SGP-TR-20-41

PROCEEDINGS
SECOND WORKSHOP
GEOTHERMAL RESERVOIR ENGINEERING
December 1-3, 1976

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Stanford Geothermal Program
Workshop Report SGP-TR-20*

*Conducted under Grant No. NSF-AER-72-03490 supported by the RANN program of the National Science Foundation and Contract No. E043-326-PA-50 from the Geothermal Energy Division, Energy Research and Development Administration.

DISCLAIMER

STATUS OF MODELING EFFORTS FOR THE WAIRAKEI GEOTHERMAL FIELD

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The theoretical model used in this study is based on an approach that combines the mass, momentum and energy balances for steam and water into two partial differential equations in terms of the dependent variables, pressure and enthalpy. The assumptions used in this formulation and the detailed development of the equations are presented in Faust (1976). The resulting two- and three-dimensional equations are approximated by finite-difference expressions, and are solved using either direct or iterative matrix techniques.

To simulate the production behavior of the Wairakei geothermal field we have chosen a two-dimensional, areal model. Although a three-dimensional model has been developed for applications to field problems, it is preferable to use two-dimensional models whenever possible, in order to avoid excessive data preparation and computing expense. The two-dimensional, areal model is obtained by partially integrating the pressure-enthalpy equations in the Z-dimension. The resulting two-dimensional equations are thus defined in terms of vertically averaged quantities. In averaging these quantities, it is generally assumed that either (1) the fluids have no segregation, or (2) the fluids are completely segregated.

If the fluids are assumed not segregated, then a further simplifying assumption is generally made: that their properties are uniform throughout the thickness of the reservoir. This leads to the easiest evaluation of the vertically averaged terms, since laboratory determined relative permeability curves may be used in the simulation. However, this assumption is very restrictive as it limits the application of the averaged equations to very thin reservoirs or to laboratory experiments.

The assumption that the fluids are completely segregated is less restrictive. It requires that the fluids are in vertical equilibrium. This concept was first introduced in the petroleum literature by Coats, Nielsen, Terhune and Weber (1967) for the reservoirs having a large capillary transition zone. It was later modified by Coats, Dempsey and Henderson (1971) for reservoirs with a small transition zone. The latter case is similar to the conditions in a geothermal reservoir in which a steam cap (or steam-water mixture at the residual water saturation) exists. In applying the concept of vertical equilibrium it is assumed that the fluid potentials are uniform throughout the reservoir thickness. This corresponds to a gravity segregated fluid distribution with the potential of each fluid being uniform in the portion of the column occupied by that fluid, and requires that the reservoir has good vertical communication. Use of the assumption of vertical equilibrium and of the additional assumption of a relatively uniform temperature distribution throughout the thickness of the reservoir, permits relationships to be derived for vertically averaged fluid properties as functions of average pressure and enthalpy.

To demonstrate the applicability of this approach to solving field problems, we used our areal two-phase model to simulate the geothermal system located at Wairakei, New Zealand. The Wairakei field was the first hot-water hydrothermal system to be utilized for the generation of electricity. Power generation began at Wairakei in 1958, and by 1968 the power stations at Wairakei were providing 192 MW, or approximately 18% of the total electrical requirements of New Zealand's North Island. Although it is believed that the field was originally all hot water, by 1962 lower portions of the reservoir, where most development is occurring, had become two phase and upper portions probably became two phase much earlier.

Our conceptual model of the Wairakei system is basically the same as that outlined in Mercer, Pinder and Donaldson (1975), with the exception that we now allow for mass leakage through the bottom of the reservoir. The Wairakei hydrothermal system is considered to have been at steady state prior to exploitation. The first step in modeling the Wairakei field is therefore the reproduction of the observed virgin or steady state conditions. These results will be used as the initial conditions for the transient model of exploitation. In order to reproduce the steady-state conditions, the following geological and hydrological data are necessary: 1) isopachs of the unconfined aquifer, the Huka Falls confining bed, and Waiora aquifer, where development is occurring; 2) structure map of one of these layers; 3) initial temperature and pressure distributions; 4) parameters such as permeability, porosity, and thermal conductivity for the aquifer and confining bed; and 5) aquifer discharge measurements.

The results of the steady state simulation are used as initial conditions for the transient model. This modeling effort represents an ongoing project, and the results to be presented will describe the current status of our Wairakei simulation.

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