Parameter Identification Within Rocks Using Genetic Algorithms

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Abstract

Transient flow analyses have numerous geophysical and geotechnical applications and they are necessary for the understanding and development of laboratory measurement techniques in rock and soil mechanics, particularly in the determination of the permeability of substances. In this paper, we formulate a Genetic Algorithm inversion technique for the retrieval of homogeneous or spacewise dependent material property coefficients.

1 PROBLEM DESCRIPTION

The accurate determination of the hydraulic conductivity of rocks is a problem frequently encountered within petroleum, civil and mining engineering. In this paper we deal with low permeability rock testing and the 'pump flow method' is employed. A cylindrical rock sample is placed in a sealed pressure cell and the permeability is measured by injecting fluid at a constant rate into the inflow end of the rock sample, see Olsen *et al.* (1991). The transient pressure response can be used to obtain information about the permeability and storage properties of the sample. Here we make use of the numerical results of Lesnic *et al.* (1997) and the formulation models a heterogeneous single piece of material, as well as incorporating the presence of a fault within rocks.

The Genetic Algorithm process optimises a fitness evaluation function which measures the accuracy of predicted pressure and/or hydraulic flux values against some known (simulated or experimental) measurements. We employ k-Tournament Selection and Two-Point Crossover.

The governing equations of mass conservation equation and Darcy's law are combined with an equation of state for the pore fluid and appropriate boundary conditions. The numerical method adopted for solving the initial boundary value direct problem is a time weighted average finite-difference method.

Both exact and simulated noisy data are incorporated at optimally selected instants in time through the test, the data measurements used being consistent with sensitivity analyses of each problem.

2 RESULTS AND CONCLUSIONS

The present research has established that GAs are a feasible technique for retrieving highly accurate estimates to unknown material parameters in hydraulic pump flow experiments based upon both exact and noisy data. When a composite sample is investigated, the hydraulic conductivities and fault location can be retrieved from the steady state analysis based upon pressure measurements at the upstream face and one port combined with an interchange of the sample ordering. With these quantities specified, the material specific storages and the compressive storage of the upstream reservoir can be readily determined from transient pressure values at the upstream face combined with a reversal of the order of the samples.

References

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