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Geothermic Power Plants of high capacity - how far?

R.H. Kozłowski*
Advanced Technology Workshop, Faculty of Mechanical Engineering,
Cracow University of Technology, ul. Warszawska 24, 31-155 Kraków, Poland
* Corresponding author: E-mail address: rhk@pk.edu.pl

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Cleaner production and biotechnology

ABSTRACT

Purpose: Over the past two hundred years, the mankind has exploited more than 50 percent of all natural resources, including energy minerals. The twenty-first century will be, out of necessity the period of intensive development of energy based on renewable resources.

Design/methodology/approach: The average geothermic gradient for the Earth`s crust (30°C/1km) can give us 10-20 MWe as a result (electrical energy) from one deep borehole heat exchanger. The value of electrical energy may be increased by introduction of a binary system with low-boiling medium into the energy system.

Findings: Geothermic power plant of high capacity characterized by the fact that the steam superheater section, which is traditional in a conventional power plants, is replaced by the system of heat exchanger in the form of u-tubes with a single length ranging from 1000 meters to up to several thousand meters, initially placed in a metal casing with a transition to the rock layers of high temperature.

Research limitations/implications: From the hot rock mass we can collect renewable resources of „dry" ascending energy from the paleo heat flow coming from the great nuclear furnace - the magma.

Practical implications: The subject invention is the use of geothermic energy using a closed water cycle in heat exchangers, made of high-temperature creep resisting steam superheater steel tubes or titanium pipes. Thermal energy of water vapour, which is obtained in this way, is transformed into mechanical energy in the turbine, powering the generator.

Originality/value: The role of a condenser can be fulfilled by a cascade system of thermal energy utilization(heat engineering, production of drinking water through desalination process, horticultural greenhouses, recreation, water pools, balneotherapy, heating sport fields, runways at airports and other transportation hubs.

Keywords: Geothermic power plants; Geo-technical borehole; Heat exchanger

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1. Introduction

Geothermic Power Plant is a power which uses geothermic energy, i.e. ***„the Earh`s thermal energy contained in the magma, rocks, water vapour, gases and water filling rock clefts".*** Over the past two hundred years, the mankind has exploited more than 50 percent of all natural resources, including energy minerals. With such intense economic development of the world and wasteful exploitation of energy resources, there is concern that in the present century all energy resources as well as most other natural resources of the world will be depleted. After the period of dominance of coal and steam (the nineteenth century),oil and gas (the twentieth century), the twenty-first century will be, out of necessity, the period of intensive development of energy based on renewable resources. Only those countries which will have access to such energy and which will be able to enjoy the benefits of the Earth uncontaminated by human action, and which will secure arequired amount of drinking water, will survive and will be able to normally exist.

The project presented is a realistic practicable idea for a substitute to system power plants, consisting in the construction of combined heat and power plants using renewable resources of geothermic energy. There are various methods of obtaining geothermic energy and various uses for it. It represents an endless renewable source of energy coming from nuclear reaction in the Earth`s nucleus, where the temperature reaches 6.000 centigrade (Figs. 1 and 2).

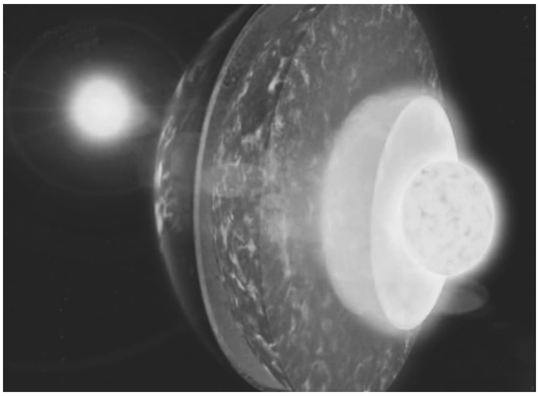

Fig. 1. The Earth as an natural nuclear power station

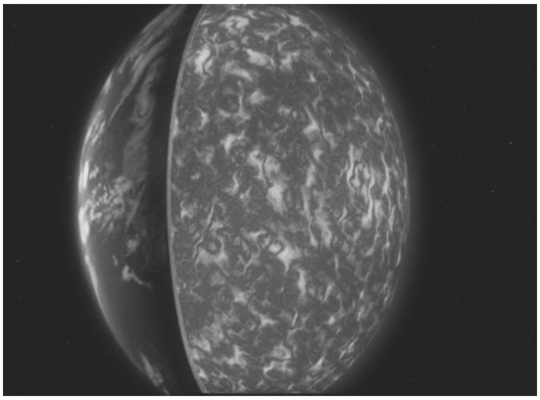

Fig. 2. Magma, the great potential of energy

2. Problem statement and theoretical as well experimental background

2.1. Motivation

The presented project is a possible to implement concept of a substitute for conventional energy, involving a construction of power plants that use renewable geothermic energy. This project is a dissenting against nuclear energy, conventional energy based on burning coal or lignite, storage of carbon dioxide in geological reservoirs, or environmentally damaging technology of shale gas exploitation.

Emission-free Geothermic Energy project, depending on the geothermic gradient ***(a value specifying the temperature increase In the Earth`s crust, accompanied by a unit increase in depth. It is usually expressed in $^{o}C$ attributable to an increase in depth amounting to 1 kilometre. The average geothermic gradient for the Earth`s crust is 30°C/1km),*** and can give us 10-20 MWe as a result (electrical energy) from one deep borehole heat exchanger. The value of electrical energy may be increased by the introduction of a binary system with low-boiling medium into the energy system. The value which specifies the increment in the Earth`s crust, accompanied by a unit increase in the temperature, is referred to as ***„the geothermic degree" (it is usually expressed in the number of meters per 1°C of temperature increase. The average geothermic degree for the Earth`s crust is 33m/1°C, but there are areas where the degree is a few meters/1°C, as well as areas where it exceeds 100 m/1°C).***

Four to eight heat exchangers (the number of exchanger, in principle, is unlimited, it must take into account the need to control heat offtake), are placed in boreholes with steel casing reaching through the water-bearing geological layers (aquifers), (a pre-requisite for environmental protection), up to the level of crystallites (in Poland it is up to 3200/4000 metres), from which they are driven at the same angle as the casing, in order to achieve the desired depth of the Orogene massif. It was initially estimated that the total electric power for eight heat exchangers in the temperature range of 200-350°C may amount to 80-160 MWe, with the controlled amount of the heat offtake in the amount not exceeding 20 percent out of 100 percent of regenerative capacity, within the same time frame,

2.2. Construction of the borehole

The borehole drilling process is carried out with the drilling rig tilted by an angle of 30^{o} (other tilting of the rig is also permitted).

Having drilled trough the Quaternary and Tertiary formations, and up to the Upper Createaceous formations, **inserting a column of pipe with an internal diameter of $18^{5}/_{8}$ and 11.5 mm wall thickness to depth of about 80 meters, in order to insulate the groundwater from the Cenozoic formation from the groundwater from the Upper Cretaceous formation, and cementation up to the surface of the area.**

Having continued drilling until reaching the roof of the malmu carbonate formations, **i.e. drilling to a depth of approximately 750 +/-10% metres under the surface, inserting a column of pipe an internal diameter of $13^{3}/_{8}$ and 11 mm wall thickness, and cementation from the depth of 750 m to the area surface.**

Having continued drilling until reaching the roof part of the shellbearing limestone (Muschelkalk), the floor of the versicolour sandstone at a depth of approximately 3050 +/-10% metres under the surface of the area, a column of pipes with an internal diameter of $9^{5}/_{8}$ " and 10.5 mm wall thickness should be inserted there, and then ought to be cemented from the bottom up to the surface. As a result, the aquifers in Lias, Dogger and Malm will be insulated.

During the process of borehole tubing, the following rules must be observed:

When pulling the pipes up to the rig (mast), the threads should be protected.

Threaded connections of the casing pipes should be twisted with a controlled torque.

Before twisting, the threads should be lubricated with pipe lubricant.

The order of inserting pipes should be observed and continuous control of the inserted column should be carried out, not only on the grounds of records and measurements, but also on the basis of indications of a drillometer.

The column of the pipes should be inserted at acontrolled rate determined on the grounds of technical and geological conditions for the executed borehole. During this process, the density of the mud fluid displaced from the borehole should be periodically controlled.

Having insert the column of the pipes, the borehole should be flushed.

In order to assure a correct sealing process of the column of the casing pipes, technical reinforcement must be installed which would be appropriate for the given technical and geological conditions as well as for the existing deposits. It is recommended as follows: to protect the bottom part of the casing column against the possibility of their unscrewing (gluing, welding), to use scrapers or wipers of clay sediment, to flush the hole, to use buffer liquid.

An important of the drilling system is its cost and time-consuming execution of boreholes. These problems have been solved through the implementation of [1]:

- New highly efficient, multi-driver drilling machines that could make a borehole up to a depth of 10,000 meters, within one month.
- New, high - performance drills, which are able to bore through a geological massif at the length of a borehole of circa 7000 to 8000 m in a single drill.

Modern drilling allows to:

- Combine drilling process with the simultaneous cementation of a Massie drilled trough under high pressure.
- Eliminate telescopic casing Pipes.
- Eliminate telescope reduction in the drilling diameter along with the depth, as well as drilling boreholes with one diameter of 10-12”.
- Perform directional drilling using turbine drilling appliances or to perform the above drilling using high pressure techniques.

During the process of heat exchanger installing, the pipes stored in a warehouse, go to the welding section and heat treatment. Before installation of heat exchangers in the borehole, the pipes are subjected to an inspection required for the detection of possible welding defects or improper heat treatment.

An essentials element of the heat exchanger is its initial part, which is to be executed by the gentle bending of the pipes. Moving the heat exchangers towards the borehole is carried out via roller tappets, powered conventionally by an electric motor with a device loading the heat exchangers pipes, over the previously prepared ramp with a gentle curve, driving the pipes into the borehole.

2.3. Materials aspects

The subject invention is the use of geothermic energy, using a closed water cycle in heat exchangers, made of high-temperature creep resisting steam superheater steel tubes or titanium pipes. Thermal energy of water vapour, which is obtained in this way, is transformed into mechanical energy in the turbine, powering the generator.

The problem of selecting a steel for superheaters is analogous to that for piping, at least in respect to resistance to rupture by flow, ductility at rupture, forgeability, weldability and hot oxidation.

The steel with 2.25% Cr and 1% Mo is used frequently for this application over a range of elevated temperatures and at a maximum of 575°C in the superheater assembly. If one makes a survey of the actual situation, however, one oerceives that in respect to the performance required in modern installations (temperatures and pressures), this steel reaches its limit of usefulness at a metal temperature of 575°C from the point of view of its mechanical strength and its resistance to hot oxidations.

When high resistance to oxidation is deemed necessary, high-chromium steels - notably the 8% Cr - 2% Mo modified steel - should be generally used [2,3].

2.4. The usage of geothermic energy in mines

The subject matter of the project is the mode of usage of high-temperature geothermic energy in exploited or operating mines, as well as and the system enabling the usage of high-temperature geothermic energy in exploited or operating mines.

The mode of usage of high-temperature geothermic energy in exploited or operating mines is characterised by an intake of high-temperature geothermic energy from the strata below the layers under exploitation and the overburden at the level of excavation deck by means of a system consisting of an exploitation well, a turbine with (or without) a heat exchanger, an electrical power generator, and an absorbing well. In an automatic, closed cycle part of the system, water or high-temperature geothermic steam performs the function of a carrier, and the whole system can be completed with successive heat exchanger attached to heat pumps.

The system enabling the usage of high-temperature geothermic energy in exploited or operating mines makes it possible for the geothermic energy contained in water or geothermic steam to pass from an exploitation well through a heat exchanger to turbine, or directly to a turbine omitting a heat exchanger, and then to let water be automatically returned to an absorbing well, while the turbine drives an electricity generator, and the remaining thermal energy of water or superheated steam can be used in the associated system consisting of heat exchangers and heat pumps installed either at the level of electricity generating system or on the ground surface.

Implementation of this project can result in production of clean and cheap electrical and thermal energies from renewable geothermic sources. In summer season this kind of thermal energy can be used in refrigerating engineering and air conditioning.

The well-know modes of usage of geothermic sources can be divided into two groups:

- System directly making use of geothermic heat on the ground surface (heat engineering, swimming pools, balneology, heat pumps, greenhouses); in the case of these systems an analogy to conventional heat-generating plants (generating heat from fossil fuels) can be drawn,
- System generating electrical energy on the ground surface; these systems can be compared to conventional steam power stations.

Similarly to conventional power engineering, there are, obviously, solutions linking both of these systems, that is, generating simultaneously both thermal and electrical energies.

Such solution can be compared to conventional heat and power generating plants. The essential element distinquising geothermic power engineering from conventional power engineering consists in the fact, that the geothermic power engineering is generated from renewable sources; it is ecological, thus, it does harm the environment.

However, not all of the numerous geothermic or geothermal sources which can be found in Poland or in other countries, allow for producing electrical energy. Temperature and pressure of geothermal water or superheated geothermic steam which can be possibly obtained at the outlet of exploitation borehole have to be taken into consideration as decisive factors.

Undoubtedly, much better conditions for operation of a steam turbine driving an electrical generator can be found at higher pressures and temperatures of superheated steam, that is, at the depths at which majority of mine decks is located, which thus, constitutes the essence of this invention.

Under the central part of the Upper Silesia Coal Basin (Górnośląska Niecka Węglowa), the geographical region of the area of 2700 km^2, there is a 1000 metres thick stratum of the Devonian limestone filled with geothermic waters of temperature from 100 to 165°C. The similar or much more better, geostructural conditions can be found and used within the areas of hard or brown coal occurrence all over the world. A higher temperature is found at the level of hot geothermic rocks. The usage of such solutions and their thermal energy together with the existing operating coal mines, would make it possible to create a geopower engineering system, mostly hidden under the ground surface (advantageous in the times of terrorism, which would secure production of electrical and thermal energies for domestic and foreign needs.

3. Concluding remarks

The project presented is a realistic practicable idea for a substitute to system power plants, consisting in the construction of combined heat and power plants using renewable resources of geothermic energy (hot rocks). Humanity has used thermal energy obtained from the depths and the surface of Earth for a long time. There are various methods of obtaining geothermic energy and various uses for it. It represents an endless renewable source of energy coming from natural nuclear reaction in the Earth`s nucleus, where the temperature reaches 6000 centigrade.

Mass production of electricity from the Earth`s heat possible in Iceland, due to the volcanic nature of those resources and the shallow depth at which they occur was difficult in other countries, due to the high cost of drilling to great depths. This barrier has been overcome by us through using a special drilling technique.

The emission free project of Geothermic energy with the temperature of over 250 centigrade from which we can obtain about 30 MPa of pressure on the turbine will give as a result field 10-20 MWe from one deep heat exchanger.

The present invention relates to a closed loop, geothermic system for production of clean energy contained in the magma, rock, water vapour, gases and water filling rock clefts.

In course of years, the production of clean energy generated from geothermic sources would increase, and the coal resources could be used in chemical plants to produce e.g. plastic, or in a gasification process for the needs of modern power plants built of coal fuel cells modules.

The natural coal resources should be used in an economical way and saved for future generations, in accordance with the sustained development rule.

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