Contribution ID: **209** Type: **Oral Presentation**

A New Numerical Well-Test Model Using an Analytically Modified Embedded Discrete Fracture Model

Tuesday, 14 May 2024 11:25 (15 minutes)

The technology of multi-stage, multi-well pad fracturing is an effective way to increase the stimulated volume and recoverable reserves in shale reservoirs. During the fracturing treatments, there are common phenomena of well interferences from the multi-well pad. However, there still lacks an effective tool to analyze the parent-child interactions and to evaluate the fracture parameters quantificationally. To narrow this gap, a numerical pad-well model is developed for pressure transient analysis in fractured horizontal wells with secondary fractures and well interferences, based on a discrete fracture model (DFM) and unstructured PEBI grid system.

Using methods of automatic differentiation and Newton iteration, the proposed model is more efficient for computations and interpretations of well testing curves. Its accuracy and practicality have been demonstrated by model verifications and field applications. The results show that the flow regime of interference effects caused by parent-child interactions are more obvious, with a larger child-well production, a smaller well spacing, and a larger hydraulic-fracture angle. The well interferences are also stronger when the child well has more secondary fractures, longer secondary fractures, and higher fracture conductivity, as the pressure drop caused by child well will propagate more quickly. Once the complex fracture networks have developed within the multi-well pad, the interactions between parent and child well will be weaker with the increase in area and conductivity of fracture networks. By comparison, the pressure transient behaviors of Parent well are remarkably affected by Child-well production rate, well spacing as well as connectivity degree. However, the angle, length, number, and conductivity of secondary fracture have weaker impacts on the pressure transient behaviors of Parent well. The field application shows that the single-well testing model without considering well interference cannot match with field data at the late stage. In this case, the estimation errors will occur. With considering the well interferences, the well testing data are interpreted and the fracture parameters are evaluated successfully. This work provides a meaningful way to understand the pressure transient behaviors and to evaluate the fracture parameters of multi-stage, multi-well pads.

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Session Classification: MS03

Track Classification: (MS03) Flow, transport and mechanics in fractured porous media