MINIMISATION OF ATMOSPHERE POLLUTING BY MEANS OF MINE GEOTHERMAL POWER INSTALLATIONS

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In article the actual problem on use of geothermal energy of mines is considered. Existing installations have number of lacks which are considered in article. Compassion of work of similar installations on use of geothermal energy of mime is spent and the new decision is offered. Installation work is directed on decrease in harmful emissions to atmosphere and economic gain reception. The scheme of functioning of installation and its key parameters is resulted. It is shown that the given installation can work not only on operating mine, but also after enterprise liquidation as object of coal mining. It is proved that it is possible to lower expenses on installation operation.

Key words: bowels, geothermal energy, mining excavations, emissions, environment.

In Lissabon's declarations necessity of use power generating installations with zero issue of pollution in the environment is marked. One of ways of reception non-polluting energy is use of geothermal resources.

In a mining industry reception of geothermal energy from bowels can be used for maintenance with kinds of energy of mines thermal and received from it or objects on a surface. It can be used both on operating, and on the preserved mines.

The way of reception of geothermal energy which is developed by Baumgertner S., Gerar A., Barma R., Vi P. is now known. It provides, that for reception of geothermal energy usually spend from a surface vertical or inclined developments to depth where the temperature of rocks exceeds temperature of boiling of water. Between the next excavations is created a site pervious crumbling massif named underground geothermal heat exchanger. To one of excavations submit the heat-carrier (a liquid or gas) and provide its movement through heat exchanger. Through another it give out and utilize the saved up energy.

Thus the technical result, as is not provided:

- efficiency of a way which is caused by limitation of expenses of water in the underground geothermal heat exchanger because of threat of «thermal breakdown», that is receipts not warm water in excavations is limited;
- the high cost price of the received energy because of high cost of works on designing, preparations and carrying out of mining excavations and the nature protection actions connected with it;
- the way has low enough reliability owing to threat of filling of emptiness of the underground heat exchanger by particles of rock or crystals of salts which are formed in water.

The closest analogue is the way of reception of geothermal energy which is taken out from mine by a stream of fulfilled air. This way is offered by Sulkovsky I., Drenda J., Rozansky Z. (Technical university of Ostrava, Czechia).

The way provides:

- giving of air from a surface through trunks in mining excavations;
- air moving on a network of operating mining excavations with admissible speed at the expense of a pressure of fans and its heating from rocks to temperature nearby 25^0C;

- air delivery on a surface through a ventilating trunk and recycling of the geothermal energy saved up by air to consumers, in particular «the thermal pump».

The range admissible in different types of mining excavations of speeds of air on the minimum and maximum size is caused by requirements «Safety rules in mines». The same document limits heating of air to temperature no more 25^0C because this size is critical on workplaces in underground conditions from the point of view of thermal influences on a human body.

Signs of this way:

- giving of the heat-carrier from a surface in underground mining excavations and its moving by means of a network of excavations of mine;
- recycling by the consumer of the geothermal energy saved up by the heat-carrier.

Thus achievement of effective technical result for following reasons is not provided:

- the efficiency of a way caused by restriction of expenses of the heat-carrier in a network of mining excavations under the factor of speed is limited;
- low indicator of extraction of energy from bowels because heat is given only by the part of a file located near to a contour of operating mining excavations for rather short time of their existence. In Donbass time of existence of one kilometre of local preparatory excavations makes 1,5... 2,5 years (in the countries of Europe this indicator is less), for clearing excavations duration of existence in borders of an invariable contour do not exceed several hours, and for this period cooling of considerable volumes of breeds is impossible;
- high cost of airing of mine and negative influence on environment because of use for work of ventilating installations of the energy received from fossil kinds of fuel which concern to irreplaceable energy kinds;
- the scope as it can be realized effectively, only airing a network of mining excavations of operating mine is limited, and it is irrational to apply after its closing owing to high operational expenses and low efficiency.

In Donetsk national technical university it is offered to use warmth of sites of the hills left after dredging of a mineral. In a basis a task in view of perfection of a way of reception of geothermal energy from the heat-carrier which stands out from mining excavations of mine in which by introduction of constructive additional signs it is provided:

- increase of efficiency of a way;
- scope expansion on liquidated mines;
- increase in extraction of geothermal energy from hills;
- decrease in expenses for realization of a way and negative influence on environment for a set of reduction of expenses of the electric power received from irreplaceable kinds of energy carriers.

The task in view dares as follows. In a known way of reception of geothermal energy which provides giving of the heat-carrier from a surface in underground mining excavations and moving by its network of excavations of mine, recycling by the consumer of the geothermal energy saved up by air, the heat-carrier from submitting excavations direct to the channel created in developed space. Thus term of a finding of the heat-carrier in the channel is defined by the formula:

$$\tau = \frac{0{,}1 \times \rho \times c \times F^2}{\lambda \times \Pi^2} \times \ln(T_m - T_b), \qquad (1)$$

where: ρ - heat-carrier density, kg*m^{-3};

c - heat-carrier thermal capacity, Dg*kg^{-1}*K^{-1};

λ - factor of heat conductivity of the heat-carrier, W*kg^{-1}*K^{-1};

F - the area of cross-section section of the channel, m^2;

Π - channel perimetre, m;

T_m - temperature of a file of rocks, K;

T_b - air temperature on an input in the channel, K.

The relationship of cause and effect of characteristics which make an essence of a way and reached technical result, speaks the following. The channels created in developed space allow to provide gathering of thermal energy by the heat-carrier from a surface of the bared rocks. In process of selection of energy it is updated by carrying over of heat from bowels. As have shown researches, at length of a way of the heat-carrier underground mining excavations of 500 m and more, dynamic balance in the course of heat of carrying over which remains tens years is established. Thus volume of received thermal energy it is proportional to the area of a surface of channels and a difference of temperatures of walls of excavations and the heat-carrier. Thus, creation of artificial channels gives the chance to raise essentially productivity of a way at the expense of increase in extraction of geothermal energy from hills. Use of capital mining excavations of existing mines allows to lower expenses for realization of a way essentially.

The scope of a way can be expanded on liquidated mines. Received ecologically pure geothermal energy promotes reduction of negative influence of mine by an environment and is provided at the expense of reduction of expenses of the electric power which is spent on heat-carrier movement on mining excavations and the heat exchanger.

The essence of a way speaks an example of concrete reception of geothermal energy. In drawing the scheme of realization of a way is presented (figure 1).

The way of reception of geothermal energy is realized as follows. As the heat-carrier air is used. It submit from a surface through a vertical trunk 1 to mining excavations on which submit air 2. From these excavations air arrives in clearing excavation 3, and then in the developed space. Regulation of directions of streams of air and its expenses is carried out by means of portable ventilating crosspieces with regulators 4. In the developed space, the formed ambassador of dredging of coal, in parallel clearing excavation with an interval 40 … 70 m spend channels 6 which represent excavation of the square form in the size 2 x 2 m. Channels 6 are connected to the excavations submitting air 2 and taking away air 5 in which deaf ventilating crosspieces 7 between steams of channels are erected so that to provide an opposite direction of movement of air in the next channels. Thus, set of excavations 2 i 5 channels 6 and crosspieces 7 create the geoheat exchanger in which air, moving on a serpentine trajectory, consistently washes all area of the developed space and heats up to temperature of a surrounding file, collecting geothermal energy.

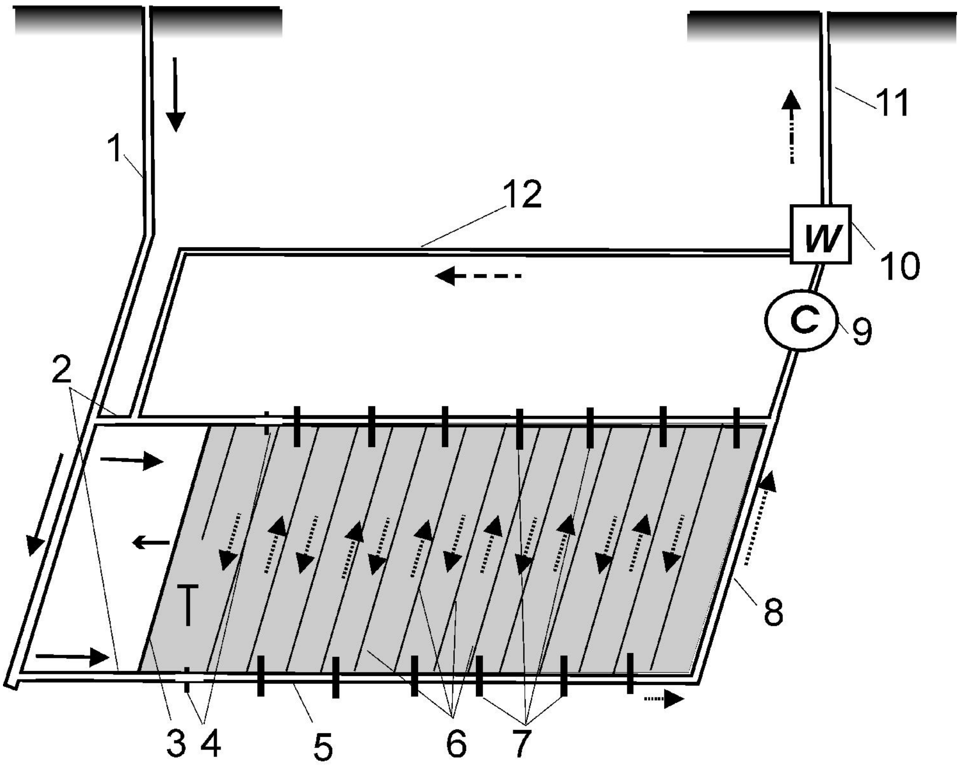

Figure 1 – Technologies of savings of resources on the basis of use of geothermal energy

1 – vertical mine trunk on which air moves; 2 – development submitting air;
3 – clearing development; 4 – ventilating crosspiece with a regulator;
5 – the development deducing air; 6 – the channels which have been passed in developed space;
7 – a ventilating crosspiece;8 – the development deducing air; 9 – the compressor;
10 – a vortical pipe; 11 – a ventilating mine trunk; 12 – development for tap of cold air.

Term of stay of the heat-carrier in channels is defined under the formula (1), where:

ρ - heat-carrier density = 1,29 kg*m^{-3};

c - heat-carrier thermal capacity = 1000 J*kg^{-1}*K^{-1};

λ - factor of heat conductivity of the heat-carrier = 0,024 W*kg^{-1}*K^{-1};

F - the area of cross-section section of the channel = 4 m^2;

П - channel perimeter = 8 m;

T_m - temperature of a file of rocks = 293 K;

T_b - air temperature on an input in the channel = 313 K.

Thus, the minimum duration of stay of air in the geoheat exchanger makes:

$$\tau = \frac{0,1 \times 1,29 \times 1000 \times 16}{0,024 \times 64} \times 3 = 456s$$

This requirement has been reached at length of a serpentine trajectory of movement of air the channel about 450 m (two pieces on 200 m which are equaled to length of a clearing face, and 50 m of distance between them) and speed of air nearby 1 $m*s^{-1}$. Air temperature on an exit from the channel makes nearby 40^0C. Energy which receives volume of the heat-carrier which is in the heat exchanger for term of passage from an input to an exit, is equaled $E=50*10^{-6}$ J.

At development of extracting works and increases in length of the channel speed of the heat-carrier can be considerably raised. Results of researches are resulted in table 1.

Table 1 – Influence of parametres of geoheat exchangers on selection of geothermal energy

Length of the channel, L, m	500	1000	1500	2000
Speed of air, V, m/s	1	2	3	3
Energy of the heat-carrier, $Q*10^{-9}$, J	0,0516	0,1032	0,4644	0,6192

Resources of warmth which arrive from bowels, are sufficient for work of the heat exchanger throughout several centuries. From the geoheat exchanger warm air arrives in taking away excavations 8, and from it in the compressor 9. The compressor 9 is the activator of movement of air a network of operating mining excavations. From the compressor warm air arrives in a vortical pipe 10 where division into two streams – hot and cold is carried out. The hot stream which contains the warmth which has been saved up in the geoheat exchanger, arrives on a surface through a ventilating trunk 11 to the consumer. Cold stream of air through development for tap of cold air 12 recirculates in mining excavations 2 which submit air.

The offered way of reception of geothermal energy consists in use of warmth of a file for heating of the day off from energy carrier mine, at the expense of it there is an increase in its internal energy. From the geoheat exchanger geothermal energy is transferred in warmly processing adaptation, in this case – a vortical pipe where the stream of molecules of air which have the greatest energy is divided, and are used for transfer to its consumer.

This way in addition created geoheat exchanger where there is an extraction of geothermal energy from the fulfilled area of a deposit of a mineral is used. It allows to raise essentially indicators of extraction of energy from bowels and productivity of process of reception of energy in comparison with known technical decisions.

The geoheat exchanger can function practically constantly. Time of its productive work is caused by stability of mining excavations and deterioration of the equipment. The considerable area it is artificial the created channels in the developed space, and also access possibility to them for the purpose of repair or clearing, allow to raise essentially reliability of work of the equipment on reception of geothermal energy. Considering a configuration and the big length of channels of the geoheat exchanger, there are impossible "breakdowns" of the cold heat-carrier from mining excavations.

At the expense of use of geothermal energy for air heating essentially decreases expenses of fossil energy carriers (natural gas or coal), that provides ecological effect from use of a way. Thus because of decrease in expenses of fuel the cost price of made production, including geothermal energy essentially decreases.

As introduction of installations of the given type is offered on already working mines, that, it is necessary to notice, that capital costs for introductions of installation will be not great in view of absence of expenses for prospecting works and insignificant expenses on designing.

As to the current expenses they will tend too to reduction due to a difference in the cost price of the energy received with the help of mine geothermal power installation and on the basis of traditional approaches. Besides received energy is possible for using for obligatory ventilation of mine space, reducing expenses for a safety of functioning of the enterprise. Also the economy will be received due to reduction of obligatory tax payments for a pollution of environment.

Thus, decrease in the current both capital expenses and reception of additional economic benefit allows to draw a conclusion on economic efficiency of introduction of mine geothermal power installation.

Well-known, that after exhaustion of stocks of a mineral the proprietor has considerable expenses for maintenance of an industrial platform in safety. To avoid these expenses and to receive additional benefit probably using mine as the enterprise-generator of geothermal energy in a current of many next years.

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