SUMMARY OF OUR RESEARCH IN GEOTHERMAL RESERVOIR SIMULATION

Charles R. Faust and James W. Mercer
U.S. Geological Survey
Reston, Va. 22091

Our research effort has concentrated on developing theoretical and numerical models for the purpose of simulating geothermal reservoirs. The first heat-transport model we developed was single-phase (liquid water), two-dimensional (areal), and was based on the Galerkin, finite-element method. This model was applied to the Wairakei geothermal field, which we were able to simulate until approximately 1962 at which time the reservoir became two-phase.[1]

More recently we have formulated the equations of two-phase (steam-water), heat transport in terms of enthalpy and pressure.[2] Formulation of the basic mass, momentum and energy balances in terms of fluid pressure and enthalpy yields two nonlinear, partial differential equations that are valid for both liquid- and vapor-dominated hydrothermal reservoirs, as well as for reservoirs that may include both single- and two-phase regions. In addition, this formulation eliminates the interphase condensation terms.

Solution of these equations is performed using both finite-element and finite-difference techniques. The finite-element method is capable of using higher order elements, including Hermite cubics. Also, Newton-Raphson iteration may be used in both models (finite-difference and finite-element).

Model results for one- and two-dimensional problems have been compared with both analytical solutions and laboratory results.[3] Hypothetical problems have been simulated and a sensitivity analysis of some parameters has been made.[4] Results of these numerical experiments have given insight into the question of which numerical techniques are suitable for a particular geothermal reservoir problem. Based on these results, work on extending the Wairakei simulation has been initiated.

REFERENCES

1. Mercer, J. W., G. F. Pinder, and I. G. Donaldson: "A Galerkin-Finite Element Analysis of the Hydrothermal System at Wairakei, New Zealand," J. Geophys. Research (1975) 80, No. 17, 2608-2621.

2. Mercer, J. W., and C. R. Faust: "Simulation of Water- and Vapor-dominated Hydrothermal Reservoirs," paper SPE 5520 presented at 50th Annual Fall Meeting of Soc. of Pet. Eng. of AIME, Dallas, Texas, Sept. 28-Oct. 1, 1975.

3. Faust, C. R., and J. W. Mercer: "An Analysis of Finite-Difference and Finite-Element Techniques for Geothermal Reservoir Simulation," paper SPE 5742 to be presented at 4th SPE Symp. on Numerical Simulation of Reservoir Performance, Los Angeles, CA., Feb. 19-20, 1976.

4. Faust, C. R., and J. W. Mercer: "Mathematical Model of Geothermal Systems," paper presented at 2nd UN Symp. on Development & Use of Geothermal Resources, San Francisco, CA., May 20-29, 1975.