Impact of Heterogeneous Fracture Aperture on the Well Productivity of Deformable Fractured Porous Media

Several hydrocarbon production wells in the North Sea reservoirs suffer from productivity reduction during primary production. Since the affected reservoirs are highly fractured, closure of natural/induced fractures around wells, due to an increase in effective stress is expected to be one of the main reasons for this reduction. Traditionally, the fracture conductivity is determined by its aperture through a cubic law. While the fracture aperture is commonly assumed either constant or uniformly distributed, it is well-known that the aperture distribution is heterogeneous and changes with varying contact stress at each point on the fracture surface. This heterogeneous aperture field can affect the flow performance, and fracture aperture evolution due to thermo-poroelastic stresses.

Moreover, variance, prior distribution, and correlation length, which are used to populate the heterogeneous field, can further enhance this effect. Hence, this study aims to investigate and highlight the impacts of fracture aperture variation, including initial stage and deformed behaviour, on the well productivity through a conceptual steady-state single-fracture reservoir. Coupled solid deformation and fluid flow in porous media is modelled utilising Complex Systems Modelling Platform (CSMP), an object-oriented application programme interface. The investigation is separated into three main parts: (i) the effect of variance, (ii) the effect of prior distribution length, and (iii) the effect of correlation length/angle on well productivity index. Moreover, the comparison among the calculation of the well productivity using the homogeneous, heterogeneity aperture field, and its arithmetic average is also investigated. Taking into consideration the limitations and assumptions made in this study, the following findings are drawn: (i) well productivity tends to be higher when the heterogeneity aperture field is introduced than the homogeneous and arithmetic average ones, (ii) this effect is enhanced when the variance is increased, (iii) there is not much difference between the well productivity results when different prior distributions, i.e. uniform, normal, and log-normal distributions, are utilised, (iv) the increase in the correlation length that perpendicular to the well direction enhances the productivity of the system, and (v) the increase in the correlation length that parallel to the well direction hinders the productivity of the system.

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