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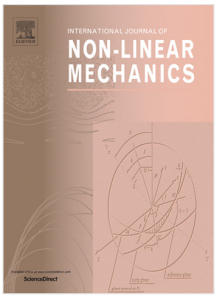

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Group invariant solution for a fluid-driven permeable fracture with Darcy flow in porous rock medium

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Abstract

Group invariant and numerical solutions for the evolution of a two-dimensional fracture with non-zero initial length in permeable rock and driven by a laminar incompressible Newtonian fluid are obtained. The fluid leak-off into the rock mass is modelled using Darcy law. With the aid of lubrication theory and the PKN approximation, a system of nonlinear partial differential equations for the fracture half-width and the extent of leak-off is derived. Since the fluid-rock interface is permeable the nonlinear diffusion equation contains a leak-off velocity sink term. Using the Lie point symmetries the problem is reduced to a boundary value problem for a system of second order ordinary differential equations.

Keywords: Lie point symmetry, Darcy flow, Nonlinear diffusion, Lubrication theory, PKN hydraulic fracture .

1. Introduction

Hydraulic fracturing is a process by which the injection of a viscous fluid under high pressure into a geological formation causes the development and propagation of fractures in rock. The propagating fractures are either man-made created by injecting a viscous fluid from a bore-hole into the subsurface reservoir rock in order to extract shale gas and to increase petroleum production, or natural fractures such as kilometers-long volcanic dykes driven by magma coming from the upper mantle beneath the earth crust [1, 2, 3, 4, 5]. Indeed, engineering applications of hydraulic fracturing technology include reservoir simulation, underground caving operations, tunnel and dam construction and rock burst mitigation amongst others. As a result, a number of mathematical and numerical models have been developed to help predict the extent of fracture growth in the complex and variable geological conditions under which oil extracting operations takes place [6]. Despite the significant progress