SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science
p-ISSN: 2308-4944 (print) e-ISSN: 2409-0085 (online)
Year: 2023 Issue: 07 Volume: 123
Published: 05.07.2023 http://T-Science.org

Issue Article

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FEATURES OF PROVIDING COMFORTABLE CONDITIONS FOR THE POPULATION OF THE ARCTIC ZONES OF THE ARCTIC

Abstract: *in the article, the authors presented the results of research on alternative options for providing comfortable conditions for workers and the population of the Arctic zones of the Arctic with extremely low temperatures that are dangerous for life and work.*

In particular, the authors presented the results of studies on the possibilities of using new methods that were not previously considered to maintain a comfortable temperature of the entire human body, as well as to provide ventilation and air convection inside a human suit, but comfort is severely limited due to the currently used airtight materials, which can even lead to inflammation of the human skin.

According to the authors, the use of energy sources, including in closed systems, such as the human body under clothing, will significantly increase the efficiency of their work and life safety at low temperatures, unless new materials are developed that will guarantee the population the safety of their presence. in these climatic zones of the Arctic.

Key words: *life support, climate, population, Arctic zones, Arctic, temperature, comfort, alternatives, suit, safety.*
Language: *English*
Citation: Blagorodov, A. A., Vilisova, M. L., Prokhorov, V. T., & Volkova, G. Yu. (2023). Features of providing comfortable conditions for the population of the Arctic zones of the Arctic. *ISJ Theoretical & Applied Science, 07 (123),* 25-45.
Soi: http://s-o-i.org/1.1/TAS-07-123-6 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2023.07.123.6
Scopus ASCC: *2000.*

Introduction

UDC 685.74: 319.47

Research, work, and search for solutions to problems related to shielding the human body from environmental influences, namely, physical influences, such as temperature changes, solar radiation, physical impact, etc., this question has always been before man and mankind, and at all times without stopping for a second. People coped with this problem as best they could, and even today there are open questions, for example, how to ensure acceptable working conditions in an external environment that is still extremely low and can stop a person's life process in a matter of minutes.

The authors did a lot of analytical work and identified an approach to solving this problem. Table 1 shows the characteristics of packages of imported polymeric materials for the production of jackets, and packages based on domestic polymeric materials.

Domestic hot-melt adhesive cushioning materials (TCPM) will find the greatest application in the manufacture of suits for civil servants in the Arctic.

But such a solution is not sufficient to guarantee comfortable conditions for the population of the Arctic zones for the entire period of their participation in labor activity and leads to a dead end in solving this problem.

Table 1. Characteristics of the package of materials for the production of jackets

Model	**Package materials**	**Thickness, mm**	**Coefficient of thermal conductivity λ,W/m °C**
1	*2*	*3*	*4*
	From imported polymer materials		
Model 1	Synthetic fabric (100% PE)	1.6	0.042
	Promaloft insulation (main)	12.0	0.034
	Gasket materials:		
	1. TKPM "Picardy" 1242\17	1.2	0.041
	2. TKPM "Kufner" R171G57	1.3	0.031
	3. TKPM "Kufner" B141N77	2.1	0.021
	4. TKPM AKR-622\AKR218	3.5	0.009
	Lining fabric	0.76	0.039
Model 2	Synthetic fabric (100% PE)	1.6	0.042
	Insulation "Hollofan" (2 layers; main)		
	Gasket materials:	12.0	0.036
	1. TKPM "Picardy" 1242\17	1.2	0.041
	2. TKPM "Kufner" R171G57	1.3	0.031
	3. TKPM "Kufner" B141N77	2.1	0.021
	4. TKPM AKR-622\AKR218	3.5	0.009
	Lining fabric	0.76	0.039
Model 3	Synthetic fabric (100% PE)	1.6	0.042
	Insulation "Combiwool" ("250 + 150"; main)		
	Gasket materials:	12.0	0.33
	1. TKPM "Picardy" 1242\17	1.2	0.041
	2. TKPM "Kufner" R171G57	1.3	0.031
	3. TKPM "Kufner" B141N77	2.1	0.021
	4. TKPM AKR-622\AKR218	3.5	0.009
	Lining fabric	0.76	0.039
	From domestic polymeric materials		
Model 1	Membrane fabric	3.5	0.06
	Sintepon (100% PE; main)	15	0.035
	Gasket materials:		
	1. TKPM "Picardy" 1242\17	1.2	0.041
	2. TKPM "Kufner" R171G57	1.3	0.031
	3. TKPM "Kufner" B141N77	2.1	0.021
	4. TKPM AKR-622\AKR218	3.5	0.009
	Fleece	1.2	0.039
Model 2	PE fabric (art.: 06617-kv)	2.1	0.040
	Termofinn Micro insulation (basic)	15	0.036
	Gasket materials:		
	1. TKPM "Picardy" 1242\17		
	2. TKPM "Kufner" R171G57	1.2	0.041
	3. TKPM "Kufner" B141N77	1.3	0.031
	4. TKPM AKR-622\AKR218	2.1	0.021

Impact Factor:

ISRA (India)	= **6.317**	**SIS** (USA)	= **0.912**	**ICV** (Poland)	= **6.630**
ISI (Dubai, UAE)	= **1.582**	**РИНЦ** (Russia)	= **3.939**	**PIF** (India)	= **1.940**
GIF (Australia)	= **0.564**	**ESJI** (KZ)	= **8.771**	**IBI** (India)	= **4.260**
JIF	= **1.500**	**SJIF** (Morocco)	= **7.184**	**OAJI** (USA)	= **0.350**

		3.5	0.009
	Visco-complex lining fabric	0.6	0.044
Model 3	Blended fabric (67% PE + 33% CL)	1.8	0.041
	Stitched fabric "wool" (2 layers; 80% PE + 20% wool; main) Gasket materials: 1. TKPM "Picardy" 1242\17 2. TKPM "Kufner" R171G57 3. TKPM "Kufner" B141N77 4. TKPM AKR-622\AKR218	20 1.2 1.3 2.1 3.5	0.038 0.041 0.031 0.021 0.009
	Lining fabric (art.: 32013)	0.69	0.049

We propose to slightly shift the point of view, I will formulate the concept, the human body, microclimate, costume, and the absence of an external environment. Moving away from paradigms, the more layers of clothing or costume, the better, and so on. But due to what it is possible to create a microclimate buffer, in a suit, namely, due to the formulation of a simple solution, the human body is an independent generator of thermal energy that can be used. At the same time, under the costume space turns into a kind of closed system with a thermal energy generator and insulation. It follows from this that all the laws of closed environments apply to a closed environment.

Main part

Fundamental for creating a costume, since different parts of the body have features, let's go through them briefly, such as increased sweating, blood flow features such features as vasoconstriction in the extremities, lack of full blood flow in tissues, the very physics of blood flow regulation terma, blood leaving the heart transfers heat to cold blood leaving the extremities, due to this, the heat balance is maintained, the organ that creates the main volume of thermal energy is the liver, etc.

The main heat losses (energy release) of the body into the environment are formulated as a percentage:

Thermal radiation 60%.

Evaporation 22%.

Heat conduction through air (convection) 15%.

Heat conduction through skin-to-material contact 3%.

It can be seen from this analysis that the main loss is radiation, followed by evaporation and convection.

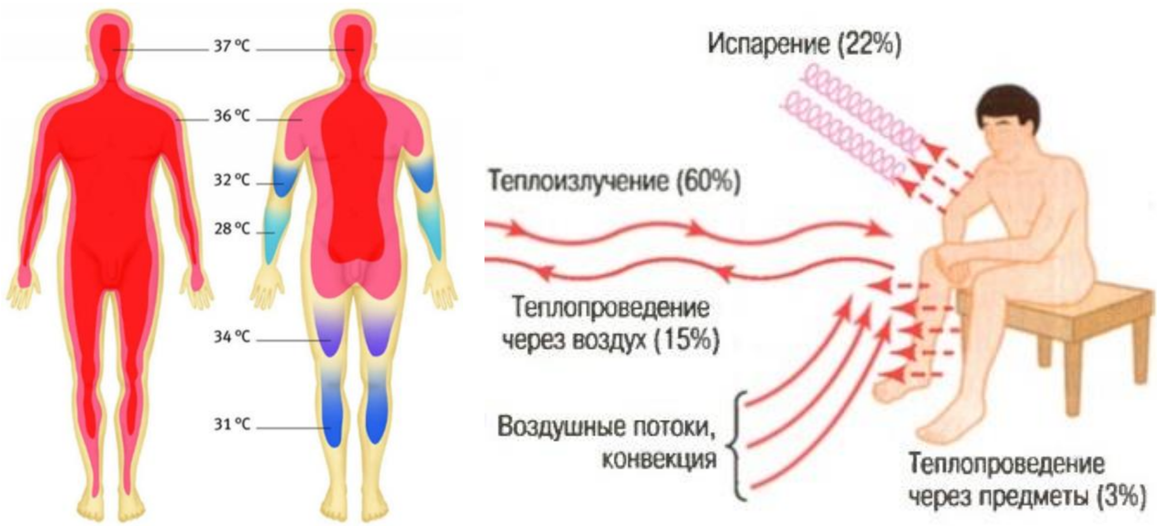


Figure 1. Mechanisms of heat transfer from the surface of the human body

But what if we consider this as a feature of a thermal energy generator.

The first thing we are trying to do is to shield the thermal energy released to people, and it turns out that the protector, that is, the suit, formulates the conditions, becoming an external environment for the body, and since the suit has the opposite property, namely, one way or another, the absorption of thermal energy. The suit becomes a cooler, and the body becomes a heater, while there is air between them, while everything is in a closed environment. Which perfectly fits the definition of an external combustion heat engine.

It is now obvious to everyone that one of the main directions of economic development and scientific and technological progress in the 21st century is the task of finding promising technologies for energy conversion and mass production of new equipment based on highly efficient thermodynamic cycles using renewable fuels and new working fluids. This means the creation, production and introduction into mass use of such highly efficient and environmentally friendly energy systems that would meet the needs of industry and the population in energy at a minimum cost of material resources.

We live in an energy world in which we cannot imagine life without electricity. we use electricity every day, these are all our appliances (electric kettles, microwave ovens, TV and much more). But many do not think about how electricity is obtained, and the answer is very simple. The most popular method is extraction from burning material (oil, natural gas, coal, bio-fuel) and nuclear and thermal stations cannot be forgotten, but there are also other less popular methods, for example: wind energy, water energy. Many people waste electricity on a huge scale, but this can lead to the disappearance of the reagents from which we extract energy (coal, oil, natural gas). Purpose of the study: production of a working model of the Stirling engine to provide a person with comfortable conditions when he is in areas with low temperatures. Research objectives:

a) get acquainted with the history of creation, device, types and principle of operation of the Stirling engine;

b) assemble a working model of the Stirling engine;

c) calculate the main characteristics of the engine; d) find out whether the engine is profitable;

e) consider possible applications of the Stirling engine;

f) create conditions for its use to ensure comfortable conditions for a person in low temperature zones.

Object of study: model of an external combustion engine.

Stirling engine - a heat engine in which the working fluid, in the form of a gas or liquid, moves in a closed volume, a kind of external combustion engine. The engine is based on periodic heating and cooling of the working fluid with the extraction of energy from the resulting change in the volume of the working fluid. It can work not only from fuel combustion, but also from any heat source. Three types have been developed so far Stirling engines:

Alpha Stirling - contains two separate power pistons in separate cylinders, one is hot, the other is cold. A cylinder with a hot piston is in a heat exchanger with a higher temperature, with a cold piston in a colder one. In this type of engine, the ratio of power to volume is quite large, but, unfortunately, the high temperature of the “hot” piston creates certain technical difficulties. The regenerator is located between the hot part of the connecting tube and the cold part.

Beta Stirling is just one cylinder, hot at one end and cold at the other. A piston (from which power is removed) and a displacer move inside the cylinder, changing the volume of the hot cavity. The gas is pumped from the cold part of the cylinder to the hot part through the regenerator. The regenerator may be external, as part of a heat exchanger, or may be combined with a displacing piston.

Gamma Stirling - also has a piston and a displacer, but at the same time there are two cylinders - one cold (the piston moves there, from which power is removed), and the second is hot from one end and cold from the other (the displacer moves there). The regenerator can be external, in which case it connects the hot part of the second cylinder with the cold one and simultaneously with the first (cold) cylinder. The internal regenerator is part of the expel

The Stirling engine is based on the fact that the volume of gas increases when heated, and decreases when cooled. Let's imagine that we have a certain closed case, of a certain volume, in which there is air. On one part of the body, we have an elastic membrane (aka a piston), which bends every time the body is heated, that is, it does a certain amount of work for a given period. This is due to the expansion of the air that fills the case. The reverse process will occur in exactly the same way, only exactly the opposite. The body must not be heated, but cooled. The membrane, due to a decrease in the volume of air, will begin to bend again, but in the other direction, again doing work.

To take advantage of this, the oscillations must occur frequently enough, and the air in the case must be constantly cooled, then heated. To automate this process, an additional piston is provided, which is called a displacer. Its role is to displace the remaining volume of air (hot or cold) from the bottom of the case (hot) to the top (cold).

This piston occupies almost half of the entire volume of the housing, and has the form of a round disk that does not fit snugly against the walls of the housing. The gap between the wall and the disk is just what is needed so that the air from the hot area of the case moves to the cooled area, and vice versa.

In theory, the piston should consist of a light material that does not conduct heat well, since it is he who is the key element in the system, which is located at the interface between two media.

Well, then, the Stirling engine consists of a conventional, crank-and-rod system that connects the piston and the membrane, which allows them to be on the same axis of rotation. This provides the whole mechanism of cycling, that is, it allows the engine to lower and raise the piston.

The Stirling engine is an external combustion heat engine, i.e. heat for work processes comes from outside, while in the internal combustion engine, the fuel burns inside the combustion chamber. Heat sources can be burners using different fuels, sunlight, flue gases from boiler plants, solar radiation, and simply hand heat (there are demonstration models that work from body heat). In the 19th century, engineers wanted to create a safe alternative to the steam engines of the time, whose boilers often exploded due to high steam pressures and unsuitable materials of their structure. A good alternative to steam engines came with the creation of Stirling engines, which could convert any temperature difference into work. The basic principle of the Stirling engine is the constantly alternating heating and cooling of the working fluid in a closed cylinder.

From thermodynamics it is known that pressure, temperature And volume ideal gas interrelated and followlaw:

$$PV = v\ R\ T$$

where:

P is the gas pressure;

V is the volume of gas;

v - quantitymolesgas;

R is the universal gas constant;

R \u003d 8.31 J / mol *

T is the gas temperature in Kelvin.

This means that the Stirling engine usesStirling cycle, which in terms of thermodynamic efficiency is not inferior toCarnot cycle, and even has an advantage. The fact is that the Carnot cycle consists ofisotherms and adiabats that differ little from each other. The practical implementation of this cycle is unpromising. The Stirling cycle made it possible to obtain an engine that works in practice in an acceptable size.

The Stirling cycle consists of four phases and is separated by two transitional phases: heating, expansion, transition to a cold source, cooling, compression, and transition to a heat source. Thus, when passing from a warm source to a cold source, the gas in the cylinder expands and contracts. In this case, the pressure changes, due to which useful work can be obtained. Heating and cooling of the working fluid (sections 4 and 2) is performed by the displacer. Ideally, the amount of heat given off and taken away by the displacer is the same. Useful work is done only due to isotherms, that is, it depends on the temperature difference between the heater and cooler, as in the Carnot cycle. In the Stirling machine, the movement of the working piston is shifted by 90 ° relative to the movement of the displacing piston. Depending on the sign of this shift, the machine can be an engine or a heat pump. With a shift of 0°, the machine does not produce any work (except for friction losses) and does not produce it. The thermal efficiency of an ideal Stirling cycle is given by:

$$\eta = (T1 - T2)/T1$$

where T1 - heater temperature

T2 - refrigerator temperature

In theory, any heat source (sun, electricity, fuel) can supply energy to an external combustion engine. The principle of operation of the engine body is to use helium, hydrogen or air. The ideal cycle has the highest possible thermal efficiency. The efficiency in this case is from 30 to 40%. An efficient regenerator can provide higher efficiency. Built-in heat exchangers provide regeneration, exchange and cooling in modern engines. Their advantage is oil-free operation. In general, the engine needs little lubrication. The average pressure in the cylinder varies from 10 to 20 MPa. A good sealing system and the possibility of oil entering the working cavities are essential. According to theoretical calculations, the efficiency of the Stirling engine is highly dependent on temperature and can even reach 70%. In the second half of the 20th century, a rhombic drive engine exceeded 35% during testing. Efficiency on a water coolant and with a temperature of 55 degrees Celsius. Improving the design in some experimental samples made it possible to achieve almost 39% efficiency. Almost all modern gasoline engines with similar power have an efficiency of 28-30%. Turbo diesels reach about 35%. The most modern examples of Stirling engines, developed by Mechanical Technology Inc in the USA, show efficiency up to 43%. After the development of heat-resistant ceramics and other innovative materials, it will be possible to further increase the temperature of the medium. Efficiency can even reach 60% under such conditions. It is ideal to combine "stirling" with a heating system. We warm the engine, it heats the water with its cooler, going to the storage. The heating power of a decent house is about 10 kW, even if the efficiency is 10% - enough for domestic needs. All losses remain inside the system and serve their primary purpose - for heating. The question is only in the manufacture of a sufficiently durable engine at a reasonable price. The assembled model of the Stirling engine was tested under two conditions.

In the first case, the engine was installed on a mug of hot water at a temperature of 400C at an ambient temperature of 200C.

Efficiency1=(313K-293K/313K)*100%=6.3%.

In the second case, at the same ambient temperature, pieces of ice were placed on top of the engine.

Efficiency2=(293K-273K/293K)*100%=6.8%

It turned out: the lower the temperature of the engine refrigerator, the higher its efficiency. This means that you can get more work without spending more heat, but you just need to improve its removal.

Disadvantages of the Stirling engine:

- Cumbersomeness and material consumption are the main disadvantage of piston engine options. For external combustion engines in general, and the Stirling engine in particular, the working fluid must be cooled, and this leads to a significant increase in the weight and size indicators of the power plant due to enlarged radiators.
- To obtain characteristics comparable to those of an internal combustion engine, it is necessary to use high pressures (over 100 atm.) And special types of working fluid - hydrogen, helium.
- Heat is supplied not directly to the working fluid, but only through the walls of the heat exchangers. The walls have limited thermal conductivity, due to which the efficiency is lower than expected. The hot heat exchanger operates under very stressful heat transfer conditions and at very high pressures, which requires the use of high quality and expensive materials. Creating a heat exchanger that would satisfy conflicting requirements is a very non-trivial task. The larger the heat exchange area, the greater the heat loss. At the same time, the size of the heat exchanger and the volume of the working fluid that is not involved in the work increase. Since the heat source is located outside, the engine responds slowly to changes in the heat flux supplied to the cylinder, and may not immediately produce the desired power at start-up.
- To quickly change the engine power, methods are used that are different from those used in internal combustion engines: a variable volume buffer tank, a change in the average pressure of the working fluid in the chambers, a change in the phase angle between the working piston and the displacer. In the latter case, the response of the engine to the driver's control action is almost instantaneous.

Advantages of the Stirling engine:

- The “omnivorousness” of the engine - like all external combustion engines (or rather, external heat supply), the Stirling engine can operate from almost any temperature difference: for example, between different layers of water in the ocean, from the sun, from a nuclear or isotope heater, coal or wood stove etc.
- Simplicity of design - the design of the engine is very simple, it does not require additional systems, such as a gas distribution mechanism. It starts on its own and does not need a starter. Its characteristics allow you to get rid of the gearbox.
- Increased resource - simplicity of design, the absence of many "delicate" nodes allows "Stirling" to provide an unprecedented margin of operation for other engines of tens and hundreds of thousands of hours of continuous operation.
- Efficiency - for the utilization of certain types of thermal energy, especially with a small temperature difference, Stirlings are often the most efficient types of engines. For example, in the case of converting solar energy into electricity, Stirlings sometimes give higher efficiency (up to 31.25%) than steam heat engines.
- Environmental friendliness - "Stirling" has no exhaust, which means that its noise level is much less than that of piston internal combustion engines. Beta-Stirling with a rhombic mechanism is a perfectly balanced device and, with a sufficiently high workmanship, has an extremely low level of vibration (vibration amplitude is less than 0.0038 mm). Stirling itself does not have any parts or processes that can contribute to environmental pollution. It does not consume the working fluid.

Application of Stirling engines:

- Universal sources of electricity

Stirling engines can be used to convert any heat into electricity. Hopes are pinned on them for the creation of solar power plants. They are used as autonomous generators for tourists. Some enterprises produce generators that operate from the burner of a gas stove.

- Pumps

The efficiency of heating or cooling systems increases if a forced circulation pump is installed in the circuit.

"Stirling" for pumping liquids can be much simpler than the usual "engine-pump" scheme. In a Stirling engine, instead of a working piston, a pumped liquid can be used, which at the same time serves to cool the working fluid. A pump based on a Stirling Engine can be used to pump water into irrigation canals using solar heat, to supply hot water from a solar collector to a house (in heating systems, they try to install a heat accumulator as low as possible so that water goes to the radiators by gravity). The Stirling pump can be used for pumping chemicals because it is hermetically sealed.

- Heat pumps

Heat pumpsallow you to save on heating. The operating principle is the same asair conditioner(an air conditioner is the same as a heat pump), only the air conditioner usually cools the room by heating the surrounding space, and the heat pump, as a rule, heats the room by cooling the outside air, water from a well or other source of low potential heat. Typically, heat pumps driven by electricity are used. A device that combines a Stirling engine and a Stirling heat pump makes the situation more favorable. The Stirling engine transfers waste heat from the “cold” cylinder to the heating system, and the resulting mechanical energy is used to pump additional heat that is taken from the environment.

- Refrigeration technology

Almost all refrigerators use the same heat pumps. With regard to cooling systems, their fate turned out to be happier. A number of manufacturers of household refrigerators are going to install Stirlings on their models. They will have greater efficiency, and they will use ordinary air as a working fluid.

- Ultra low temperatures

The Stirling engine can also operate in the refrigerating machine mode (reverseStirling cycle). To do this, it is set in motion by any other external engine (including with the help of another Stirling). Such machines proved to be effective for liquefying gases. If large volumes are not required (for example, in a laboratory), then Stirlings are more profitable than turbine plants. Small "Stirlings" are beneficial to use for cooling sensors in ultra-precise devices.

- Submarines

The advantages of the Stirling led to the fact that as early as the first half of the 1960s, naval reference books indicated the possibility of installing themon submarines. The engines run on liquid oxygen, which is later used for breathing, have a very low noise level, and the disadvantages mentioned above (size and cooling) are not significant in a submarine.

- Energy accumulators

You can store energy with it, using heat accumulators on molten salts as a heat source. Such batteries are superior in terms of energy storage to chemical batteries and are cheaper. Using a change in the phase angle between the pistons to adjust the power, it is possible to accumulate mechanical energy by braking the engine. In this case, the engine turns into a heat pump.

- Solar power plants

The Stirling engine can be used to convert solar energy into electrical energy. To do this, the Stirling engine is installed at the focus of a parabolic mirror (similar in shape to a satellite dish) so that the heating area is constantly illuminated. The parabolic reflector is controlled in two coordinates when tracking the sun. The energy of the sun is focused on a small area. Mirrors reflect about 92% of the solar radiation falling on them. Asworking bodyThe Stirling engine is usually usedhydrogen, orhelium.

Practical part.

In our studies, the gamma-type Stirling engine model is used, which is a compromise between betta and alpha types. Assembly steps:

1. Assemble the slave cylinder.
2. Make a working piston.
3. Make and attach the water jacket to the cylinder.
4. Make a hole for the tubes and bushing.
5. Make a membrane piston.
6. Make a superstructure and holes in it.
7. Make connecting rods.
8. Make a crankshaft.
9. Make and install the moss wheel.

Thus, a model of the Stirling engine was assembled.

Table 1. Characteristics of Stirling engine models

Model #1	Model #2	Model No. 3	Model #4	Model #5
The very first and simple model	1. removed the extension 2. put the entire system of connecting rods and crankshaft on bearings; 3. installed an electric motor;	1. changed the cooling system; 2. replaced the working cylinder with a more reliable one 3. improved the system for removing power from the motor;	1. painted the engine; 2. changed the moss wheel; 3. increased piston stroke;	1. Remade engine rack. 2. The cooling system was redesigned, in this model antifreeze is used as a refrigerant. 3. We attached the second diaphragm piston directly to the cylinder (previously it was attached through silicone tubes). 4. Improved the system for removing power from the motor.

Experience number 1. Engine capabilities.

We conducted an experiment to find out the ability of the engine to generate electric current, namely, we measured the current and voltage using an electronic multimeter, and calculated the power according to the formula.

Conclusion: Different types of substances did not affect the value of current strength, voltage and power. They only affected the running time of the Stirling engine.

Experience number 2. The efficiency of the Stirling engine.

First, we found out how much we pay for electricity per month. It is the families who pay 8 rubles a month for 60-70 kW of electricity. Next, they found an industrial Stirling engine. Its power ranges from 2-9 kW. Therefore, in order to generate 60 kW, it is necessary to provide 8 hours of engine operation. Gas is used as a fuel resource in this example. In 1 hour, 0.4 cubic meters will burn. m. of gas, this is about 15 kopecks. Therefore, for 8 hours of work we spent 1.2 rubles. Conclusion engine cost-effective.

Experience number 3. Comparison of different types of fuel resources.

Table 2.

	Gas	Alcohol	Petrol	Kerosene	Coal
Price per l.\m3\kg	0.30 RUB	37 rub.	1.51 rub.	3.5 rub.	0.14 rub.
Consumption for 8 hours of work (m3\l.\kg.)	3.2	0.144	12	-	3
Cost, rub.)	1.2	5.3	18	-	0.42
Conclusion	Profitable	Profitable	Not cost effective	-	Profitable
How much are we paying now?	8 rub. per month / 26 kop. in a day				

Experience number 4. How to calculate a Stirling engine.

When developing a Stirling engine at home, improvised materials and tools are often used. So for a small engine model, you can replace the piston with a membrane. Heating of the working fluid occurs in the heat exchange cylinder. At the same time, excess pressure P is created, acting on the piston (membrane) with force F. In this case, work is done.

The primitive calculation of the Stirling engine consists in determining its power and the volume of the working fluid required for it. To do this, you need to know the value of P and F. To determine the pressure P, remember that when a gas is heated by one degree, its volume increases by 1/273 of the volume occupied by the working fluid before heating. Then the instantaneous pressure can be calculated by the formula:

$$P=(V/273)*T$$

V is the working volume of the engine, consisting of the volume of the working cylinder and the heat exchange cylinder.

T is the temperature difference between the working fluid and the environment.

When calculating the Stirling engine, it should be remembered that its efficiency does not depend on the temperature of the heat source and the heating of the working fluid, but on the temperature difference between the hot and cold cylinders. To calculate the force, it is necessary to determine the working surface on which the working fluid acts. This surface is the area of the piston or the area of the membrane. It is also necessary to calculate the vertical stroke of the piston. The calculation can be made according to the formulas: F=S*P, where S=3.14*R2. As follows from the above calculation, the force is directly proportional to the area of the piston. At first glance, it seems that to increase the efficiency of the device, it is enough to simply increase the size of the piston, and with it the entire device. But at the same time, the dimensions of the device, its inertia and the mass of individual parts increase, which leads to losses in engine power. During the calculation of the engine, it is necessary to find the optimal ratio of its size and the resulting torque. To do this, you can use special computer programs. But this also has its advantages.

Stirling engine calculation

$$P=(V/273)*(T2-T1),$$

where V is the working volume, T1, T2 are the heating and ambient temperatures.

$$F=S*P, S=3.14*(R*R),$$

where R is the radius of the circle.

$$A=F*h,$$

where A is useful work, h is the vertical stroke of the membrane

$$\eta = A/Q, Q=c*m*(T2-T1),$$

where η is the efficiency, Q is the amount of heat given off by water, c = 4200 J / (kg * deg) is the specific heat of water, m is the mass of water

$$N=A/t$$

N - power, t - operating time

What should not be forgotten:

- The calculation gives peak pressure values when the working fluid is fully heated to the design temperature. This means that the pressure calculated by us will appear only in a certain short period of time of the working cycle of the Stirling engine, increasing up to this moment and falling after it. But, this is only under the condition of complete heating of the working fluid to the temperature of the heater, which is practically unattainable due to the high thermal resistance at the boundary of the heater-working fluid!
- The smaller the stroke of the working piston - the higher the engine speed, but less power!
- The smaller the stroke of the displacer (displacer), the better the working fluid warms up, and accordingly gives a pressure increase as close as possible to the calculated one.
- The larger the heater area, the higher the Stirling efficiency. The above method for calculating

the Stirling engine is not very accurate, but it allows you to determine the performance of the Stirling before construction begins.

Experience number 5. Calculation of the number of revolutions of the Stirling engine.

A tachometer was developed to calculate engine speed. This tachometer was created based on the Arduino Uno board. This system is programmed in the Arduino ide development environment. The code is written in the C++ programming language.

Experience number 6. Plotting the dependence of efficiency on the temperature of the heater (refrigerator) for the Carnot cycle and the Stirling cycle.

The graphs were plotted using Microsoft Excel 2013. These calculations are available on our website (dvigatel.fun) in the “About Research” section.

Conclusions on practical research.

1. During the research work, a working model of the Stirling engine was made.
2. We disassembled the structure and principle of operation of the Stirling engine.
3. We found out the profitability of the Stirling engine.
4. We checked the possibility of using it in everyday life.
5. Proven engine safety.
6. Created a booklet.
7. Created a website

Stirling engine model advantages:

This model of the engine can work from any source of heat. Little noise, little vibration during operation. The engine does not emit harmful exhaust gases. Creating a more advanced model of the Stirling engine would fully justify itself at home.

This model can be used in physics lessons at school and lectures on general physics at the university when discussing the basic laws of thermodynamics and the principles of operation of heat engines. In addition, on the basis of this model, laboratory work can be developed, during which students can be asked to independently find answers to the following questions:

*Will the flywheel turn faster if the amount of travel is changed?

*What happens if the angle between the cranks is made other than 90? Why does the value of this angle play any role at all, and why should the “hot” crank overtake the “cold” one?

*Is it possible to use another material as a regenerator to increase the speed of the engine?

*Will the efficiency increase? engine, if instead of water we take a different liquid? (Do not use flammable or explosive liquids!)

*What happens if you change the length of the connecting rods by decreasing or increasing the height of the air column in the cans?

Conclusion

Today, the Stirling engine is used in almost all areas and industries. It is used as a universal source of electricity, as pumps, in refrigeration systems, on submarines, as batteries, in solar power plants and so on. It is for this reason that the Stirling engine is now a universal device for performing any kind of task.

Our application suggestions.

It is ideal to combine the Stirling engine with the heating system. We warm up the engine, with its cooler it heats the water going to the drive. The heating power of a decent house is about 10 kW, even if the efficiency is 10% - enough for domestic needs. All losses remain inside the system and serve their primary purpose - for heating. The question is only in the manufacture of a sufficiently durable engine at a reasonable price. We assumed that if a heating area is built into the heating main, and a cooling system into the cold water supply circuit, then the engine will become more profitable. Consequently, the temperature in the heating main will decrease, and in the cold water supply it will increase, in addition to this, electricity will be generated. At any nuclear power plant there is a cooling system, it is represented by a cooling tower or a reservoir. Here we thought.

It's no secret that enterprises have waste, woodworking is no exception. But from the waste of the woodworking industry they make fiberboard, chipboard, OSB. But, unfortunately, not all waste can be used for a second life. We propose to use this waste as fuel for the Stirling engine.

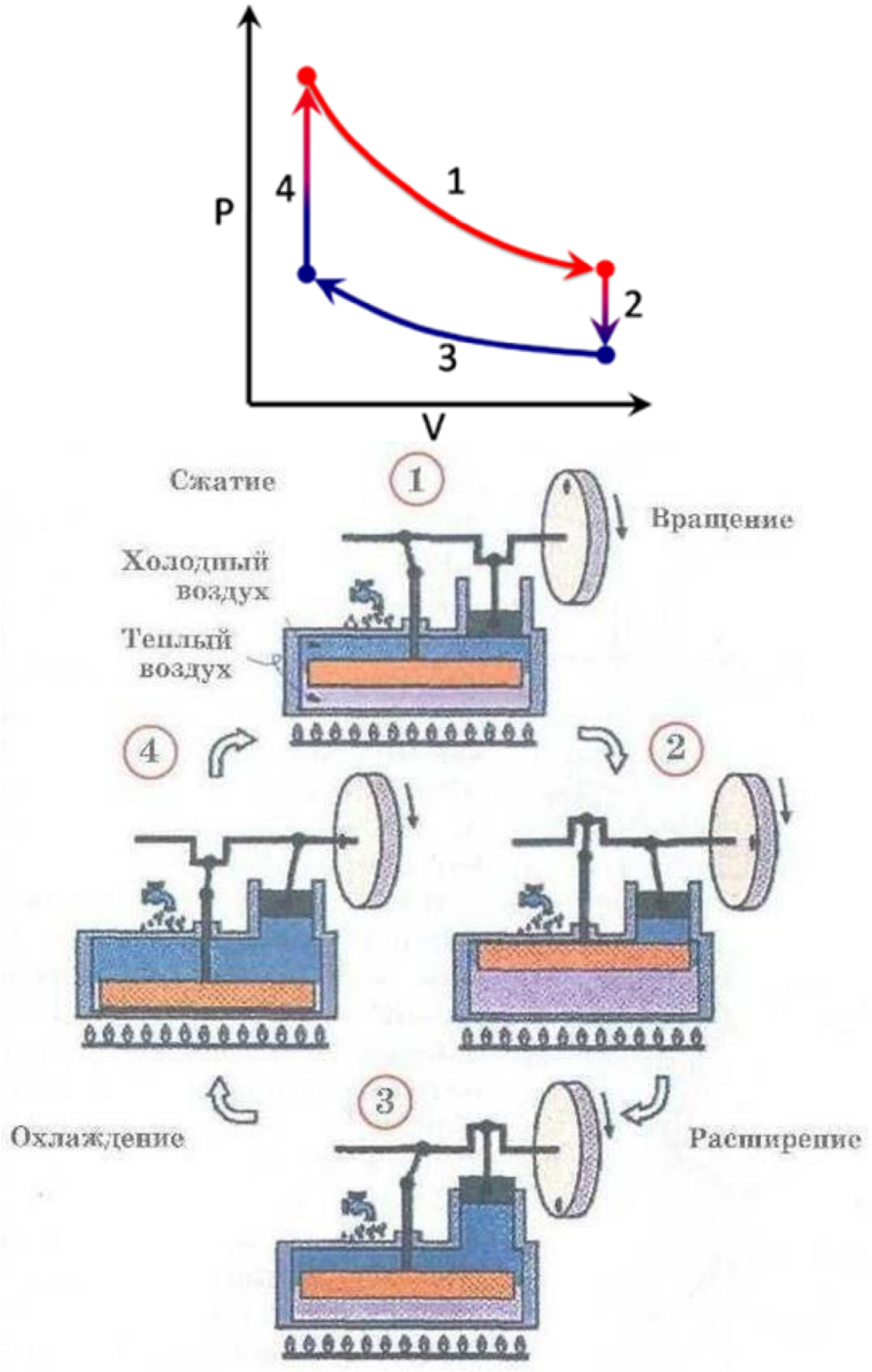
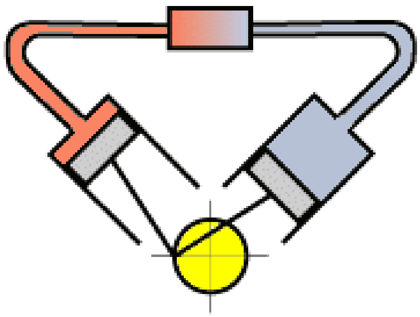
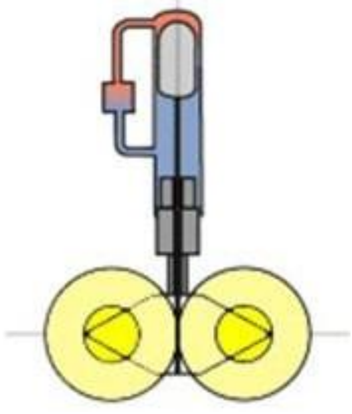


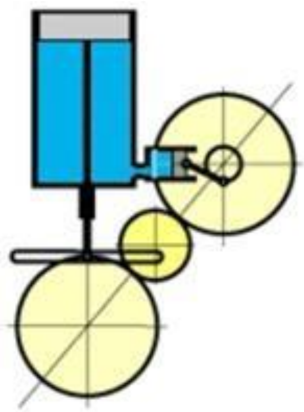
Figure 2. Stirling cycle.



Alpha Stirling



Beta Stirling



Gamma Stirling

Figure 3. Stirling views.

Substance/parameters	Current I, A	Voltage U, V	Power P, W
Water	1.0.04 2.0.06 3.0.03 4.0.04 5.0.06 Average value 0.04	1.2.3 2.2.5 3.2.1 4.2.4 5.1.9 Average value 2.3	1.0.092 2.0.1 3.0.152 4.0.098 5.0.094 Average value 0.098

ammonium nitrate solution	1.0.05 2.0.08 3.0.04 4.0.05 5.0.06 Average value 0.05	12 2.2.3 3.2 4.2.1 5.2.4 Average 2.1	1.0.094 2.0.112 3.0.142 4.0.094 5.0.09 Average value 0.112

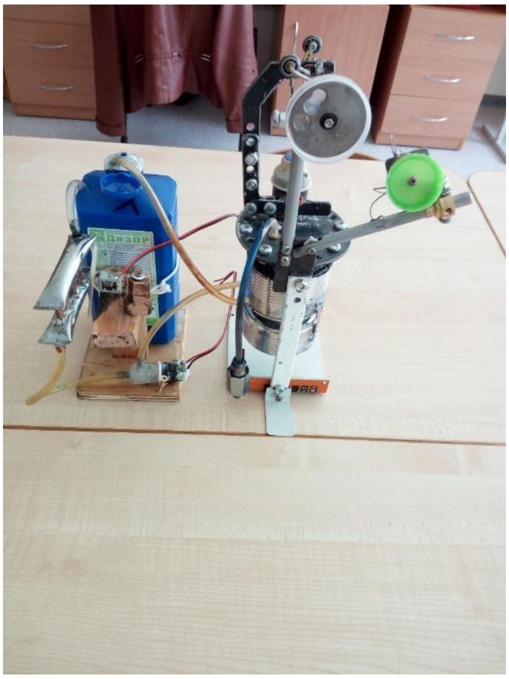
Figure 4. Comparison of different fuel resources.

Model 1.

Model 2.

Model 3.

Model 4.



Model 5.

Figure 5. Stirling engine models.

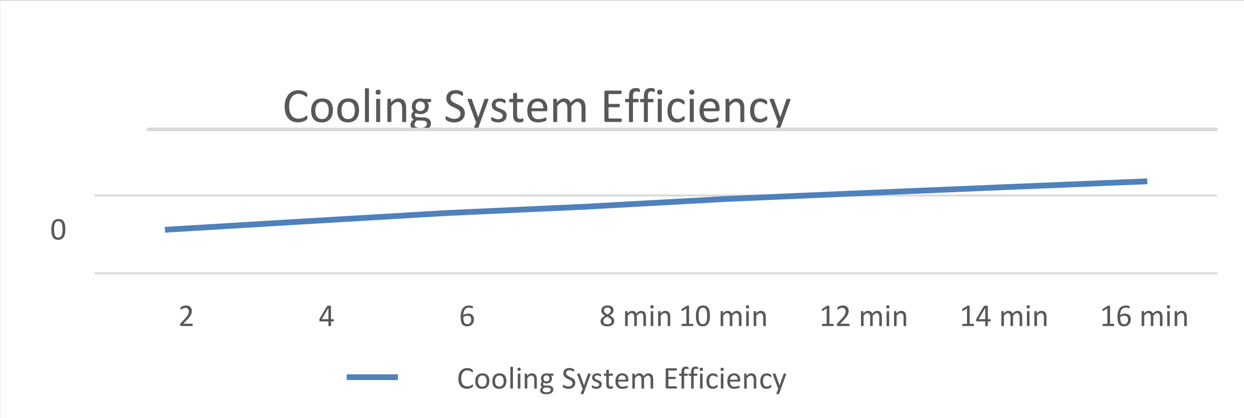


Figure 6. Efficiency of the cooling system.

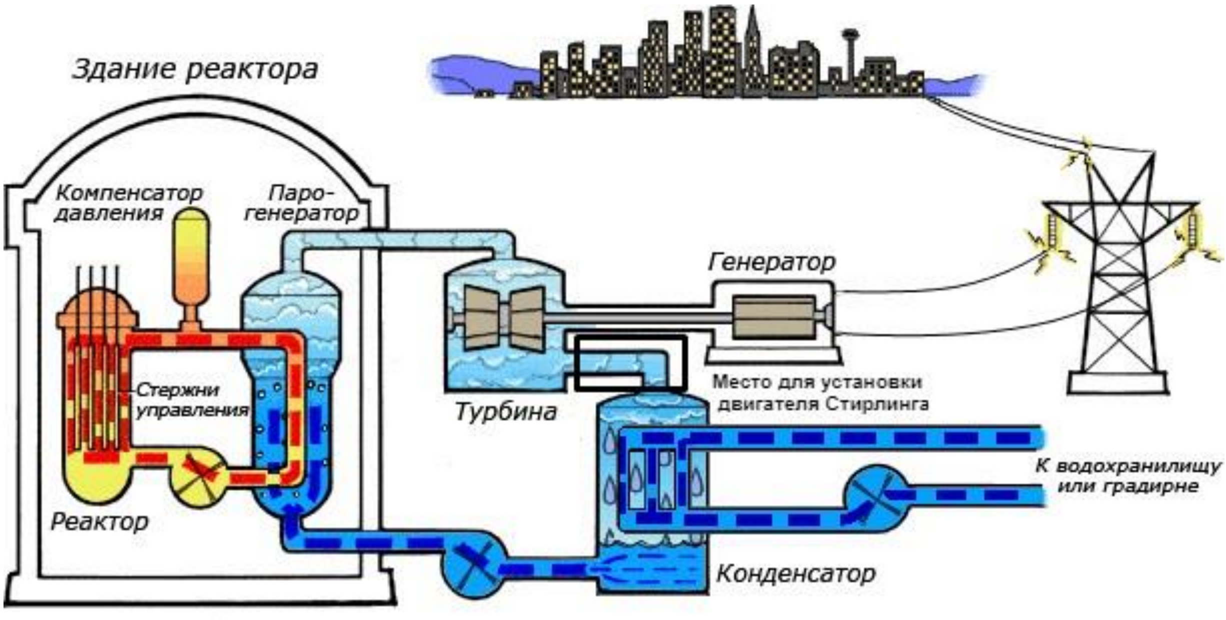


Figure 7. A place for installing a Stirling engine at a nuclear power plant.

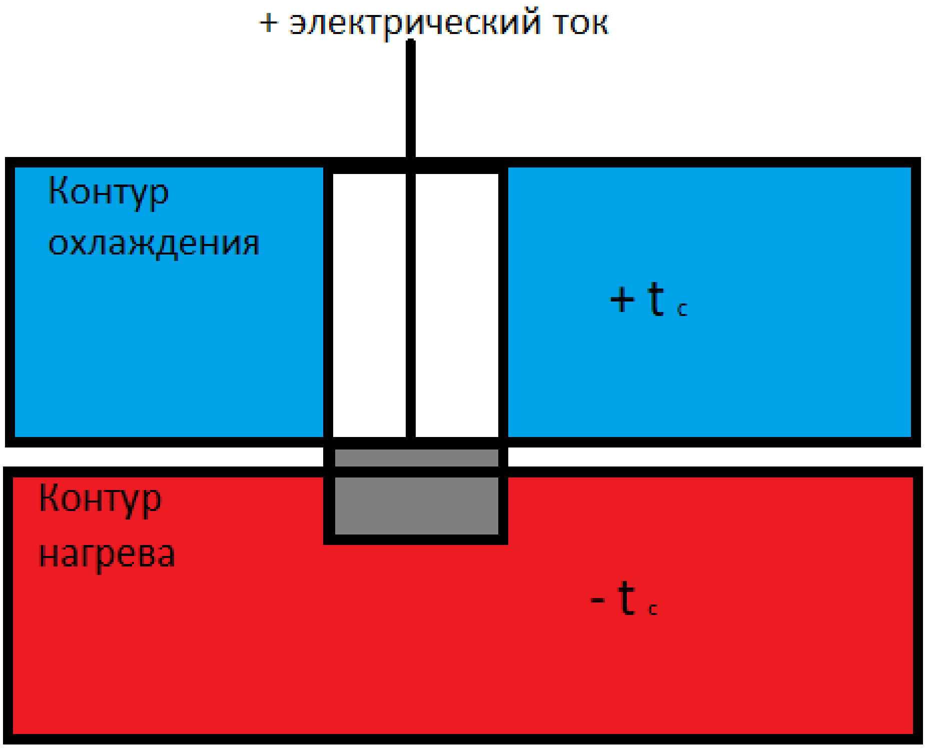


Figure 8. Installing a Stirling engine in a heating main.

Figure 9. Heat pumps.

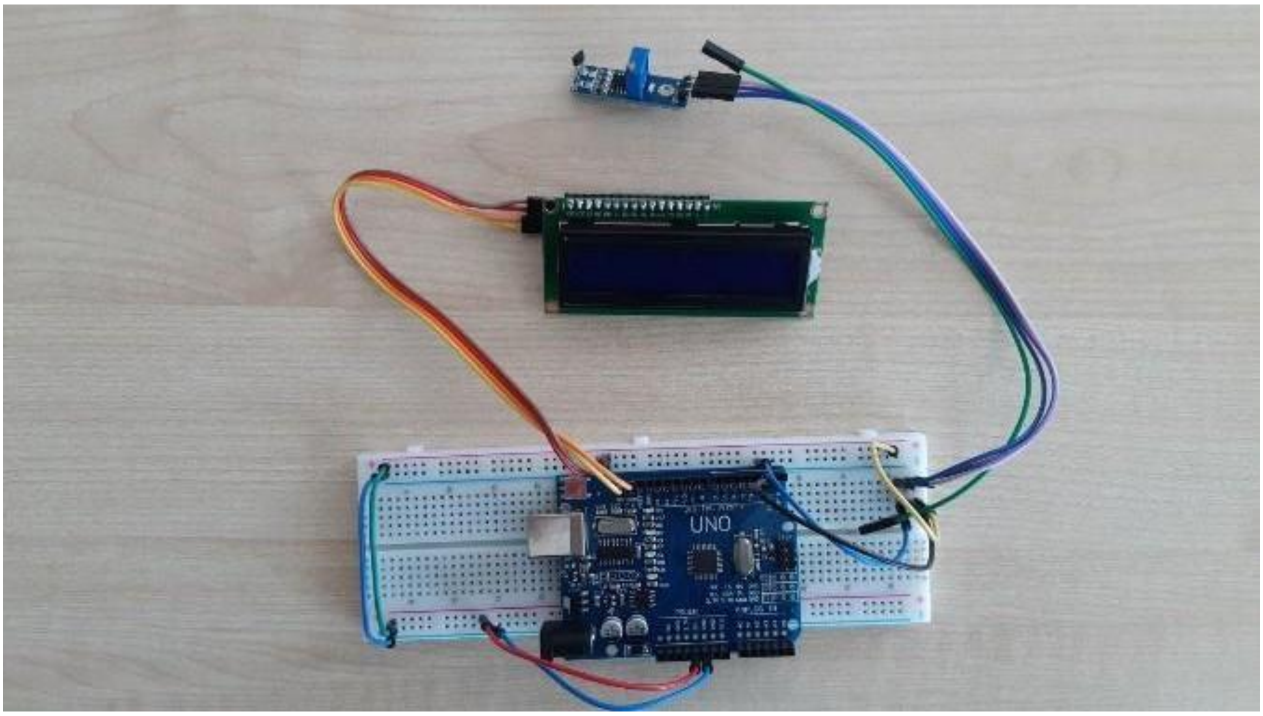
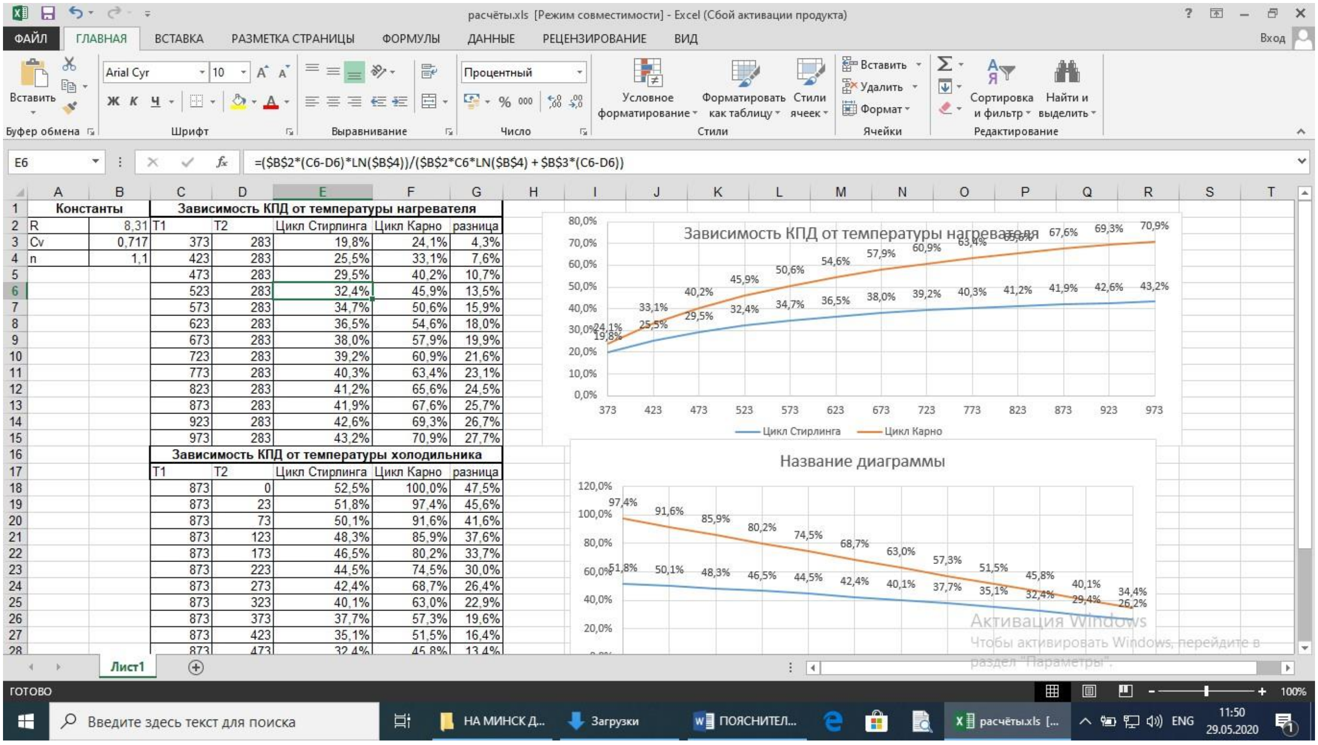


Figure 10. Tachometer.



	A	B	C	D	E	F	G
1	Константы		Зависимость КПД от температуры нагревателя				
2	R	8,31	T1	T2	Цикл Стирлинга	Цикл Карно	разница
3	Cv	0,717	373	283	19,8%	24,1%	4,3%
4	n	1,1	423	283	25,5%	33,1%	7,6%
5			473	283	29,5%	40,2%	10,7%
6			523	283	32,4%	45,9%	13,5%
7			573	283	34,7%	50,6%	15,9%
8			623	283	36,5%	54,6%	18,0%
9			673	283	38,0%	57,9%	19,9%
10			723	283	39,2%	60,9%	21,6%
11			773	283	40,3%	63,4%	23,1%
12			823	283	41,2%	65,6%	24,5%
13			873	283	41,9%	67,6%	25,7%
14			923	283	42,6%	69,3%	26,7%
15			973	283	43,2%	70,9%	27,7%
16			Зависимость КПД от температуры холодильника				
17			T1	T2	Цикл Стирлинга	Цикл Карно	разница
18			873	0	52,5%	100,0%	47,5%
19			873	23	51,8%	97,4%	45,6%
20			873	73	50,1%	91,6%	41,6%
21			873	123	48,3%	85,9%	37,6%
22			873	173	46,5%	80,2%	33,7%
23			873	223	44,5%	74,5%	30,0%
24			873	273	42,4%	68,7%	26,4%
25			873	323	40,1%	63,0%	22,9%
26			873	373	37,7%	57,3%	19,6%
27			873	423	35,1%	51,5%	16,4%
28			873	473	32,4%	45,8%	13,4%

Figure 11. Searling cycle efficiency calculations.

With this system, we provide a constant temperature of the entire surface of the human body, which provokes a comfortable feeling during the wearing of the suit. Further, heating pads can be used to maintain a comfortable temperature. We chose a catalytic heating pad; it has a number of advantages over analogues.

Figure 12 - Catalytic heating pad

Heating pad catalytic—chemical heating pad, designed for individual warming of a person due to the flameless oxidation of high-purity gasoline vapors, for example, Nefras C2 80/120 or alcohol 95-97% in the presence of a catalyst. Often incorrectly called a catalytic heating padinfrared heater.

At present, heating pads for individual heating of a person incamping trip, onfishing,hunting, in conditions associated with work on the street, on winter sports and so on. The Soviet industry produced a gasoline catalytic heater GK-1, which, when fully refueled, could generate heat for 8-14 hours at temperatures up to 60°C, that is, at the levelpain threshold.

The heater consists of a reservoir filled withcotton wool, nozzles with a mesh cartridge in whichcatalyst, and covers with ventilation holes.

The principle of operation of the heating pad is based on the releaseheatin flameless vapor oxidationgasolinein the presencecatalyst. Couples gasoline from the reservoir pass throughcatalytic cartridgewhere they are oxidizedoxygenair (burn without a flame) on the surface of a heatedcatalyst. Oxidation products exit into the ventilation openings of the cover. Simultaneously through the ventilation openings of the cover to the surface catalystair containing oxygen. catalytic mesh (catalyst) has the appearance of a wick and is located inside a steel mesh cartridge, made ofplatinum- This is the most important part of the heating pad. To start, the grid in the catalytic cartridge is heated for 10-15 seconds using a flame that does not give soot (for example,lighter).

Fuel for heating pad - gasoline of the highest degree of purification. Gasoline for lighters or some varieties of non-fras are well suited for these purposes:C2-80/120("Galosha") or C3-80/120. The use of other types of fuel can lead to rapid deterioration of the catalytic mesh (a phenomenon called "catalyst poisoning"), which will affect its efficiency. The efficiency of a clogged catalyst can often be improved by firing the mesh cartridge with the catalyst inside on a non-smoking (gas) flame or in a muffle furnace.

The use of individual catalytic heaters indoors can be hazardous to health, as gasoline oxidation products are toxic.

Further, it is necessary to effectively screen the heat in the system, knowing that a person loses more than half of the heat by radiation, we propose to create a screen by analogy with the American design.

TurboDown was first used on Columbia products in 2014. The company's specialists did not participate in the eternal dispute, which insulation is better: natural or artificial.

They combined the best natural insulation in the world - down - with their own development, synthetic materialOmni-Heat Thermal Insulation. The result was a new innovative type of insulation, which was called TurboDown - Turbo Down.

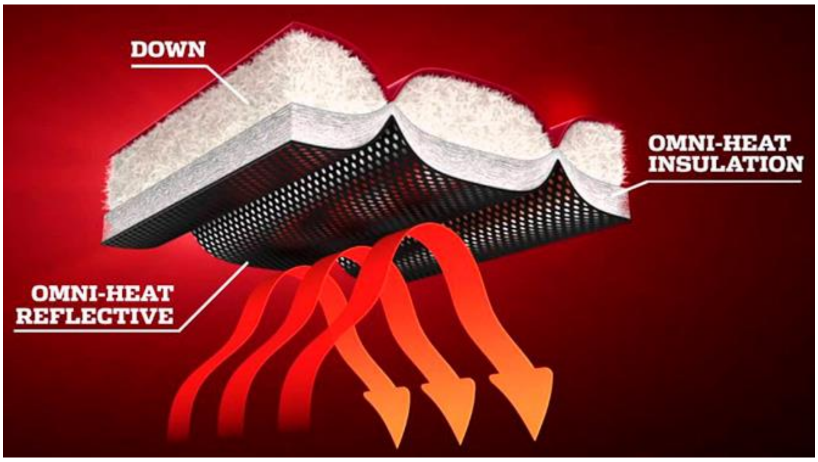


Figure 13 - Innovative insulation Turbo Down - Turbo down

TurboDown technology is layers of different types of material that retains heat and a special mirror fabric. The layers are arranged in the following order:

- The top layer of insulation is high quality natural fluff, treated with a special impregnation that protects against moisture.
- After the down comes a layer of the company's patented Omni-Heat Insulated synthetic material. It is lightweight and very soft.
- The bottom layer is represented by Omni-Heat Reflective technology - a mirror fabric with silver dots that retains human heat.

Synthetics and down have their drawbacks. Natural fluff gets wet easily and at the same time ceases to warm, and synthetic filler has low vapor permeability.

Combining different types of insulation in a certain proportion allowed Columbia specialists to retain heat as much as possible and reduce its losses. Another advantage of the material is its high performance in wet conditions. In addition, innovative development is cheaper than natural fluff.

The insulation was created primarily to provide warm winter jackets designed for outdoor activities. Down jackets with hybrid insulation are very warm and at the same time light and comfortable.

TurboDown is a technology that is used in the production of winter jackets under the Columbia brand. Their main advantage is improved heat retention with smaller volumes. Down jackets are used primarily for outdoor activities up to -25 degrees and do not lose their properties even when wet.

This is a variant of our colleagues, as it seems to us, the principle is quite promising. But the package of materials that they offer, we do not agree with them, this package is insufficient, although the development is really worthy of attention. In addition to solving heat retention, silver coating is an antimicrobial environment, which increases its hygienic properties.

Today, the issue of producing high-quality domestic footwear with the provision of the necessary consumer properties is very acute. Shoes should protect the foot from the adverse effects of the environment. Together with protection, shoes should provide a comfortable stay in the foot for a long period of time. Comfort is a complex ergonomic property of footwear that characterizes its ability to ensure the normal condition of the foot and the entire human body under various conditions and throughout the entire period of operation, determined by the purpose of the footwear. The components of shoe comfort are the conformity of the internal shape and size of the shoe to the shape and size of the foot in the absence of excessive pressure on the foot when worn. Hygiene - the ability to maintain a normal moisture-temperature regime of the foot and the whole body with the inadmissibility of exposure to harmful and toxic substances on it. The microclimate of the human skin surface created by shoes is one of the comfort factors and should have parameters that ensure the normal condition of the foot and the whole body during the operation of shoes (air temperature, relative humidity, air speed, carbon dioxide content): - no mechanical damage to the foot and injuries ; - no toxic effects on the foot and the body; - foot temperature 27-33°C; - the temperature of the air inside the shoe is 21-25°C; - relative humidity of the air inside shoes 60-90%; - the content of CO_2 in the intra-shoe space is not more than 0.08% - the pressure of the shoe on the foot is 1060-8010 Pa. Air humidity is an important factor in hygiene requirements. Shoes must be able to transfer moisture from the surface of the body to the environment. If this does not happen, then overheating of the body occurs. Air temperature. In any seasonal conditions, shoes should provide the necessary comfort, the microclimate inside the shoe - temperature, humidity and air movement. Should not have odor and release of chemical ingredients into the shoe space and the environment. This property is of particular importance for footwear used both in southern regions, where it is exposed to high temperatures and intense radiation, and in low temperatures, where strong winds are observed and sufficiently thorough protection of human feet is required. Creating comfortable shoes is impossible without an objective assessment of the microclimate of the intra-shoe space, depending on the various packages of shoe materials by selecting rational combinations of uppers, linings, insoles and soles. For the production of shoes, natural, artificial and synthetic leather, fabrics and felt are used. The value of natural leather is due to its high hygienic properties, beautiful appearance, reliability, extensibility and ease of cleaning. The hygienic properties of shoes are largely provided by indicators of vapor and air permeability, moisture absorption, etc. upper material properties. They have high dimensional stability, softness, resistance to weathering and wear, beautiful appearance. The range of artificial and synthetic shoe materials includes artificial and synthetic leathers, rubbers and plastics, cardboards. The advantages of these materials are: uniformity of properties over the entire area, the ability to form the necessary properties in the production process, high equipment productivity, low labor intensity in the manufacture of finished parts and shoe assemblies, and the disadvantages are lower wear resistance and hygienic properties than natural leather. The modern leather industry has learned to copy any kind and type of natural leather. Synthetic leather material is in great demand in the market, primarily for its low cost. Dozens of types of artificial leather substitutes with excellent performance properties and spectacular appearance have been developed. When using artificial materials for the uppers of shoes, when choosing materials for lining and intermediate materials, it becomes important that the materials accumulate moisture in themselves and ensure its output to the external environment due to the design of the upper and lower parts of the shoe. Currently, membrane materials with high resistance to water penetration, vapor permeability, and sorption of condensed sweat have found wide use in footwear; wind resistance. Membrane is a thin layer covering the inner surface of various tissues. There are two types of membranes: microporous and hydrophilic. The size of the microporous membrane is 20,000 times smaller than a water drop, but 700 times larger than a vapor molecule (water drops do not penetrate into shoes, body moisture vapor easily evaporates). The most promising polymeric materials, allowing to modify the properties of shoes are, first of all, polyurethanes, thermoplastic elastomers, rubbers used for soles, and polyamides - for textile materials for uppers. Shoes create a certain microclimate around the human foot, the state of which is influenced by three main factors: the body of the wearer, environmental conditions and the package of materials from which these shoes are made. The influence of the body of the carrier is determined by its thermal state and the intensity of perspiration, depending on the level of physical activity and the individual characteristics of the person; the influence of the external environment - temperature, humidity and air velocity; the influence of footwear is its design and the properties of the materials used. Problem, which designers and technologists have to solve is to provide a comfortable microclimate of the shoe space, which will provide moderate humidity and a certain temperature regime. These properties of shoes are vital for the body, especially in conditions of very high or low temperatures. The change in temperature and humidity of the intra-shoe space can be used as quantitative criteria for the comfort of shoes. Microclimate parameters - temperature and humidity, have not been sufficiently studied so far, they are not included in the standards for assessing the quality of footwear, there are no methods and means for measuring them. Creation of a certain microclimate inside the shoe, i.e. environment with a certain temperature and humidity at the surface of the foot, it is necessary for the normal functioning of the foot and the entire human body.

Conclusion

Arguing about these methods and solutions, the concept of heat regulation for the comfort of the wearer of the suit "produce, store, distribute" is formulated. This is just a general requirement for a suit as a system that creates and maintains comfortable conditions for a person, no matter in what conditions. A person works or performs any other activity, he must always be confident in his abilities, this work can only guarantee time, a safe and comfortable stay in conditions of low or high temperatures. This system is able to maintain temperature control forcibly regardless of the external environment.

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