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"Heat Mining"

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ABSTRACT

In Hungary the geothermal gradient is relatively high which means that there are high-temperature rocks underground. In theory the extraction of the heat of the rocks would be a perfect solution to ensure the heating of the country. The mathematical model written in the essay demonstrates that the exothermic system –consisted of two wells- is operable. The re-pressing was proved to be highly possible by many measurements, so the technological solution is ensured.

1. INTRODUCTION

Approaching the depth of earth the temperature is continuously grows. The rise in temperature was already noticed in the 17^{th} century on the basis of the measurements taken in different mines and observations of English and French scholars. For the sake of the exploration of the water and the hydrocarbon, in the last century the exploration work gradually developed the technology of the deep-drilling that is why deeper drills could take place. In the depth of more than thousand meters not only did they find water, oil and gas, but they also ascertained the existence of the geothermal energy, its physical parameters and they examined their conformation in the function of different geological, hydrogeological conditions.

The presence of the geothermal energy in every points of the earth can be ascertained but its extent is significantly influenced by local conditions. Therefore approaching to the depth the measure of the warming is territorially changing. The index number of this warming's value called temperature gradient (°C/km or °C/m), which shows how much °C rise in temperature belongs to the accreation of 1 km (or m) depth in the examined area. In the practice we use invent of the gradient (Figure 1). In world average it is 30°C measured on earth radius but in some territory it is more higher and for instance it is 50-60°C. The value more higher in the post vulcanic areas.

The origin of the geothermal energy can be attributed to the processes of the atomic fission, in which processes the earth functions as an atomic furnace and at this process the heat flows towards the surface. This ground heatflux's index number 62 mWm^{-2} in average. In Hungary it is higher, 84 mWm^{-2}. We can say that this value is extremely low nevertheless it is sufficient to warm up the solid rock-mass very slowly. Practically the present geothermal energy production exploits these accumulated heat energy. If you use equations, define all symbols, either after the equation, or in a Nomenclature section at the end of the paper.

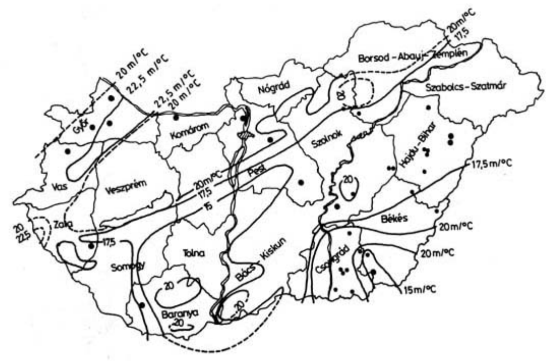

Figure 1: The geothermal gradient in Hungary

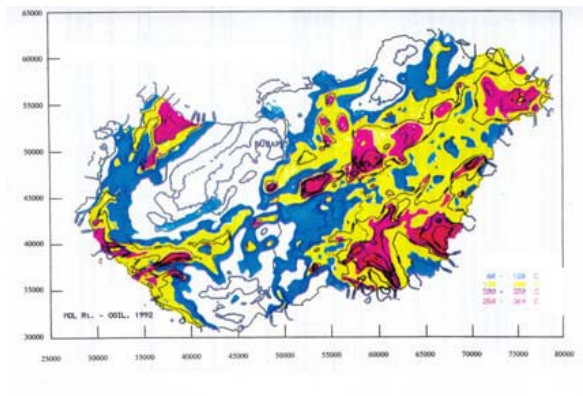

Figure 2: The basic mountain temperature

2. THE METHOD OF THE USAGE

However this accumulated heat energy only can be bring to surface from hot solid rocks with the help of a heat carrier. Up to this point it was only possible where in greater depth different liquid or gaseous substances take place, which absorbs the temperature of the environment. The heat carrier could have appeared as a geyser, thermal water in a natural way of deep-drillings. These drillings can be different gases, oils but most frequently the water - being in different state - fills the part of the heat carrier. In the depth, the water takes place in the porous rocks, cracks and getting to surface being depended on its temperature, it presents in the form of 100 Celsius thermal- water. If there is no heat carrier medium, with the help of a producer and a pressing pair of wells can we exploit heat. As in Hungary more than one thousand prospector wells exist therefore can we develop this kind of system in almost every borders of any settlements.

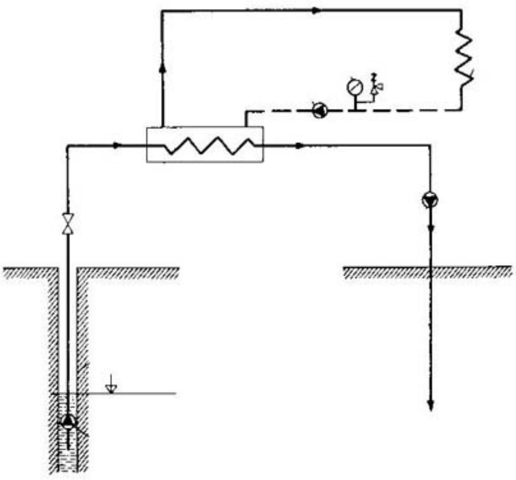

Figure 3: Two wells system model

3. THE MATHEMATICAL MODEL

After that we have to examine that one producer and re-pressing pair of well's how we storage heater medium affect the geothermal and hydrogeological's relation. The selected area is average 20-25 meter thick Upper-Pannon sandstone (700 mD) with good permeability. Minimal hydraulic gradients to be developing regional size flow systems in this good permeability layer. The thickness of layer is in negligible next on horizontal extent. As follows the leaking water is available two dimensions with good approach.

The flowing layerwater is uncompressible, the developing velocity field is rotary free. In the vertical level the linear partial equation is describable with the XY linear and orthogonal coordinate system and the v_x, v_y components of leaking velocity:

$$\frac{\partial v_x}{\partial x} + \frac{\partial v_y}{\partial y} = 0 \qquad (1)$$

$$\frac{\partial v_y}{\partial x} + \frac{\partial v_x}{\partial y} = 0 \qquad (2)$$

The first equation means the uncompressibility, the second equation means the rotary free. If these equations to be realized in every points of the layer, to be exist two scalar equation which satisfy the LAPLACE criteria and one another harmonic pairs. v_x, v_y velocity components are represent with these F1 and F2 function:

$$v_x = \frac{\partial F_1}{\partial x} = \frac{\partial F_2}{\partial y} \qquad (3)$$

$$v_y = \frac{\partial F_1}{\partial y} = \frac{\partial F_2}{\partial x} \qquad (4)$$

The third and the fourth equation are the CAUCHY-RIEMANN differential equation-pair. These have got infinite solutions. The flow complex potential is:

$$P = F_1(x, y) + i \cdot F_2(x, y) \qquad (5)$$

This is a regular complex variable function, and its real part the F_1 velocity potential, F_2 flow image is the imaginary part. The leaking velocity's conjugal is the P function z numeral derivation:

$$\bar{v}(z) = \frac{dP}{dz} = v_x - i \cdot v_y \qquad (6)$$

In the knowledge of these equations any parameters are calculable. The Figure 4 shows the position of the wells. The wells' distance is 2*d, the pressing well's label is –m, the re-pressing well's label is +m.

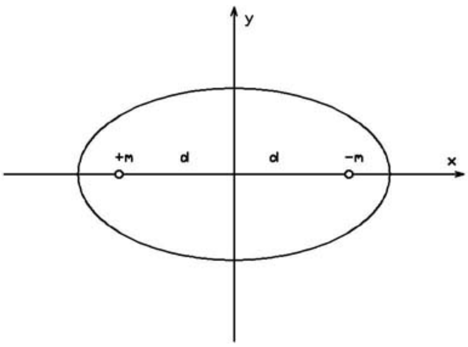

Figure 4: The wells' position

The v_{0x} velocity's direction is same the x axis direction. It is the undisturbed and the shortest flow picture. The complex potential's function:

$$P = v_{0x} \cdot z + \frac{m}{2 \cdot \pi} \cdot \ln(z + d) - \frac{m}{2 \cdot \pi} \cdot \ln(z - d) \qquad (7)$$

Near the wells the velocity field is:

$$\bar{v} = v_{0x} + \frac{m}{2 \cdot \pi}\left[\frac{1}{z+d} - \frac{1}{z-d}\right] \qquad (8)$$

After simplification:

$$v_x = v_{0x} + \frac{m}{2 \cdot \pi}\left[\frac{1}{z+d} - \frac{1}{z-d}\right] = v_{0x} + \frac{m}{2 \cdot \pi} \cdot \frac{d}{d^2 - x^2} \qquad (9)$$

The minimum of velocity is:

$$\bar{v} = v_{0x} + \frac{m}{2 \cdot \pi}\left[\frac{1}{z+d} - \frac{1}{z-d}\right] \qquad (10)$$

The average of velocity is:

$$v_{av} = \frac{1}{2\pi}\int_{-d}^{+d}\left(v_{0x} + \frac{m}{2 \cdot \pi} \cdot \frac{d}{d^2 - x^2}\right)dx \qquad (11)$$

The average time while the water circulated once is:

$$y_{av} = \frac{2 \cdot d}{v_{av}} \qquad (12)$$

The energy balance is:

$$\int_V \frac{\partial}{\partial t}\left[(1-p)\cdot \varsigma_r \cdot c_r \cdot T_r + p\cdot \varsigma_w \cdot c_w \cdot T_w\right]dV =$$
$$= \int_A \left[(1-p)\cdot \lambda_r + p\cdot \lambda_w\right] gradT\,\overline{dA} \qquad (13)$$

where p-porosity, c_r- specific heat of rock, c_w-specific heat of water, T-temperature, ς-density, λ-thermal conductivity.

The heat energy from the pressing well is:

$$E_p = \varsigma_{wp} \cdot c_w \cdot t_{wp} \cdot m \qquad (14)$$

where m-water mass flow

The heat energy into the re-pressing well is:

$$E_r = \varsigma_{wr} \cdot c_w \cdot t_{wr} \cdot m \qquad (15)$$

The gain heat energy is:

$$E_{gain} = E_p - E_r \qquad (16)$$

4. CONCLUSION

The gain heat energy is 2-3*1011 kJ/year if the average time while the water circulated once is 0,8-1,3 year and m=1 million m3/year and tvp-tvr=50-60 °C. The re-pressing was proved to be highly possible by many measurements, so the technological solution is ensured. This mathematical model works individual wells and many wells system. The gain is positive, and with the clean electrical energy from wind turbines, we got really clean heat energy for the buildings.

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