FUNDAMENTAL STUDY OF CHANGING OF PHASE IN POROUS MATERIALS

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The research program on geothermal energy developed in our laboratory for the last two years is mainly focussed on the fundamental problem of changing of phase in porous media.

In this report I would like to discuss two points: the main objectives of this program and our current activities.

Statement of the Problem

A high energy geothermal system is generally defined as an aquifer in which thermodynamic conditions, i.e., pressure and temperature, are relatively important and thus may be used to produce mechanical and electrical energy.

A number of studies have been conducted during the last ten years to understand the existence of hot temperature geothermal fields; convection is now recognized as one of the main causes.

The effect of convection is to induce an important upward head flux and therefore very high temperatures in the upper part of the reservoir.

The heat accumulation in the upper part of a geothermal field, i.e., the stored energy, is composed of two parts:

(1) The energy stored within the solid phase. This is generally the more important aspect, and

(2) The energy stored within the fluid phase.

Although during production only the f uid is recovered, due to changing of phase in the reservoir, heat transfer occurs between the solid matrix and the fluid phase. It is therefore evident that solid contr bution to the vaporization may be considered as most important as far as the recovery of energy and the thermodynamic evolu ion of the reservoir are concerned.

This problem of heat transfer between the porous matrix and the fluid is particularly important in the case of a fissured medium with large block dimensions, which often occurs in geothermal fields. In that case it is unrealistic to assume an equilibrium temperature between the fluid and the matrix blocks while the fluid is flowing and changing of phase within the fissures is taking place. The best we can do is to try to define a mean heat transfer between the rocks and the fluid. If the blocks are microporous, the problem is very similar to that of heat transfer with changing of phase in a dispersed medium. This is the problem we are interested in.

Mathematical Model, Dimensionless Parameters

In a first approach, by making the following assumptions:

a. Rigid porous media
b. Capillary effects negligible
c. Negligible compressibility work
d. Steam is considered as a perfect gas
e. Equilibrium Temperature between the fluid and the solid.

The governing equation may be written as

Mass continuity equation, heat transfer equation and the pressure equation

Dimensional analysis from these equations leads to dimensionless qualities, taking into account the influence of

- Porosity
- Nature of porous medium
- Grain-size or pore diameter
- Initial conditions
- Boundaries conditions

This model will be tested and used to determine experimental correlations by using the data obtained on an experimental model which is described next.

Experimental Model

This model is one dimensional with a circular section of 5 an diameter and a length of two meters. To avoid perturbating influences in the production section it is constituted of two symmetrical parts so the temperature gradient in this section is equal to 0 and then no ends effects can modify the steam quality.

The porous media is set inside an insulating envelope and an outside metal cylinder maintains the pressure and ensures controlled heating.

The fluid is injected into the porous media and maintained under pressure, saturation (gamma ray absorption), mass balance and steam quality (condenser).

By using these results and having defined the heat transfer from envelope to the porous media (this parameter takes an important place in the energy balance), we will determine (1) the porous material contribution to the vaporization, and (2) the ossibilities of testing the mathematical model.

The experimental mode is now almost finished and a simple numerical model has been established to est mate the heat transfer from the envelope to the porous media.

We have obtained a qualitative simulation of the effect, in the example where saturation is uniformly varying in the porous media.