Ultra-fast hydraulic fracturing model for multi-well simulations

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Hydraulic fracture models are developed to satisfy the industry needs to simulate and to better understand processes that occur underground with the purpose of optimizing productivity of the well(s). Early models were developed for single bi-wing fractures, such as KGD model, PKN model or pseudo-3D model. With the development of computational resources, trends have shifted towards more computationally expensive fully planar fractures and have an ability to capture lithology more accurately. Current industry needs have shifted again towards having an ability to propagate multiple fractures per stage simultaneously, propagate fractures in multiple stages and from multiple wells, account for stress shadow between the fractures within the stage and between the stages and wells, include the effect of the depletion zone of the neighboring well(s), capture natural fractures and bedding interfaces, incorporate small-scale variations of properties, etc. Clearly, the complexity of the problems has increased by orders of magnitude and in response, so have the numerical simulators.

There are numerous commercial and academic hydraulic fracturing simulators that are trying to address these problems. In most cases, the trend is to include more detail in the simulations and to apply more computational power to solve the problem. While this approach allows interaction of one (or multiple) phenomenon at a time, it quickly reaches computational bottlenecks for practical applications. In other words, one may use an advanced hydraulic fracture simulator to simulate a stage or several stages within a reasonable amount of time. But when it comes to pad-scale development with tens of wells and hundreds of stages, it becomes less practical due to computational costs and time constraints. In addition, there might be a need to have an ability to do real-time hydraulic fracture modeling during the field treatment and to be able to simulate several scenarios such as adjusting pumping schedules immediately in response to a given event in the field data. Such an application is hard to satisfy with highly complex models. To provide an alternative, a conceptually different approach is introduced in which only the essential pieces of the computations are retained and in return an ultra-fast hydraulic fracturing simulator arises.

The developed ultra-fast hydraulic fracturing simulator has been thoroughly tested against existing solutions for radial fracture in all regimes, for a single planar fracture propagating in various lithologies and generated by various pumping schedules, as well as for multi-well multi-stage scenarios. Several examples are presented to illustrate capabilities and potential usage of the ultra-fast simulator.