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V. KOSTENKO (doctor of technical sciences, prof.),
S. SALEHIRAJ (postgraduate student)
Donetsk National Technical University

A **METHOD OF OBTAINING GEOTHERMAL ENERGY IN DEEP COAL MINES**

The paper provides a theoretical study and practical solution of the scientific and technical problem of improving the environmental safety of mining areas through the use of a clean inexhaustible resource of low geothermal energy obtained from waste rock massif of deep mines, the theoretical basis and experimental verification of the basic parameters and structural elements of mine geothermal heat exchangers, as well as assessing the effectiveness of their use. First it was theoretically substantiated and experimentally confirmed that the geothermal heat exchanger channels is the maximum mass flow of coolant, the excess of which leads to lower final temperature. Environmental effectiveness of the developed suggestions is to reduce the consumption of mine exhaustible natural energy resources and the negative impact of their burning on environment.

Keywords: geothermal energy, mathematical model of heat transfer, coal geothermal heat exchanger, heat-conducting glue, thermal conductivity, fractured rocks, thermal depression, environmental efficiency.

Introduction. Deterioration of the ecological situation in mining regions is substantially connected with intensive consumption by mines of different types of energy made from traditional types of fuel resources: natural gas, coal, oil products and uranium. The main stationary consumers of energy and fuel are electric motors of mining equipment, mine boiler installations, service equipment. Their work leads to emissions of heat, greenhouse and toxic gases, aerosols that affects, first of all, the condition of abiotic factors of nature and significantly reduces the level of ecological safety of mines. Increased environmental pollution and transfer in atmosphere thermal balance would gradually change the world climate. Shortage of energy and limited sources of energy would direct us to the use of new sources and replace them with traditional fuels. Renewable energies, including solar energy, earth and wind, are among the new sources with no negative effect on environment and. Geothermal energy under the crust increases with the depth and temperature increases by 3 degree per 100 meters depth. In other words temperature would be about 50-70 C at 1500-2000 depth which however depends on geologic structure of the area, increasing or decreasing temperature [4].

Deep coal mines may be changed into a source of geothermal supply of the required energy for mines and residential units. The benefits can be the foreseeable energy production rate, decreased greenhouse gases emission, being independent form climatologic changes compared with solar and wind energy and decreased consumption of non-renewable natural sources. For mining regions of Ukraine in which there are no superficially located high-potential thermal resources, a promising source is the heat obtained from the walls of mine workings of deep mines [3].

Geothermal energy disseminated in space can be concentrated in extended channels of labyrinth configuration. The plan can be used in closed or active mines. One of the most important benefits of the plan is that no excavation would be necessary for extraction of geothermal energy but existing tunnels and wells in underground mines can be used which decreases the charges. As well underground tunnels are assessable and required information about ventilation and surrounding rocks properties in tunnels is obtained.

Materials & Methods and Results. In this plan the work is based on the usage of air as a heat carrier. To extract geothermal energy the void spaces can be used in mines and air ventilation routes. Air, entering the mine moves in some kilometers depth and reaches the surrounding rocks temperature. Thermal operation can remain unchanged for some decades as a result of thermal current transferred to the surrounding rocks from the deep earth. To obtain more energy, a heat exchanger consisted from different channels and tunnels in the extraction part can be constructed in excavated parts of the rocks. Air would act as a thermal carrier in this exchanger (Fig.1).

It is supposed to provide energy extraction, creating in the fulfilled parts of a massif, mine geothermal heat exchangers (MGHE). They represent a system of channels mine workings in the developed space of the face on which the heat carrier, as a rule, is air [1].

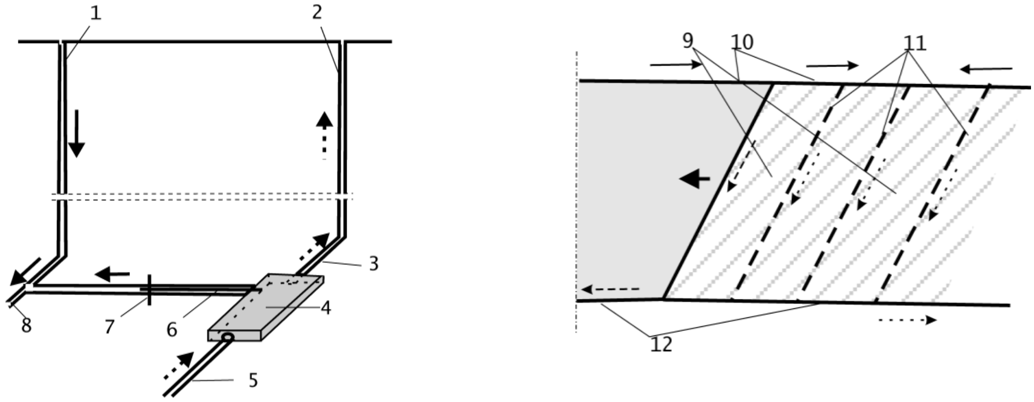
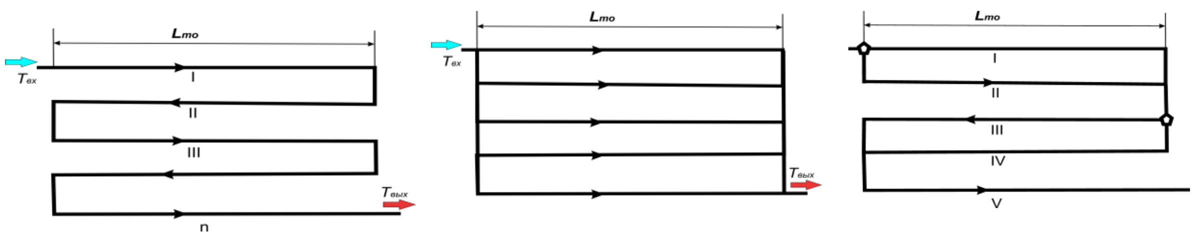


Figure 1 – Schemes of airing of a mine with the use of geothermal energy (a) and air heat exchange in the mine-out space (b):

1,2 - mine shafts, respectively, air giving and ventilating; 3,8 cross-cuts, respectively ventilating and air giving ; 4 – spiral pipe; 5,12,10 – developments, respectively, main and local air taking away and the local air giving; 6 – the pipeline of the cooled air; 7 – ventilating crossing point; 9 – the geothermal heat exchanger (the shaded part of drawing); 11 – the channels passed in mine-out space at distance 50... 70 m from each other

The channel network of mine geothermal heat exchanger can be in different forms including parallel, continuous and combinatory. They should increase the air temperature to that of the surrounding rocks (Fig.2)



a) b) c)

Figure 2 – a) Continuous structure; b) parallel structure; c) combinatory structures

The above structures have all their weaknesses and benefits but the most important weakness is that continuous and parallel structures cannot produce energy continuously for, when the rocks around the channels are cooled down; the network should be closed for recharging. The weakness can be removed with the use of combinatory structures. It is made from continuous and parallel structures having their benefits in a single system. As well using special switches part of the system can be closed for recharging while the other part is active at the same time. In this way required energy is taken from the network continually. Air passing the network channels reach the surrounding rocks temperature and then enters an energy transformer which may be a thermal pump, spiral pipe, etc., being divided in two warm and cold currents[2]. Warm current can be directly or with the help of steam turbines transformed to electricity and be used. Warm gas, with a temperature higher than water boiling point can be used to evaporate water of high minerals density changing it from a harmful environmental pollutant to a useful product in industry and agriculture. The second current produced in energy transformer, the cold air current, can be used for cooling the air in labor working place. This would solve one of the problems in underground mines in which ventilation is important. Using this method will increase the possibility to cool the air beside the entry channel to working area, as a result of which excess heat is discharged to geothermal exchanger channels and increases the source. For reduction of expenses on fuel resources it is possible to use mine air for heating of feed water before its giving in system of heat supply and hot water supply, and also for heating of the air used for the intensification of burning of fuel, directly in a fire chamber of the boiler. In the latter case the economy of fuel is provided also at the expense of containing in mine air of methane and coal dust (Fig. 3).

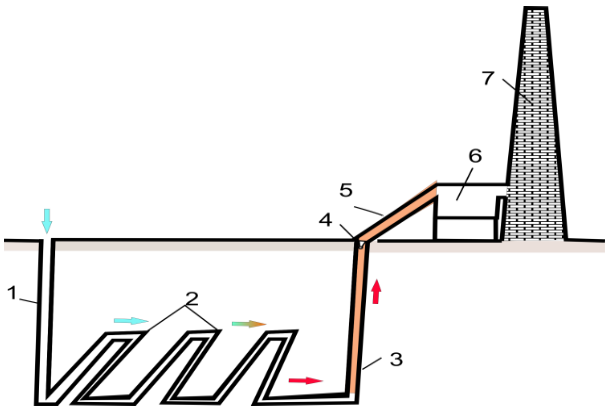


Figure 3 – For reduction of expenses on fuel the Scheme of preparation of air for the use in a mine boiler room: 1 – air giving shaft, 2– heat exchangers; 3 – ventilating shaft; 4 – additional fan; 5 - the heat isolated pipeline; 6 – boiler room units; 7 – chimney

Resulted geothermal energy can be used for years even after extraction of minerals. Useful life of geothermal exchanger network depends on stability and strength of channels, tunnels and equipment’s used in the system. The network would improve the mine economy and total mine conditions and lowers the charges for production of minerals. Long term performance of heat exchangers makes it possible to decrease social problems in the mine area, for instance with completion of extraction work, labor can be employed for protection and maintenance of channels or inexpensive electricity and thermal energy and be supplied to the residential areas around the mine. Recommended method for extraction of geothermal energy is relatively harmless from the environmental viewpoint and can decrease damages from extraction of coal mines. The method given in this paper is a new idea which requires more technical and economic studies as well as thermodynamic calculations, however the method may be considered as one solving the energy security and crisis in Ukraine coal industry.

Conclusion

1. Defined technology for extraction of geothermal energy form existing rock masses in deep underground mines would decrease charges for production of mineral and negative effects on environment through lowering the consumption of fossil fuels in electricity generation

2. The method can increase investment yield for mine productivity would continue years after the mine being closed

3. Geothermal energy should in first place fulfill the mine requirements, for instance in generation of inexpensive electricity. In addition it can be used for mine ventilation, cooling the air and desalination of mineral water, etc.

References

1. Патент на корисну модель № 17751, МПК F24 J3/08. Спосіб одержання геотермальної енергії / Костенко В.К., Костенко О.В., Костенко Т.В. – Опубл. 16.10. 2006. Бюл. № 10.
2. Костенко В.К. Математическая модель операционного способа получения шахтного геотермального тепла / В.К. Костенко, И.Р. Венгеров. //Весник Донецкого горного института. – 2007. – №. 2. – С. 86-89.
3. Зборщик М.П. Защита рабочих глубоких шахт в зонах разгрузки/М.П. Зборщик, В.В.Назимко. – Киев: Техника, - 1991. – 248 с.
4. Sulkovsky Y., Drenda Ya., Rozansky Z. Find and use more energy in the mines, Netradičnн metody využitн ložisek / Vzsokб škola bбňskб - Technickб univerzita Ostrava // Ostrava 12-13 Listopad, - 1998. - P. 259-267.

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В. К. КОСТЕНКО, С. САЛЕХІРАДЖ

СПОСІБ ОДЕРЖАННЯ ГЕОТЕРМАЛЬНОЇ ЕНЕРГІЇ В ГЛИБОКИХ ВУГІЛЬНИХ ШАХТАХ

Вирішена науково-технічна задача, що полягає в підвищенні екологічної безпеки гірничодобувних регіонів на основі використання екологічно чистого невичерпного ресурсу низькопотенційної геотермальної енергії, одержуваної з відпрацьованих гірничих масивів глибоких шахт, теоретичному обґрунтуванні та експериментальній перевірці основних параметрів і конструктивних елементів шахтних геотермальних теплообмінників, а також оцінці ефективності їх використання. Екологічна ефективність розроблених пропозицій полягає в скороченні споживання шахтою вичерпних природних енергетичних ресурсів і супутнього їх спалюванню негативного впливу на навколишнє середовище.

Ключові слова: геотермальна енергія, математична модель теплообміну, шахтний геотермальний теплообмінник, теплопровідний анкер, коефіцієнт теплопровідності, тріщинуваті гірські породи, теплова депресія, екологічна ефективність.

В. К. КОСТЕНКО, С. САЛЕХИРАДЖ

СПОСОБ ПОЛУЧЕНИЯ ГЕОТЕРМАЛЬНОЙ ЭНЕРГИИ В ГЛУБОКИХ УГОЛЬНЫХ ШАХТАХ

Решена научно-техническая задача, заключающаяся в повышении экологической безопасности горнодобывающих регионов на основе использования экологически чистого неисчерпаемого ресурса низкопотенциальной геотермальной энергии, получаемой из отработанных горных массивов глубоких шахт, теоретическом обосновании и экспериментальной проверке основных параметров и конструктивных элементов шахтных геотермальных теплообменников, а также оценке эффективности их использования. Экологическая эффективность разработанных предложений заключается в сокращении потребления шахтой невосполнимых природных энергетических ресурсов и сопутствующего их сжиганию вредного воздействия на окружающую среду.

Ключевые слова: геотермальная энергия, шахтный геотермальный теплообменник, теплопроводные анкер, коэффициент теплопроводности, трещиноватые горные породы, тепловая депрессия экологическая эффективность.