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Development of Critical Hydraulic Gradient Criterion for Onset of Non-linear Fluid Flow through Rock Fractures and Deviation from Darcy's law

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Extended Abstract: The aim of this paper is to develop a quantitative and easy-apply criterion for determination of threshold state of non-linear flow onset. To reach this goal, a quantitative criterion so-called "Critical Hydraulic Gradient" was developed based on the comprehensive combination of Forchheimer's law and Critical Reynolds number. A set of laboratory flow-stress-displacement experiments were performed and then, the results of non-linear fluid flow were analyzed based on the developed criterion. The results of this study show that the Forchheimer's law was fitted very well to experimental results of non-linear fluid flow through rough-walled fractures and it can be demonstrated that the Forchheimer's law can probably be applied over the entire range of flow rates where it effectively reduces to Darcy's law at low flow rates. Moreover, in most of the cases, the critical Hydraulic Gradient is lower than 25, where this range of hydraulic gradient occurs during operation conditions in hydrocarbon reservoirs. Based on the results of this paper, it can be concluded that, the regime of fluid flow is non-linear in most of the fractured hydrocarbon reservoirs and Darcy's law will be associated with considerable miss predictions.

Key words: *Hydraulic Gradient, Non-linear Fluid, Rock Fractures, Darcy's law*

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