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# EQUIPMENT TO PREVENT FREEZING OF BACK PRESSURE VALVE OF THE OIL WELL X-MAS TREE

**Bashirova Polina Eduardovna, Muktasipov Damir Rustemovich*, Safiullina Elena Ulubekovna**

*Oil and Gas Faculty, St. Petersburg Mining University, St. Petersburg, Russia*

** chuxarev96@mail.ru*

*This paper presents a device designed to prevent freezing of back pressure valve of the oil well X-mas tree. The work indicated the relevance of the problem, considered the devices used in oil fields and analyzed their shortcomings. The result of the work was an easy-to-use, easy-to-repair and inexpensive device, which is devoid of the shortcomings of the considered models. Analysis and deduction were chosen as the main methods of study. This work contains 8 figures, 2 tables, a bibliographic list of 15 titles.*

*Keywords: back pressure valve freezing, oil well X-mas tree, oil well operation at low temperatures, flow line heating*

## 1 INTRODUCTION

The current stage of development of the oil and gas industry is characterized by a significant complication of the conditions for the development and operation of oil and gas fields. At any field in Russia there are a large number of problems that appear during the working process. Some of them are typical for most regions of the country, others are typical for certain regions, and sometimes they are completely unique [1].

As you know, the geography of oil and gas fields in Russia is extremely wide. Industrial development is carried out throughout the country, and this suggests that the climatic conditions at each field are diverse. According to various estimates, the Arctic part of Russia accounts for about 40% of oil reserves and about 70% of natural gas reserves [2]. The conditions for drilling, development and exploitation of deposits, as well as transportation of extracted raw materials differ significantly from other areas of the country - the winter here is extremely severe and lasts from 7 to 10 months a year with temperatures down to -60℃ [3]. Of course, it becomes obvious that classical development methods are simply not applicable in such conditions. Moreover, in this regard, new problems appear that limit the successful development of industrial facilities.

As mentioned above, low winter temperatures play a significant role in many problems in the fishery. One of the important and up to this point unresolved problems is the freezing of back pressure valve of the oil well X-mas tree. Fluid temperatures at the wellhead can even be negative, so plugs can form in certain "vulnerable" places that restrict the movement of fluid through the pipeline. One of the first such places on the way of fluid from the well to the consumer is the back pressure valve of the oil well X-mas tree. When the temperature drops to certain values, in combination with the throttling effect of the annulus gas, the ball freezes to the valve seat, which leads to the formation of a dense impermeable plug and it ceases to perform its functions. The first consequence of this is an increase in gas pressure in the annulus due to the impossibility of bleeding it into the line. After that, the back pressure on the formation increases and, obviously, the fluid inflow to the bottom of the well decreases. Then there can be a significant displacement of fluid inside the well up to the intake of the pump, which can cause gas to enter it, reduce the flow or completely fail. Reducing the gas pressure in the annulus is an extremely important operation necessary to increase the oil production reserve. Every year, companies lose a lot of money due to the temporary stoppage of the back pressure valve, which is the need to develop a universal solution to this problem [4].

Despite the fact that many companies face this unpleasant task every year, there is still no universal solution to this problem. At different fields, they come up with their own unique devices, the usefulness of which is aimed at eliminating the freezing of the back pressure valve. Most of them are the result of the labors and inquisitive mind of the oil and gas operators of the operated facility. Of course, their inventions are not without drawbacks, therefore they are not widely used in the country.

It becomes obvious that it is necessary to find a unique solution to this problem, which would be suitable for any operating conditions of oil and gas industry facilities. First of all, it is important to analyze the existing most successful prototypes of inventions, study their advantages and disadvantages, and develop a device project that would absorb most of their advantages and be devoid of as many of their shortcomings as possible.

## 2 DEVICES USED IN THE FIELDS

### 2.1 CBT

This is a device designed to heat the flowline of the oil well's X-mas tree. This invention was developed by employees of OAO «Gazpromneft-Noyabrskneftegaz» Grigory Chernov, Sergey Berlizev and Alexander Trunin. It bears the name according to the first letters of its creators - CBT. The device is shown in Figure 2.1.1.

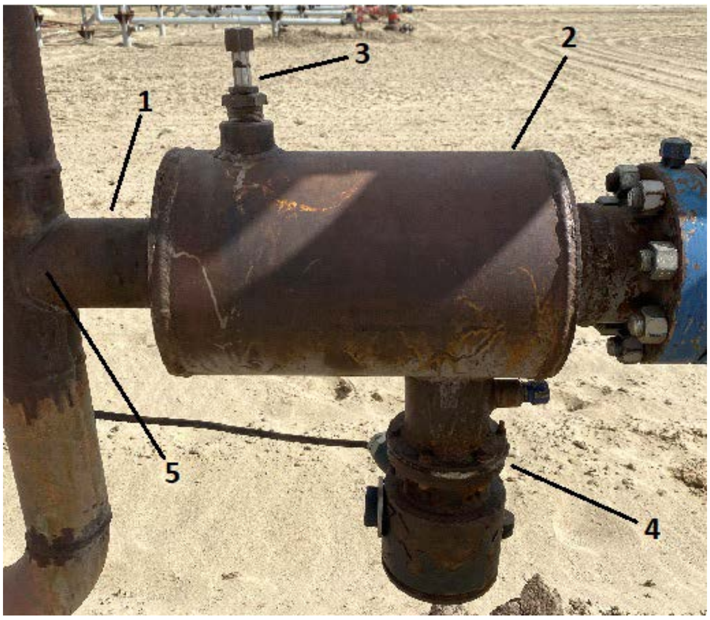


Fig. 2.1.1 - General view of the CBT device

The design consists of the following elements: flow line pipe (1), body-pipes (2), filler neck (3), branch pipe (4). The number 5 in Figure 1 indicates the X-mas tree back pressure valve.

The principle of operation is as follows. Gas from the well enters the annulus. When it passes through the device, the gas is heated due to the transfer of heat from the coolant heated by the electric heater (4), poured into area 2. Area 2 is a space filled with coolant between the outer wall of the flow line and the device body. The electric heater heats the liquid, which in turn heats the outer wall of the flow line, which allows the gas inside the annulus to be heated. The operator only needs to occasionally top up the anti-freeze liquid in the filler neck. The heated gas prevents the non-return valve from freezing. Any non-freezing liquid can be used as a heat carrier, but a liquid of the Tosol-40 type has become especially widespread.

This design has a number of significant disadvantages, the main of which is the need closing in during welding. Everyone knows that closing in is an extremely undesirable event both from the point of view of economics (every minute of downtime of a well is lost money) and from the point of view of technology - the need to restart pumping equipment (if any), the abscission of shedding loose sections of the well, and also clogging or waxing of oil-conducting pores and channels. That is why there is no clear certainty that the initial flow rate before the closing in will be the same after the restart of the well. Of course, the company does not always come to this method. Often practiced is a method of redirecting fluid flow from a well into the annulus of an adjacent well. This is done by means of several pipes, which are connected to each other by means of a quick-detachable connection. This method is much more profitable than stopping the well, but it may not be applicable in all cases. Sometimes the distance between wells within one cluster is quite large or neighboring wells are under repair.

Other important shortcomings should also beto mentioned. First, the use of an intermediate coolant. The more intermediate heat transfers in the design of the heater, the lower its efficiency. Given that the thermal conductivity coefficient of antifreeze is about 0.4 W / (m * K) (even less than that of water), this is a significant drawback. Secondly, a large area of heat loss. The device has large dimensions and is located almost along the entire length of the annular line, which indicates a large area of heat loss and a decrease in efficiency. Thirdly, the need for additional thermal insulation. Since the body of the product is mainly made of steel, in order to prevent large heat losses to the environment in the fields, it is additionally insulated with thermal covers, which significantly complicates the design and increases its cost. Fourthly, high weight and size indicators. As mentioned above, the body is made of steel, which makes the device quite heavy, and the need to install on the flowline is the reason for the large dimensions. It is also necessary to mention that the equipment is one-piece, as it is attached by welding. It follows that for installation it is necessary to attract additional personnel, which further increases the cost of the design. Moreover, antifreeze and its vapors are extremely toxic to humans, which indicates an increased danger of the device for human work.

This device is a simple and affordable way to heat the flow line of X-mas trees, but it has a number of significant drawbacks that limit its use in the fields.

### *2.2 Induction valve heater INK-150 (300)*

X-mas tree heater, which contains a rigid body with an electric heating element, which is an inductor connected to an alternating current source of various frequencies. The working area is brought to the outer side of the body, which mates with the heated section of the pipeline [5]. The general view of the device is shown in Figure 2.2.1.

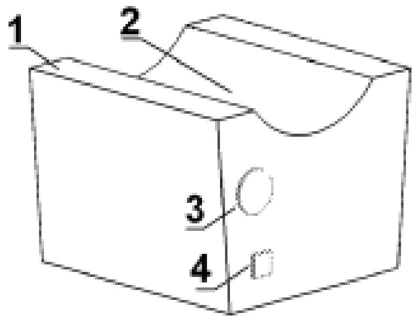


Fig. 2.2.1 - INK-150

The main components of the device: heater body (1), working surface (2), cable entry (3), "Network" indicator (4). The case is made of non-magnetic material, sealed. To maintain the temperature in the heating zone, a thermostat is installed in the housing.

The principle of operation of the device is based on the heating of the metal wall of the pipeline by an alternating electromagnetic field, which forms an inductor. Eddy currents are created in the walls of the reinforcement, which leads to heating of its body. In working condition, the device is shown in Figure 2.2.2.

Fig. 2.2.2 - Working condition of INK-150

Although this device at first glance looks more technological and modern in comparison with the CBT, it is also not without drawbacks. Firstly, the increased complexity of the equipment and the need for qualified personnel in case of repair or to adjust the equipment. Secondly, interacting materials with induction heaters must be free from oxidation products to achieve the greatest effect. Due to oxidation, some alloying elements may be lost, which will significantly reduce the efficiency of the device. Thirdly, the lack of a protective mechanism on the device. The device is quite vulnerable to both mechanical and climatic influences. Fourth, large power consumption. These devices are manufactured in versions for 150 and 300 watts, which is ten times more than the energy consumption of heating cables. It is also worth mentioning that for the operation of this device, it is necessary to have a power source near the well. Obviously, this is not a problem for wells equipped with ESPs, but on well pads where wells are operated using a sucker rod pump or a flowing method, there are not always sources of electricity near the wellhead, which limits the use of this device in such fields.

In general, the device is a good alternative to the CBT, but it has a number of disadvantages that complicate the design and require improvement of this invention.

### *2.3 Insulation of pipes with heat-insulating materials*

Due to the fact that at the moment there is no single solution to the problem of freezing of the X-mas tree back pressure valve, the vast majority of wells at various fields in Russia use this simple method of winterizing the X-mas tree, but due to inadequate thoughtfulness and often incorrectly selected structural components, the efficiency is very low.

The essence of the method is as follows: the section of the pipeline necessary for insulation is wrapped with a special heat-insulating material (glass wool is usually used due to the price-quality ratio) and fixed on top with a thin layer of polyethylene film to strengthen the insulation on the pipeline. In case of extremely low ambient temperature, a heating cable is additionally wound [6]. The general view of the device is shown in Figure 2.3.1.

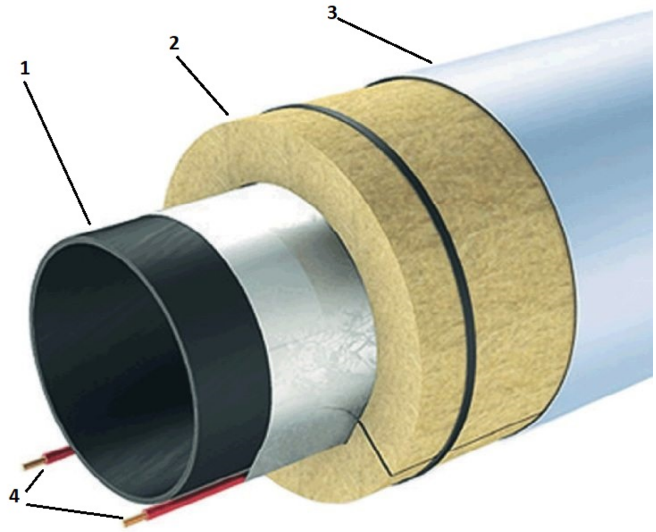


Fig. 2.3.1 - General view of the pipeline insulation

On fig. 2.3.1 number 1 indicates the section of the pipeline to be insulated, 2 - heat-insulating material (glass wool), 3 - polyethylene film, 4 - heating cable (if any).

Despite the ease of use, this design also has its drawbacks. Firstly, the relative complexity in the installation and dismantling of equipment. Glass wool has a high density (it is quite heavy), so it is inconvenient and difficult to insulate long sections of the flow line with it, because you need to simultaneously hold it and wrap a polyethylene film on top. In addition, it severely cuts hands, which adds to the difficulty in its installation. Moreover, at the fields in Russia, oil and gas operators who do not have special competence in working with electricity (the majority of them) are not allowed to coil heating cable on pipelines. This indicates the need to attract additional personnel to carry out such a primitive event as well insulation [7]. Secondly, during dismantling during strong winds, small pieces of glass wool and polyethylene film can fly outside the working area and remain outside the territory of the cluster. This problem is extremely relevant for Russian regions with difficult weather conditions (YaNAO, Khanty-Mansiysk Autonomous Okrug, Eastern Siberia, Far East), since deposits there are often located far outside the city, right in the wild. This disadvantage is primarily significant from the point of view of the ecology of the regions. Thirdly, the inefficiency of the technology without the use of a heating cable, which complicates the operating conditions in the event of a cable breakage - it is necessary to completely disassemble the structure and assemble it again.

This technology has rightly become widespread in Russia, but it is not without its drawbacks. First of all, it lacks integrity, this type of insulation is assembled literally in parts and requires additional involvement of specialists to install a heating cable.

## 3 SUGGESTED SOLUTION

### 3.1 Sample requirements

It is easy to formulate the main requirements for a universal device after analyzing the main used in the oil fields check valve heating devices:

1 The device must be able to be easily assembled and dismantled. This is an extremely important condition, since most of the well stock in the field has problems with freezing of the back pressure valve, so the number of wells required for insulation is extremely large and it is important not to spend a lot of time on installation and dismantling. Moreover, this condition will contribute to the possible simplification of the repair of equipment, its transfer from one well to another in the event of, for example, well closure, and will also facilitate the work of operators in preparing the facility for the summer period of operation.

2 The device should be easy to operate and be repairable promptly. It is very important that each of the component parts of the equipment can be replaced in the event of a breakdown as soon as possible, because a downtime of a well is unacceptable - this is a loss of money. It is important that the constituent parts are publicly available, do not require special qualifications for replacement, because some fields in the Arctic are far away not only from airports, but even from residential villages, so it is simply not possible to send equipment for repair in some places.

3 The device should be a single design of fastened parts, and not be a superposition of poorly fastened elements. This condition is important for reasons of the environmental component at the facility, which was described above, as well as on the basis of facilitating the conditions of human labor - operators of oil and gas production.

4 The device must be protected from mechanical and climatic conditions in the field. It must be resistant to snow, rain, hail, sand (minimally abrasive), as well as possible mechanical influences (animals, birds).

5 The device must have a minimum cost, while the requirements for its operation must be fully met - it must prevent freezing of the X-mas tree back pressure valve. To do this, it is necessary to make a feasibility study of the materials chosen for its construction, which would satisfy the given goals and would be the most accessible and cheap.

6 The device must be safe for both humans and the environment. It should not contain chemically hazardous reagents that are dangerous to humans and animals.

### *3.2 Drawing and description of the model*

A general view of the proposed solution is shown in Figure 3.2.1.

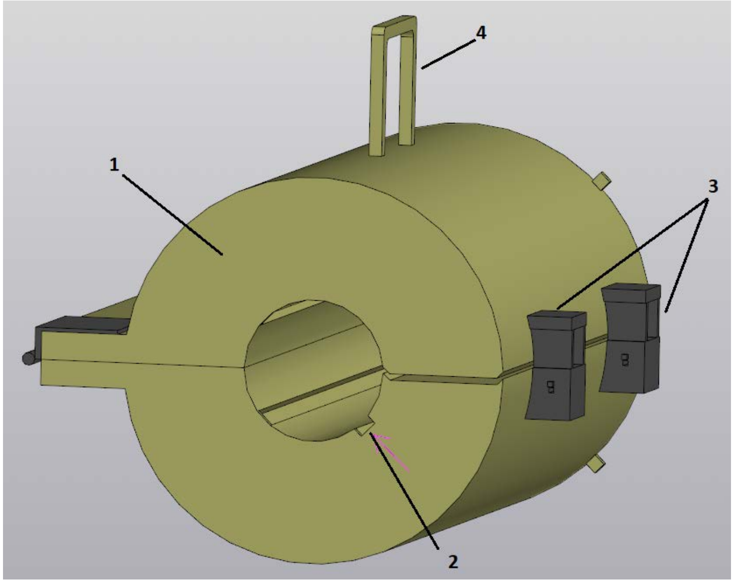


Fig. 3.2.1 - General view of the designed product

On a general view, the following elements can be seen: 1 - body (length can be any depending on the size of the flow line to be heated), made of high-density low-pressure polyethylene - HDPE (this type of plastic is very common in many applications, since such a material has high strength, it is chemically neutral, water resistant ; operated at high temperatures - melts at 130℃, and the maximum operating temperature is 110℃, non-toxic, difficult to burn, recyclable and has a low price - $ 1.5 per 1 kg) [8]; 2 - a groove for accommodating a heating cable that is held onto the body with any heat-stable construction adhesive - it is good because it ensures the cable is securely fastened at high heating temperatures without a noticeable decrease in efficiency (the dimensions of the grooves can be any, but in this case they are selected for the standard size of the selected heating cable); 3 - mount connecting the upper and lower parts of the structure, fastex type mount; 4 - handle for easy transportation.

Other elements are shown in figures 3.2.2 - 3.2.4.

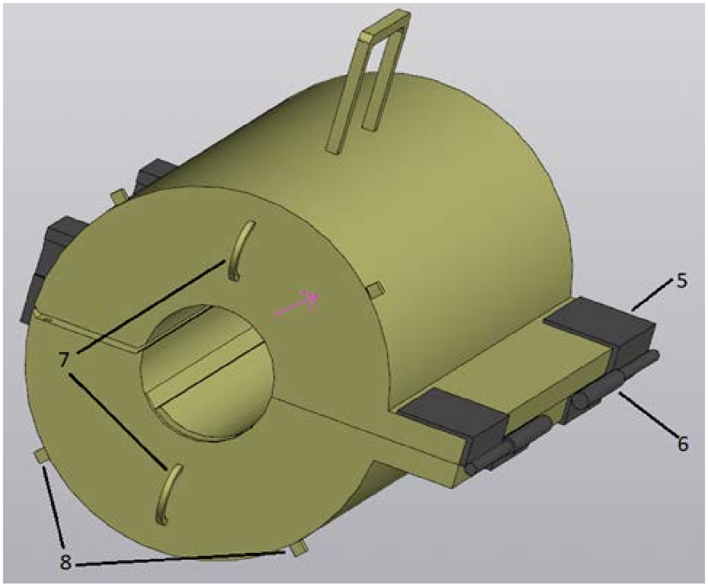


Fig. 3.2.2 - Image of the rear cover of the object

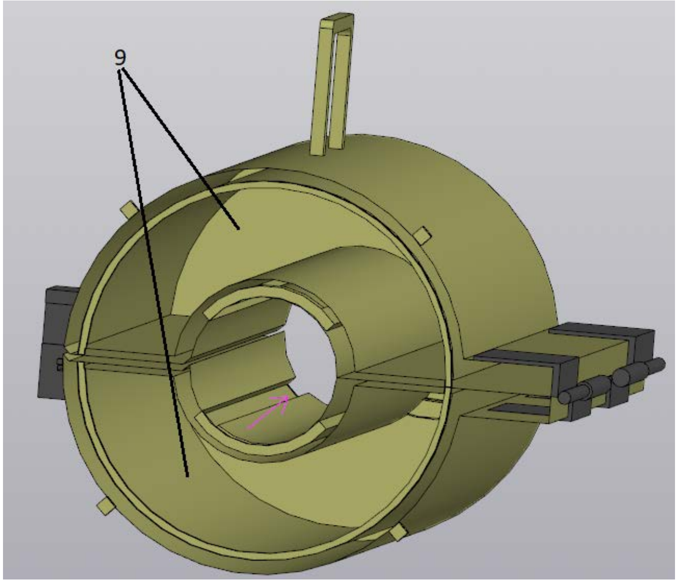


Fig. 3.2.3 - Image of the object with the rear cover removed

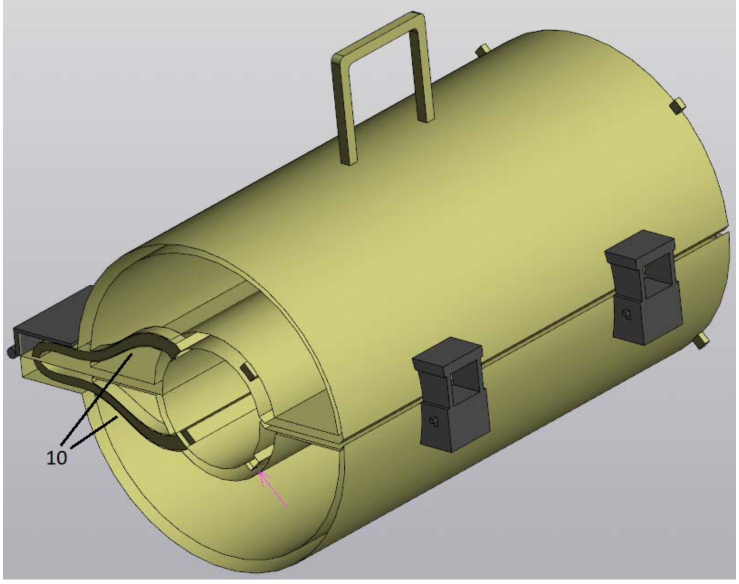


Fig. 3.2.4 - Image of the cable transition area from the lower half to the upper

On fig. 3.2.2 the numbers indicate: 5 - metal fastening for hinge 6; 6 - cylindrical hinge; 7 - handles on the lid for easy removal; 8 - fastening elements of the cover in the body.

On fig. 3.2.3, the number 9 indicates the cavity, which is filled with heat-insulating material.

On fig. 3.2.4, the number 10 shows a special area for connecting the grooves for the heating cable located in the lower and upper parts.

In general, the design is a pipe element that is put on the flow line of the X-mas tree. The product is fixed with the help of special fastexes(they are made of metal) located on the side surface. The design provides for a small backlash, which provides fastening of the equipment in tightness. Along the entire length of the product, there are special grooves (2 on top and 2 on the bottom) for the heating cable, which are connected by a transition element (fig. 3.2.4 number 10), which allows using one heating cable in the device. The body is hollow, inside it is a heat-insulating material that prevents the dissipation of heat flow. The cavity is closed with a special lid, which is attached to the body with special extruded elements (when pressed, they go inside the lid, and it is removed). The lid also has two handles for easy removal. The mobility and integrity of the structure is provided by cylindrical hinges. In the drawings, all metal products are shown in gray, and plastic products are shown in gold.

### *3.3 Selection of thermal insulation material*

The selection of heat-insulating material is one of the key tasks in solving the problem. It is extremely important to choose the material so that it fully meets both technological and economic requirements - it is optimal in terms of price / quality ratio.

The main parameters that you need to pay attention to when choosing a heat-insulating material are the ratio of thermal conductivity and density. Lower values of the ratio of thermal conductivity indicate better insulating performance, and lower density indicates easier operating conditions. The most popular thermal insulation materials used in construction, with their most important characteristics, are shown in Table 3.2.1 [9].

Table 3.3.1 - Characteristics of various thermal insulation materials

| Material name | Thermal conductivity ratio, W/(m*K) | Density, kg/m$^3$ | Price, $ |
|---|---|---|---|
| Aerogel | 0,015 | 110-200 | 80 - 1 m$^3$ |
| Mineral wool | 0,050 | 50-100 | 25 – 1 m$^3$ |
| Caoutchouc churn | 0,033 | 82 | 12 – 1 m$^3$ |
| Cellular polystyrene | 0,038 | 40 | 8 – 1 m$^3$ |
| Foamed polyurethane | 0,03 | 40-80 | 15 – 1 m$^3$ |
| Glass wool | 0,03 | 155-200 | 30 – 1 m$^3$ |
| Ecowool | 0,033 | 35-60 | 30 – 1 m$^3$ |

By analyzing the table, it is possible to draw some conclusions. Firstly, aerogel is extremely overpriced and generally quite rare, so not suitable. Secondly, mineral wool and glass wool have a higher density compared to other thermal insulation materials, which will significantly increase the dimensions of the sample, limit the possibility of its transportation due to the higher weight, so they are also not suitable for use in the manufactured sample.

Thus, among the presented samples and their characteristics, caoutchouc churn, cellular polystyrene, foamed polyurethane and ecowool clearly stand out. If we consider each of these materials separately, it becomes obvious that foamed polyurethane is not applicable in this design, since it is quite difficult to synthesize (it must be done on site using additional equipment), supports combustion, and is toxic to humans. Cellular polystyrene has a limited mechanical density, it is also toxic to humans, and a fire hazard. Moreover, in the design of the manufactured sample, the heat-insulating material must take an irregular shape, which indicates the need to create a special insulation, because the material is not susceptible to changes in shape and size. This will limit the use of cellular polystyrene, since it is mainly supplied in the form of rectangular parallelepipeds.

Based on this, it becomes clear that the best options are caoutchouc churn and ecowool. Both materials have similar thermal conductivity characteristics, ecowool is slightly lighter than caoutchouc churn, and their price is approximately the same. With a detailed study of the advantages and disadvantages, it becomes obvious that ecowool is the most applicable in this design due to a number of key advantages [10]:

- High thermal insulation properties, which provides a low ratio of thermal conductivity;
- Low density, which will make the structure lighter and more compact;
- Solidity of the insulating layer;
- The material is eco-friendly, since it does not harm the environment and humans both during production and during further operation;
- Resistance to biodegradation;
- Fire resistance;
- Durability and economy;
- Fast and safe installation. A particularly important point, since the thermal insulation material in the sample takes an irregular shape.

In summary, ecowool is the most applicable option as a thermal insulation material for the sample. Although it has a slightly higher cost, ecowool has a number of undoubted advantages compared to its competitors, which offset this, and the amount of this material used is not so large as to reduce costs.

### *3.4 Model calculation*

The main task of calculating the model is to determine heat losses per unit length of the pipeline (in this case, per unit length of the X-mas tree flow line). As a result of the calculation, based on the available initial data, the number of watts per unit length, which will be lost in the annulus, will be obtained. The ultimate goal is to select such a heating cable that would emit such an amount of heat that would cover the lost heat in the pipe section with a margin.

For an approximate calculation, it is necessary to set some initial characteristics. Let's take data from Russia's northernmost onshore field - Vostochno-Messoyakhskoye. The fields in Yamal are characterized by low temperatures both at the wellhead and in the ambient air. On the coldest winter days, the air temperature reaches -50℃, and at the mouth - up to 0℃. Under such conditions, the check valve freezes very quickly, so it makes no sense to maintain the temperature in the annulus. The final temperature should be at least 10-15℃. Let's take the air temperature as -50℃ and designate it as $T_{air}$ = -50℃, and the required temperature in the annulus is 15℃ and designate it as $T_{in}$ = 15℃.

As for the diameter of the flow line, each well here has its own unique values. For the calculation, we select one of the values according to GOST 13846-89 [11]. Let the conditional passage of the lateral outlet of the calculated well be 100 mm. Since the wall thickness of the annular space is a variable value (it depends on many factors, including the time of operation), we will take this value as 5 mm. Thus, the outer diameter of the annulus (as well as the inner diameter of the thermal insulation) will be equal to $d_{in}$= 110 mm. The diameter of the heat-insulating layer is selected from the expediency of choosing one or another heating cable - the larger the diameter of the heat-insulation, the less power of the heating cable will be required. Let us choose such an insulation diameter that will ensure the choice of heating cables in a wide range, but at the same time will not increase the dimensions of the model to a non-transportable state. Let it be $d_{out}$= 300 mm.

Total losses over the entire length of the pipeline are calculated as follows [12]:

$$Q = \frac{(T_{in}-T_{air})*K*L}{R_{is}+R_{out}}, \quad (3.4.1)$$

where $T_{in}$ - the temperature of the liquid in the pipeline, ℃;

$T_{air}$ – ambient air temperature, ℃;

L – the length of the pipeline section under consideration, taken as 1 meter;

$R_{is}$ – the linear thermal resistance to heat transfer of the insulation layer, (m * ℃) / W;

$R_{out}$ - linear thermal resistance to heat transfer of the outer surface of the wall of the insulated object, from the summary tables for these conditions 0.07 (m * ℃) / W is taken;

K - the ratio of additional losses taking into account heat losses through heat-conducting inclusions in heat-insulating structures, due to the presence of fasteners and supports in them, as well as minor losses in the voids of thermal insulation, in the intermediate element between the heating cable and the annulus. The recommended value of this coefficient from the summary tables is 1.5.

Linear thermal resistance to heat transfer of the insulation layer is calculated as follows:

$$R_{is} = \frac{1}{2*\pi*\lambda}*\ln\frac{d_{out}}{d_{in}}, \quad (3.4.2)$$

where λ - the coefficient of thermal conductivity of the insulation, W/(m*℃);

$d_{out}$ - diameter of the pipeline with thermal insulation, mm;

$d_{in}$ - diameter of the pipeline without thermal insulation, mm.

$$R_{is} = \frac{1}{2*\pi*\lambda}*\ln\frac{d_{out}}{d_{in}} = \frac{1}{2*3{,}14*0{,}033}*\ln\frac{300}{110} = 4{,}841\frac{m*℃}{W};$$

$$Q = \frac{(T_{in}-T_{air})*K*L}{R_{is}+R_{out}} = \frac{(15-(-50))*1{,}5*1}{4{,}841+0{,}07} = 19{,}853W.$$

Thus, with the given initial data, the heat loss from one meter of the flow line is 19.853 W. In order to maintain the required set temperature in the flow line, it is necessary to choose a heating cable that would be more than this value with some margin. It should be noted that when the outer diameter of the thermal insulation is reduced to 200 mm, the loss per unit length will be 33.01 W/m, which is 1.66 times greater than with the selected insulation diameter.

### *3.5 Selection of heating cable*

The heating cable generates the necessary amount of heat to maintain the required temperature in the flow line of the X-mas tree in order to prevent the back pressure valve from freezing. There are several types of heating cables that are used in construction: resistive, zonal, self-regulating and mineral insulated cables. In industry, for the purpose of heating pipelines, resistive and self-regulating heating cables have found the greatest use [13].

If it is considered each of them separately, then it can be said about the resistive heating cable that automatic power control is not provided here, there is a big risk of overheating of the cable in some places due to the uniform distribution of power along the entire length, it cannot be cut off or extended, and in case of failure of a separate section of the cable, it is necessary to completely change the product. Although it costs a little less than a self-regulating cable, the use of this kind of cable is now fading into the background.

The self-regulating heating cable automatically heats the object depending on the ambient temperature, it is easy to install - it can be crossed, cut, spliced, overlapped, the risk of overheating in it is minimal. Also, a cable of this kind is characterized by high efficiency, significant energy savings and a long service life (up to 25 years). Although this cable is more expensive than resistive cable, its operating conditions and significant savings in energy consumption quickly pay off the capital investment [14].

Thus, the necessity of using a self-regulating heating cable in the developed product becomes obvious. Based on the given initial data, the heat losses of the flow line of the X-mas tree were calculated, which are equal to 19.853 W/m. It is necessary to choose a heating cable of such power that the amount of heat emitted by it is with a certain margin more than what is spent in a given area. This reserve is explained by possible voltage drops, power loss in a certain section of the heating cable, uneven thickness of thermal insulation in some places of the structure, changes in ambient temperature in a wide range reaching critical values (-60℃ and below).

Since the inside of the product provides for cable laying in both parts of the structure (bottom and top), the required length of the heating cable is just over 2 meters. After conducting a market analysis, comparing various cable models, it is proposed to use heating cable model 17NRK-F-2. Specifications of the cable are presented in table 3.5.1 [15].

Table 3.5.1 - Some technical characteristics of the heating cable 17 NRK-F-2

| Characteristic | Value |
|---|---|
| Heat release power, W/m | 17 |
| Number of cores | 2 |
| Shielded cable | Yes |
| Minimum installation temperature, ℃ | -60 |
| Maximum operating temperature, ℃ | 65 |
| Maximum operating temperature, ℃ | 85 |
| Power supply, V | 220-240 |

This heating cable satisfies the operating conditions of the product casing, because the maximum temperature during use does not exceed 85℃, and the operating limit of the product casing is 110℃.

Since the developed product will contain more than 2 meters of the presented cable (taking into account the cable transition space from the bottom to the top), the total output power will be more than 34 W, which is 1.71 times more than the minimum required. This reserve is completely sufficient to heat the flow line and prevent freezing of the X-mas tree back pressure valve.

## *4 CONCLUSION*

During the development of the proposed model, it was possible to create such equipment that meets all the requirements: it is easy to install and remove from the flow line of the X-mas tree, the device is easy to operate and can be quickly repaired, it is a single design of fastened parts, has protection against mechanical and climatic impacts, the device has a minimum cost and meets all the requirements, and it is completely safe for humans.

Based on this, it becomes obvious that the proposed model can be used in an oil field, as it has a number of significant advantages in comparison with its competitors.

## *5 REFERENCES*

[1] Neftegaz-2023. Russian oil and gas industry in economic conditions, from https://www.neftegaz-expo.ru/ru/articles/osobennosti-neftegazovoj-otrasli/, accessed on 2022-09-09

[2] Tass. Arctic oil reserves in Russia, from https://tass.ru/ekonomika/12276891?utm_source=google.com&utm_medium=organic&utm_campaign=google.com&utm_referrer=google.com, accessed on 2022-09-09

[3] GoArctic. Climate in the Arctic: winter, from https://goarctic.ru/news/klimat-v-arktike-zima/, accessed on 2022-09-09

[4] Trunin A.M., Chernov G.A., Wellhead valve heater, from https://www.elibrary.ru/download/elibrary_38378066_66549050.pdf, accessed on 2022-09-09

[5] Geoburservice, from http://gbsufa.ru/ink.html, accessed on 2022-09-09

[6] FontArm. X-mas wellhead fittings, from https://fontarm.ru/articles/obogrev-fontannoy-armatury/, accessed on 2022-09-09

[7] Utepliks. Glass wool is the most popular heater, from https://uteplix.com/materialy/steklovata.html, accessed on 2022-09-09

[8] UpakSnab. Low pressure polyethylene: pros and cons, from https://upacksnab.ru/articles/polietilen-nizkogo-davleniya-plyusy-i-minusy/, accessed on 2022-09-09

[9] Xiron Cold. from http://vse-dlja-doma.com/tablitsa-teploprovodnosti-stroitelnykh-materialov, accessed on 2022-09-09

[10] SRBU. Ecowool - disadvantages and advantages of insulation, from https://srbu.ru/stroitelnye-materialy/8-ekovata-nedostatki.html, accessed on 2022-09-09

[11] Electronic fund of legal and normative-technical documents, from https://docs.cntd.ru/document/1200021293, accessed on 2022-09-09

[12] Bukhmirov V.V., Sozinova T.E., Solnyshkova Yu.S., (2015). Calculation of heat transfer through imperable walls, 10-14

[13] Electrical heating cable systems. What is a heating cable, from https://antiledgroup.ru/blog/post/chto-takoe-greyushij-kabel, accessed on 2022-09-09
[14] Teplokabel. Device and principle of operation of the heating cable, from https://teplokabel.ru/info/articles/obshchaya-informatsiya/ustroystvo-i-printsip-raboty-samoreguliruyushchegosya-greyushchego-kabelya/, accessed on 2022-09-09
[15] Premium cable, from https://premiumkabel.ru/magazin/product/samoreguliruyushchiysya-nagrevatelnyy-kabel-17nrk-f-2, accessed on 2022-09-09

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