cdot l = \pi \cdot \frac{(0.028)^2}{4} \cdot 0.4 = 0.000248\, m^2$$

$$P_i = V \cdot p_w \cdot g = 0.00028\ m^3 \cdot 1000\text{kg}/m^3 \cdot 245{,}282 \text{ m/s}^2 = 60{,}382N$$

while in the field of gravitational forces, such a roller will weigh 2.41N.

If we take a hydraulic roller with a centrifugal weight, that is, the weight in the field of centrifugal forces is 60’382 N and “transfer” it to the field of gravitational forces, where the acceleration is 9.81 m / sec^2, then this hydraulic roller should have a mass of 6’155 kg. And since the volume of the hydraulic roller is equal to $V = \pi \cdot Dr^2 / 4 \times \ell = 0.000248\, m^3$, and the mass is $= V \cdot \rho w$, then the density of the roller should be equal to 25’020’325 kg/m^3.

We exist in three-dimensional space, where gravitational forces are caused by the presence of mass and create the space-time curvature, which is determined by Einstein’s equations. The phenomena occurring in systems with multiple fields, in which the elements of the technological plant operate in the field of centrifugal forces and which we consider from the point of view of an observer in the field of gravitational forces, are completely unique.

In a hydraulic roller pump, the density of water is 1000 kg/m^3, and the hydraulic roller for a moment acquires the properties of a material three thousand times denser than steel or behaves like a material with such a density, this is called the inertial pseudo-compression effect. This phenomenon is considered in detail in a two-field system: centrifugal and gravitational.

The rotor is assembled using separate discs made of stainless steel, with electrical insulation washers between them. Position 1 in Fig. 3 shows the pump rotor. The discs are secured with pins at position 9, which are also separated from the metal discs by electrically insulating bushings at position 10. This decision was made for the following reason. The process water that is poured into the first circuit of the process plant is completely desalinated water with a monomolecular structure. It is known that water consists of 33 isotopes. The molecules of each of the isotopes have an individual frequency of their own fluctuations (oscillations). In order to carry out the process of circular condensation collapse, which gives the main output of thermal energy in a thermal power generator, a water structure with molecules having the same natural oscillation frequency is necessary. The technology for producing such water has been developed and tested. About 340 ml of monostructured water was extracted from one liter of conventional water. The technological cycle of water production includes double distillation and freezing in specially shaped vessels. Freezing is carried out in a certain temperature range, followed by separating the necessary piece of ice. Like any distillate, this water is a dielectric.

During the movement of water in the collapse chambers of the rotor, the rotor material is strongly electrified (triboelectric effect); and since the rotor is an electric capacitor in essence, a powerful electrostatic charge accumulates in it. Because the charge of the water and the rotor material is the same, after a while the contact of the water and the rotor material, as the water moves through the collapse chamber, stops.

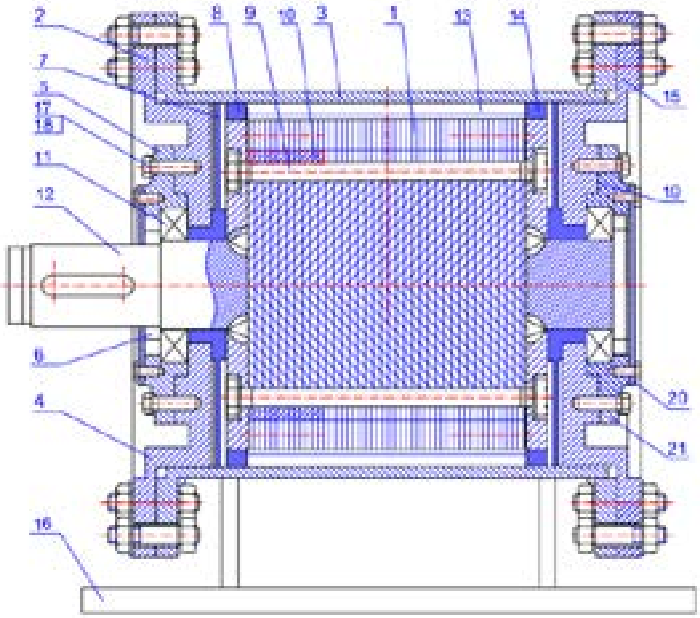

Figure 3 – Collaptic dynamic heat generator in cross-section

The contact is realized through a micro-electrostatic layer, and this removes friction between the water and the rotor material. This fact prevents the appearance and development of a boundary layer in the near-walled areas of the collapse chambers and allows the hydraulic rollers to rotate with any number of revolutions, that is, rotations occur on a micro-electrostatic cushion. Special experiments have proved that in this case there is no friction between the water and the electrostatic cushion.

Figure 4 shows a cross section of a hydro roller pump. There are 18 collapsing chambers in the pump rotor, a chamber point diameter is 28 mm. The rotor diameter is 380 mm. When rotating, the camera approaches the supply nozzle (indicated in Fig. 4 by the letter A) and pumps in a portion of water.

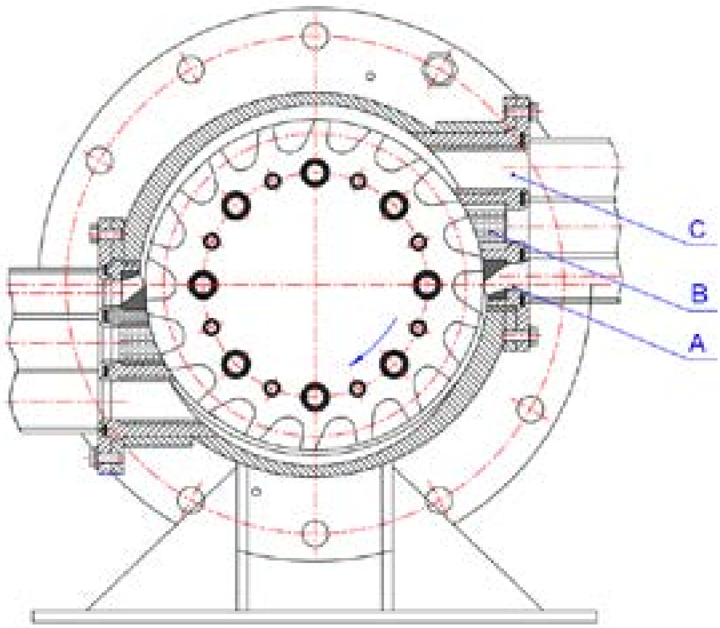

Figure 4 – The cross section of the hydraulic roller pump

After passing the feed nozzle, an intensely rotating vortex is formed in the chamber. The estimated number of revolutions of the vortex for this structure is 30’900 rpm. At high speeds in the hydraulic roller, a steam blowhole is formed, its diameter is 14÷16 mm.

To stabilize the formed steam blowhole, an increase in the diameter of the case radius is organized along the rotation of the rotor. The hydraulic roller becomes elliptical rather than cylindrical. This form of motion of the swirling liquid was proved in experiments on ultrafine water purification. In Figure 5 it can be seen according to the trajectories of particle motion that depending on the geometry of the channel the hydraulic roller takes an elliptical shape. The hydro roller is a pump blade and helps pumping water, therefore such a blade will not be subjected to cavitation wear.

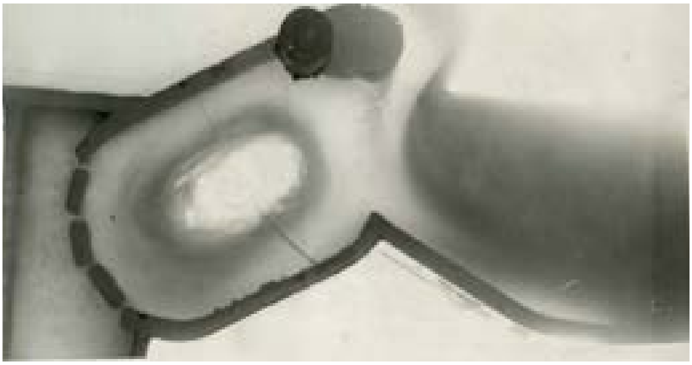

Figure 5 – The hydraulic roller

After reaching the maximum diameter of the case radius, its reduction begins and the hydraulic roller is knocked out into the nozzle C, from where water is supplied to the heat exchangers. When the hydraulic roller moves along the path from the supply nozzle to the exhaust pipe, it moves all the time with variable angular acceleration. First, the number of revolutions of the roller when moving along the path decrease with an increase in the inner diameter of the case due to the law of conservation of rotational momentum; then the number of revolutions of the hydraulic roller due to movement along the path increase with a decrease in the inner diameter of the case. When a body moves with variable angular acceleration, all the effects caused by movement in the field of centrifugal forces increase significantly. With the described movement of the hydraulic roller, at the moment of a sharp increase in its diameter, in the exhaust pipe the so-called ring condensation collapse effect occurs, that is, the collapse (condensation) of the steam bubble inside the hydraulic roller. Moreover, this collapse is not just high–speed condensation, but an explosion with the formation of a shock wave directed from the periphery of the steam bubble to the center of the rotating volume.

In a conventional explosion, the shock wave propagates from the center to the periphery, and the intensity of its impact decreases in proportion to the square of the radius. In this case, the shock wave moves from the periphery to the center, and the intensity of its impact increases proportionally to the square of the radius, so in the center of the vapor volume the pressure reaches very large values. When a steam cavitation bubble with a diameter of 1 mm collapses, the pressure in its center can be $3 \cdot 10^6$ kgF/cm^2, or three million atmospheres. When the diameter of the collapsing steam volume is 14÷16 mm, the pressure will be even greater. The steam exposed to such compression must heat up and form a high-temperature micro or nano cord having a temperature of about a million degrees. In the presented thermal power generator, this cord gives off heat to the surrounding water, which heats up and then releases its heat in the heat exchanger to the system water. This confirms that the cavitation effect in the thermal power generator is sharply increased.

When cavitation occurs, individual micro-bubbles of steam with a diameter of

0.1÷1 mm collapse, and the collapse takes place in a vapor volume with a diameter of 14÷16 mm. This brings forth another effect: when a shock wave originates in the collapse chambers of a rotating rotor, the shock wave action becomes asymmetric and a powerful tangential force arises, which is directed along the rotation of the rotor. This force contributed to the rotation of the rotor, and the laboratory tests of the technological plant proved that due to its action the electric motor's power consumption was reduced.

The laboratory model testing demonstrated that the initial power of the electric motor on cold water was 18.5 kW, when entering the operating mode, it made 3.5 kW. The rotor of the process plant is conceptually a heat engine. The design flaws of the first technological plant did not allow it to enter autonomous operation mode. At the beginning of the test drive, the thermal power generator did not have an additional emptying system for the collapse chambers. The collapse chambers approached the feed nozzle A in Fig. 4 waterlogged, so the thermal power generator simply could not operate at full capacity. However, the generator rotor took over 81.57% of the load and the thermal generator produced a multiplicity of energy conversion $K = 21.43$.

The system of additional emptying of the collapse chambers has been introduced into the design of chamber B in Fig. 4. In this chamber, a negative pressure of - 2.2 atm is created by means of a siphon pump. A siphon pump, which has no rotating parts, is in this case an integral part of a thermal electric generator and can create negative pressure (static stretching of the medium by the effect of ejector thrust) until the water breaking point, and we know that this is 220 atmospheres of negative pressure.

If complete emptying of the collapse chambers can be achieved, then the estimated power of the collapse engine, which is a hydraulic roller pump, makes 546 kW. Thus, the presented thermal power generator, in addition to thermal power, can also produce electrical power. The redistribution between thermal and electrical power can only be determined empirically.

The thermal power generator is a sufficiently powerful source of heat and electric energy for independent heating supply, which in the future may not consume electric energy at all, but work on specially prepared water as a fuel.

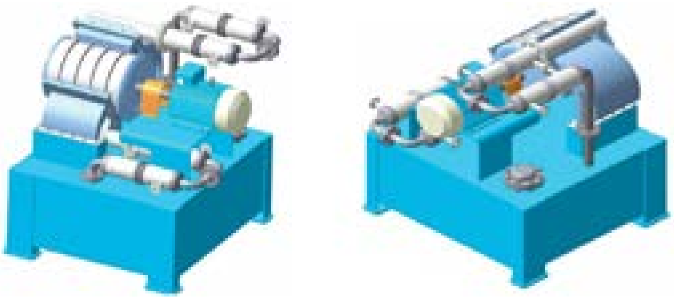

Figure 6 – The technological plant

The rotor is powered by any kind of engine: a gasoline-diesel generator or an electric motor with a speed of 3000 rpm.

The power consumed by the starting electric motor at idle speed when there is still no power water in the first circuit of the technological plant makes N = 4.6-4.8 kW.

Let us consider the operation of a technological plant prototype. Specially prepared process and power water is poured into the first circuit of the technological plant. The first 20 minutes the power water is heating slowly. The power consumed by the starting electric motor during this period is 18.2-18.5 kW. When the power water of the primary circuit reaches a temperature of 60-62 ^{o}C, the arrow of the wattmeter installed on the starting electric motor begins to drop to a power of 3.4-3.6 kW; and the water temperature in the primary circuit begins to rise sharply. At this point, system water is supplied to the second circuit, and the technological plant starts working producing heat with a new capacity of 74-76 kW. Conditionally, this can be called the entering of the technological plant the operating mode.

Results. When the technological plant enters the operation mode, the power supply of the starting electric motor automatically turns off, and the generator rotor starts generating its own electricity and, further, begins to work independently, in autonomous, automatic mode, generating both thermal and electrical energy.

The tested technological plant consumed an average of 3.5 kW of electric power and produced, on average, 75 kW of thermal energy (or 64500 kcal/hour). That is, the energy conversion factor *k* (ECF)=21.43 (or the ratio of power conversion PCR = 21.43). Therefore, the coefficient *K* = 21.43 shows the efficiency of the technological plant over the operation of an electric boiler.

In order to obtain 75 kW of thermal power in a conventional electric boiler, it is necessary to spend 75 kW of electric power (excluding boiler efficiency). Knowing the cost of 1 kW of electricity, it is not difficult to calculate the cost of operating a conventional electric boiler and the presented technological plant.

Discussion. Comparing these indicators, it is easy to make sure that the cost of heating using the technological plant will be 21.43 times lower than when operating a conventional electric boiler without taking into account the generation of additional, own electricity after the technological plant goes into an autonomous operation mode.

The presented technological unit demonstrates promising potential for increasing energy efficiency and minimising environmental impact. The advantage of the plant is its high energy efficiency, which is relevant in the context of a shortage of traditional energy sources and rising electricity tariffs.

The plant promises long-term energy savings, but requires significant up-front investment and maintenance costs, which may limit its deployment in countries with low levels of investment in innovative energy technologies. The possible environmental consequences of using natural water resources may affect its economic attractiveness and sustainability. Further research is essential to assess its adaptability and ability to compete in the market.

Conclusion

Since the presented generator is a unique technological product used as an environmentally friendly technological plant, it can bring great benefits to the economy and the environment in practical application. In the context of the use of new rational designs, original technology in the production of hot water, heat and electricity, to date, some information about the construction of this plant presents a commercial secret, the test work was carried out in a closed-door mode.

The material of the publication was prepared jointly with Anatoly Alexandrovich Filippov, the leading specialist of "TSEB" LLP, the winner of the "Energy of the Future" Competition of innovative projects within the East Kazakhstan Mini EXPO-2014 exhibition framework.

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ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Директор отдела издания научных журналов НАН РК *А. Ботанқызы*
Редакторы: *Д.С. Аленов, Ж.Ш.Әден*
Верстка на компьютере *Г.Д.Жадыранова*

Подписано в печать 15.12.2024.
Формат 70x90$^{1}/_{16}$. Бумага офсетная. Печать – ризограф.
14,5 п.л. Тираж 300. Заказ 6.

РОО «Национальная академия наук РК»
050010, Алматы, ул. Шевченко, 28, т. 272-13-19