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The energy conversion of termal water in electricity

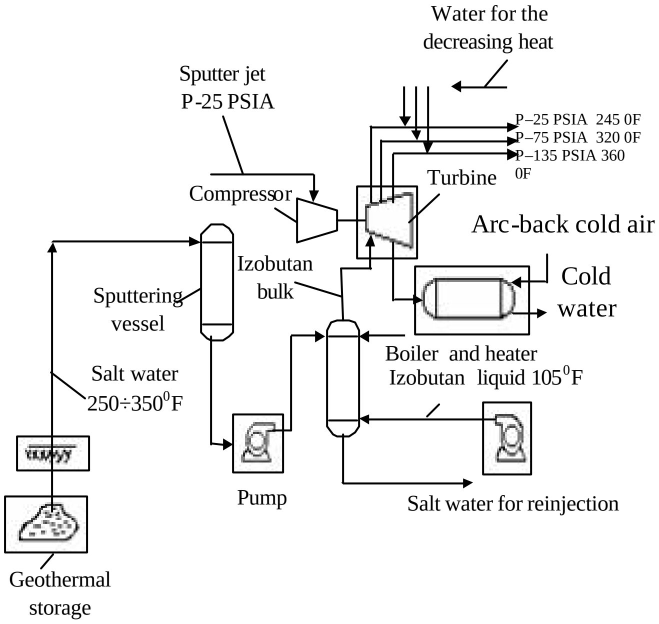
Mircea PANTEA
University of Oradea, mpantea@uoradea.ro

Abstract: in this paper we present the geothermal energy which represents the termal energy. We are interested in the determination of an optimal cycle of function; the optimization must be made according to the criterion of the maximal power in conditions of an imposed capacity.

1.Introduction:

The geothermal energy represents the thermal energy (the heat) from under the crust. Its use in order to produce electric power is relatively recent. Thus, in 1904 in Lardarello, Italy, it has been produced the electric power for the first time, with the help of the geothermal energy. Nowadays there is a thermoelectric power station of 400MW, station that uses vapor at 245°C that is obtained at a depth of 1000m. In the same time it has been formed a geothermal energy conversion international study center.

Base systems for the increasing grade of using the geothermal fluids



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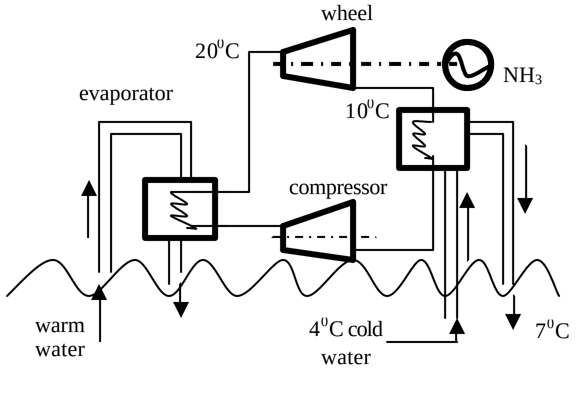
The functioning cycle in the diagram of the pressure enthalpy of dioxide carbon.



The cycle is determined only if it is known at least two state parameters for every point of the cycle.We are interested in the determination of an optimal cycle of function; the optimization must be made according to the criterion of the maximal power in conditions of an imposed capacity.

For every possible cycle, as the cycle type in the figure, the thermal efficiency of the cycle, the power of motor device, the power of the pump, the CO_2 flow are calculated in order to make the plant function possible, taking into consideration the imposed bulks (warm water efficiencies, pressure, etc).

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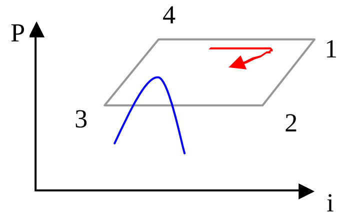
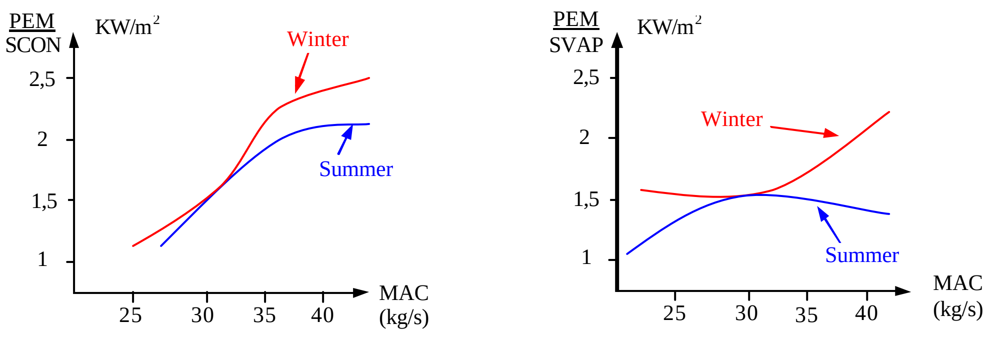


For a graphical cycle, a part of the obtained results for two summer – winter varieties, that is for entering cooling water temperature 10^0C, 14^0C .

One of the special problems of geothermal electrical plants, for which at least one of the isobaric processes of thermodynamic cycle of function crosses the biphasic zone, is the correlation of the rotative speed of the piston pump, for the liquid phase of working agent, in order to avoid reaching the biphasic zone in the active elements of the pump, as a result of the pressure decrease in the aspiration phase.

It is considered that the sub cooling (that is the enthalpy decreasing for 1 kg of CO_2) is realized by supplying the cooling agent, and the piston pipe is used as a pumping device.

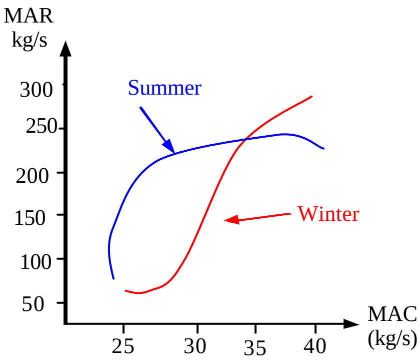
During the functioning of these pumps there appear considerable inertial forces which limit the rotative speed. Professional literature recommends that the speed regime should not overpass 300 rot/min



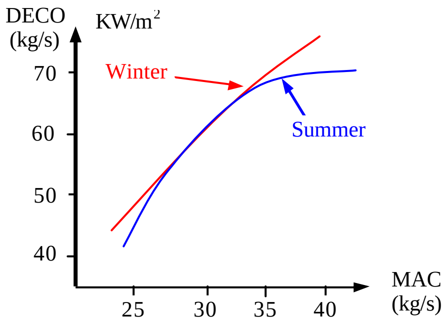
(a) (b)

(a) – the power obtained per unit of the condensation surface unit in function of the warm water flow capacity

(b) – The power obtained per surface of the vaporization unit in function of the warm water flow capacity, MAC



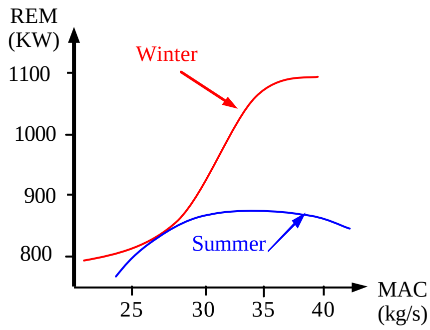
(c)



(d)

(c) The cooling water variation MAR, in function of the warm water flow capacity variation MAC.

(d) The CO_2 DECO flow capacity variation in function of the warm water flow capacity MAC.



(e)

(e) – The motor device power variation PEM, in function of the warm water flow capacity variation MAC

The liquid evolution in the pump during the aspiration phase is considered an isotherm evolution, and the pressure decreases in function of the pump rotative speed.

In order to avoid the biphasic area it is imposed that the pressure corresponding to the saturation state of the liquid phase pv, corresponding to the liquid temperature, be smaller or, at least equal to the pressure in the aspiration junction during the aspiration phase (equal with the limit pv), it is given by the relation:

$$n_{max} = \frac{30F'}{\pi F}\sqrt{\frac{p + vH_A - pV}{vI_A r}}$$

where: F' – the passing area from the aspiration pipe,

F – the transversal area of the cylinder,

l_A – the aspiration pipe length,

r – the radius of the pump turned shaft,

H_A – the aspiration height,

P – pressure at which is found the liquid pressure

V – the liquid specific weight

This relation allows to establish the maximal rotative speed of the pump if the pressure and liquid temperature are known, or the temperature at which the liquid must be sub cooled being at a certain pressure for a given rotative speed of the pump.

The difference between the enthalpy of the saturation state of the liquid phase under pressure and that of the liquid state under the same pressure represents the heat quantity yielded by 1 kg of liquid in order to realize the sub cooling. This quantity of heat is transmitted to a supplementary flow of the cooling agent which is so coupled that it heats with the same temperature interval as the cooling agent that realizes the condensation of the vapors extended in the motor device.

According to Mercer, Faust and Pinder (1974) the additional relations necessary in the examination of the parameters from equations 1 and 2 contain:

(1) porosity as temperature function only;
(2) the average density of rock granules, treated as a constant;
(3) the rock enthalpy judged as a temperature function;
(4) the viscosities judged as temperature functions;
(5) the relative permittivity as a saturation function;
(6) the thermal dispersion phenomenon treated like an environment feature.

The implicit of the upper development is the hypothesis that the geothermal liquid can be treated as a pure and watery system. For geothermal fields with high salinity, this supposition is not valid.

Unfortunately, for a correct calculation of chemical species transportation, kinetic reactions data are not available. More than that, partial differential equations which must be included into such a formulation, would produce a model which would be non performantly used.

There is however, a method to avoid these difficulties in the case of systems with high salinity or with hot water; the thermo dynamical state equation for pure water, must be modified taking into consideration the solid – fluid interactions.

Using the same concentration and the equations adequately modified, we won't need significant changes in the mathematical model already present.

A numerical model used to solve the equations 1 and 2 combines for the spatial solution Calekin's finite elements approximation with a finite differential approximation in time. This method is well differentiated in Zienkiewicz (1971) and Mercer (1973) gives details of this approach applied to equations similar to 1 and 2. Further on we will make only a short presentation of this method.
The partial differential equations 1 and 2, are transformed in order to approximate the integral equations using a method of the finite elements.

The dependent variables p and h are approximated using the polynoms on sections and thus the problem comes to find the polynoms coefficient.

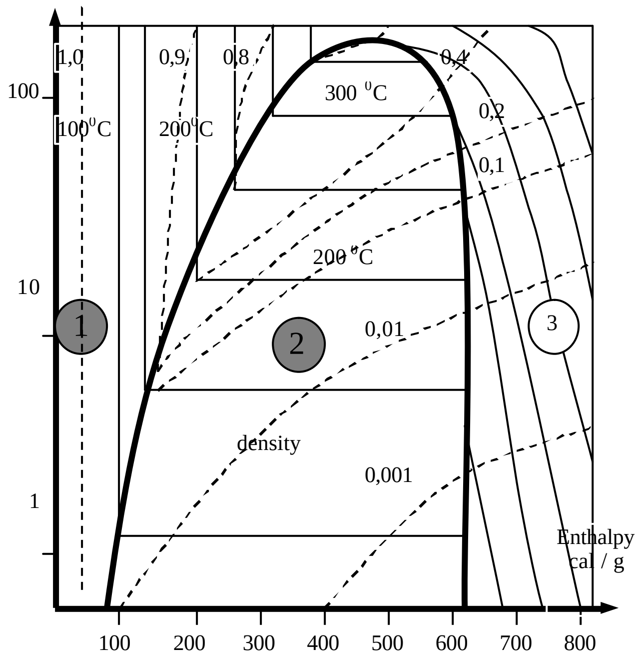


Figure 3. The pressure – enthalpy diagram for pure water, showing the thermo dynamical regions between the critical point of parabola.

(1) Compressed water
(2) Double phase water – vapor
(3) Overheated vapor.

In order to apply the finite elements method, the interest area must be divided in sub fields called finite elements, which are connected through modal points. The model is designed for high coordinated elements, the linear elements being used for one dimensional problem. The linear polynoms are in this manner and the enthalpy is determined in the crucial points.

In the case of the problems depending on time, there is a common practice, that is to approximate the derivate in time through different methods of differentiation.

Galerkin's finite elements method offers more advantages, because the thickness of the finite elements may be arbitrary. This method offers a good approximation of the internal and external edges.

It has been proved that for the linear problems which suppose thin fronts the finite elements method offers better possibilities than the finite differential method.

It is also possible to present the partial differential equations coefficients which vary in space (for instance: permeability and density).

Conclusions: One of the special problems of geothermal electrical plants, for which at least one of the isobaric processes of thermodynamic cycle of function crosses the biphasic zone, is the correlation of the rotative speed of the piston pump, for the liquid phase of working agent, in order to avoid reaching the biphasic zone in the active elements of the pump, as a result of the pressure decrease in the aspiration phase.

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