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Multivariate Analysis of Completion Design Parameters and their Effects on Effective Fracture Volume

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Summary

Hydraulic fracturing is one of the most important processes for developing tight oil and gas reservoirs. A key challenge in hydraulic fracturing is how to optimize fracturing/completion design parameters to enhance hydrocarbon production. To answer this question, we need to understand and develop correlations that explain how completion design parameters affect the efficiency of fracturing treatment. Therefore, the objective of this study is to perform a multivariate analysis of completion design parameters and effective fracture volume.

Theory / Method / Workflow

We propose a workflow that uses flowback data analysis to estimate effective fracture volume and relate it to completion design parameters for 16 shale gas wells and 6 oil wells completed in Eagle Ford formation. First, we apply rate-decline analysis to estimate initial effective fracture volume. Second, we estimate the fracture-volume loss during flowback using an iterative method involving fracture compressibility and fracture porosity. Third, we use multiple linear regression to quantify the relationship between the effective fracture volume and key completion design parameters. These parameters include total injected water volume (TIV), proppant concentration, gross perforation interval (GPI), pumping rate, and extended shut-in time. We also evaluate the effects of flowback strategy on fracture volume loss by comparing it with choke-size change.

Results, Observations, Conclusions

Figure 1 shows the sensitivity of initial effective fracture volume to each completion design parameter. It shows that proppant concentration and GPI are the key completion design parameters for creating a large fracture volume. Shut-in time, total vertical depth and injected water volume per foot have less effect. **Figure 2** shows the effect of completion design parameters on fracture-volume loss (i.e. closure rate). It suggests that proppant concentration is the key parameter controlling fracture-volume loss. **Figure 3** compares the fracture-volume loss to choke-size strategy during flowback. It shows that increasing choke size leads to a significant loss in fracture volume during early-time flowback, while it has negligible effect on fracture-volume loss at late-time flowback.

Novel/Additive Information

In this study, we introduce empirical correlations between completion design parameters and effective fracture volume. The outcomes improve the understanding of how completion-design parameters affects the effective fracture volume. Also, this study should help oil and gas operators optimize fracturing design parameters and enhance efficiency of hydraulic fracturing treatment.

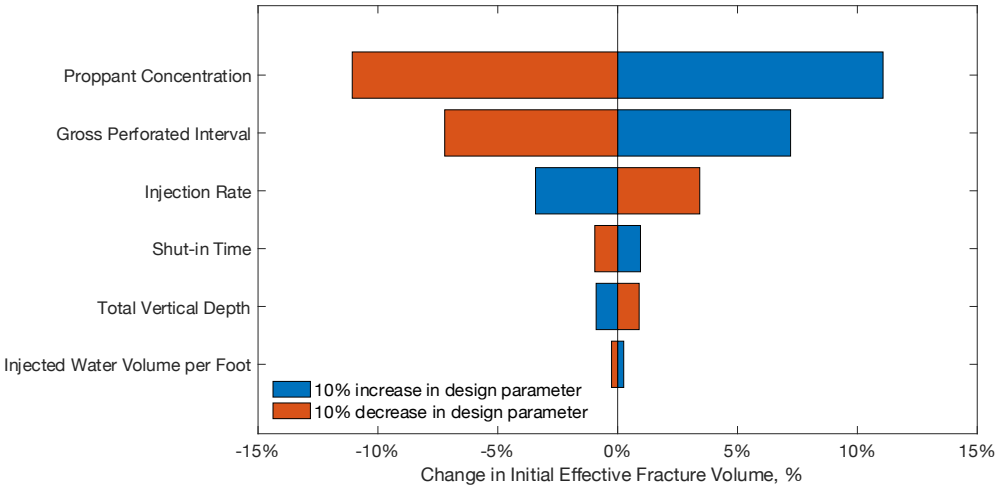

Figure 1 Sensitivity of initial effective fracture volume to 10% change in completion design parameters. Increasing proppant concentration by 10% increased initial effective fracture volume by 11.1%. 10% increase in gross perforated interval increased fracture volume by 7.2%. While 10% increase in injection rate reduced fracture volume by 3.4%. Shut-in time and total vertical depth have less effects. Injected water volume per foot has insignificant effect.

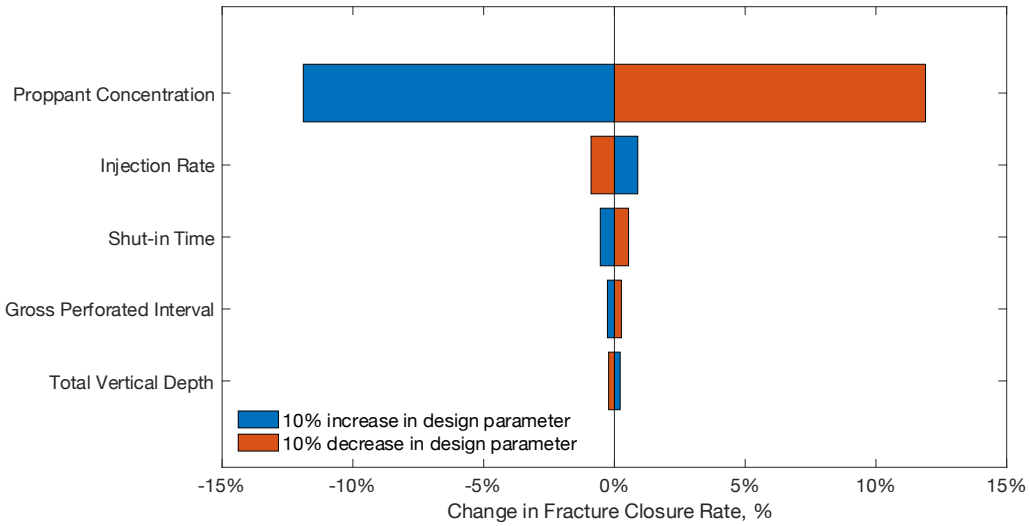

Figure 2 Sensitivity of fracture closure rate to 10% change in completion design parameters. Proppant concentration has the most significant effect of fracture closure rate which decreased by 12% when proppant concentration increased by 10%. Other completion-design parameters have insignificant effect.

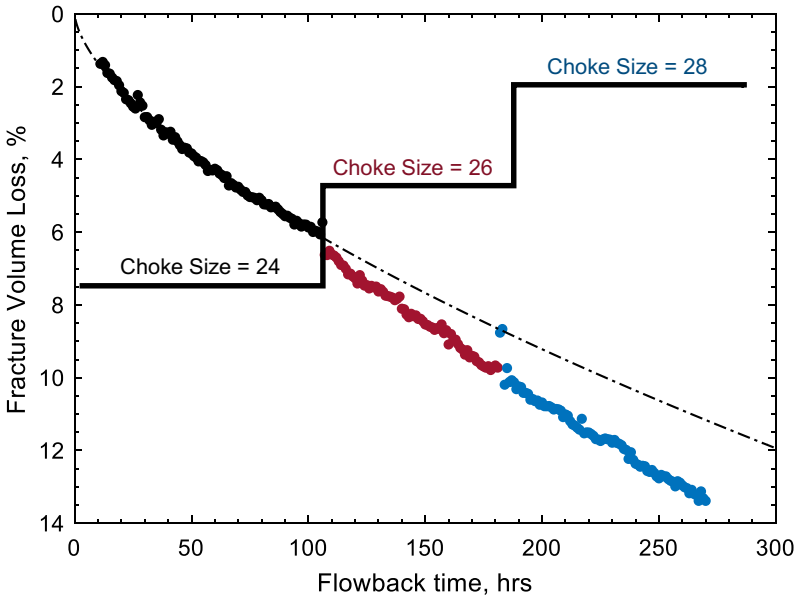

Figure 3 Comparison of fracture volume loss with choke-size showing a sudden drop in fracture volume when changing choke-size from 24 to 26, while the effect of changing choke-size on fracture volume is negligible during late flowback. Modified from (Moussa, Dehghanpour et al. 2019)

References

Moussa, T., H. Dehghanpour, Y. Fu and O. Ezulike (2019). Dynamic Fracture Volume Estimation using Flowback Data Analysis and its Correlation to Completion-Design Parameters. SPE Hydraulic Fracturing Technology Conference and Exhibition. The Woodlands, Texas, USA, Society of Petroleum Engineers: 23.