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Determining Optimum Well Spacing Using Completion Characterization in Unconventional Reservoirs

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Abstract

Early in the development of a shale gas resource, optimal well spacing remains unknown as wells are sparsely drilled to hold leases by production. Developing the acreage requires operators to select locations, specify drilling plans, and design completions for multi-stage horizontal wells to maximize the operating metrics as defined by the company.

This presentation builds on our earlier work which presented sensitivity analysis for optimal well spacing with respect to permeability, fracture spacing and half-length under the assumption of uniform and symmetric completion configurations. The well spacing sensitivity to heterogeneity in completion configurations (i.e., non-uniform fracture half-length, asymmetric fracture spacing and SRV overlap) are presented in this paper using deterministic modeling and stochastic modeling approaches.

Deterministic modeling results show a strong bias towards the longest repeated fracture half-length in determining the optimal well spacing. Higher reservoir permeability abates the impact of fracture heterogeneity. Fracture modeling, con-strained by production logs, temperature logs, and/or micro-seismic, can be used to aid in the identification of the longest repeated half-length.

This work demonstrates the challenges associated with stochastic modeling of well performance. Examples from synthetic and field case studies are presented to illustrate uncertainty in reservoir and completion parameter determination. The spacing optimization workflow used captures this uncertain range to effectively determine the impact on recovery factor and Net Present Value (NPV). The importance of the quantity of production history needed to determine optimal well spacing is also presented. Results reveal that with increasing heterogeneity longer production history is required for reliable determination of optimal well spacing. A field case study ap-plying fracture modeling is examined to identify the impact of non-uniform fracture spacing and fracture half-length heterogeneity.

This work shows the impact of changes in reservoir properties such as permeability, completion properties as fracture spacing and completion footprint or the areal configuration of the stimulated reservoir volume (SRV) in determining optimal well spacing.

As additional development or infill wells are drilled in a section, the possibility of SRV overlap increases. When the stage/cluster placement is not staggered between the neighboring wells, the created fractures may intersect resulting in SRV destruction i.e. the fracture area accessible to the neighboring wells is less than the total fracture area created in absence of SRV overlap. With staggered placement of stages, the created fractures are at an offset and the SRV's overlap without the fractures intersecting. This results in accelerated depletion of the region between the wells by reducing the rock volume each hydraulic fracture has to drain. Thus, the neighboring wells rob some late life production potential by draining the reservoir within the study well drainage volume.

The impact of the percentage of fracture overlap, fracture spacing, and reservoir permeability on overall recovery and economic value is evaluated using synthetic models. For the scenario of SRV destruction, the NPV decreased with increasing SRV overlap. With staggered placement of fractures, there is a minor loss in NPV for less than 50% SRV overlap under the economic constraints considered. Higher than 50% overlaps may be detrimental depending on permeability and fracture spacing. Changes in cost/economic constraints also impact optimal well spacing for SRV overlap.

These conclusions, via the application of deterministic and stochastic modeling on production from field cases and synthetic wells, will aid operators in answering the multi-billion dollar question: how many wells should be placed in a given area? The workflow described in this presentation not only can answer this question but also help operators considering planning closer well spacing by optimizing capital expenditures and hydrocarbon recovery.