Challenges in modelling of hydraulic fracturing in low-permeability coal seams with complex cleat networks and stress regimes

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Introduction

Hydraulic fracture simulators are essential for the design and evaluation of stimulation treatments, however, most recent modelling advancements are focused on shale reservoirs. Despite significant improvements for shales, the special characteristics of hydraulic fracture treatments in coals have been overlooked and require more research. For instance, complications arise during hydraulic fracture treatment of cleated coals, particularly in the complex stress regimes in Eastern Australian Basins (Flottman et al. 2013, Johnson et al. 2010). These effects are overlooked or oversimplified in hydraulic fracture simulators, resulting in ineffective stimulation design and evaluation.

The ability of existing commercial and new-generation hydraulic fracture models to manage low permeability, naturally fractured (NF) or cleated coal seam gas (CSG) reservoirs in non-normal stress regimes need further research and improvement.

Aims

This study compares the existing hydraulic fracture models for their adeptness in simulation of hydraulic fracturing in CSG reservoirs. The study focusses on the following:

- Numerical methods used for modelling of fracture growth and behaviours of rock and fluid flow;
- Effect of natural fractures on hydraulic fracture growth in low-permeability reservoirs;
- Simultaneous growth of hydraulic fractures in unconventional reservoirs; and
- Inclusion or representation of natural fractures in hydraulic fracture models.

Benefits of study

This study will contribute to the development of best practices and improved hydraulic fracture models that can better inform operational decisions regarding production from low-permeability coals and ultimately the conversion of currently classified contingent resources to reserves.

Comparison of existing models

Software / Model (Owner)	Solution method	Design capability	Three dimensional	Horizontal well	Multiple HF (stress shadowing)	Non-planar HF Growth	Mixed-mode HF/NF	Inclusion of natural fractures	Matrix Leak-off	proppant transport	Pumping schedule	Non-newtonian fluid	Post frac production	Economics optimization	Time / resource efficiency
StimPlan P3D (Premier), FracProPT (Carbo), FracCade (Slb)	P3D								Carter						
StimPlan 3D (v8) (Premier)	FEM							Leakoff& storage		Multiphase			Single phase with DFN		
GOHFER (v9) (Barree)	FDM						Decoupled	Leakoff& storage							
Kinetix Shale (Slb)	P3D, 3D FEM							Mathematical representation							
MFrac 3D (BHGE)	DFN							Mshale							
ResFrac (McClure)	DDM, FV												Compositional		
FracMan (Golder)	FEM, Empirical														
ELFEN tgr (Rockfield)	FDEM								Carter						
3DEC (Itasca)	DEM														
PFC3D (Itasca)	DEM														
Xsite (Itasca)	DEM														
TOUGH-FLAC (Berkeley-Itasca)	FEM														
Y-Geo (Academic)	FDEM, CZM														
CSIRO	Semi analytical , FEM		2D, P3D and 3D												

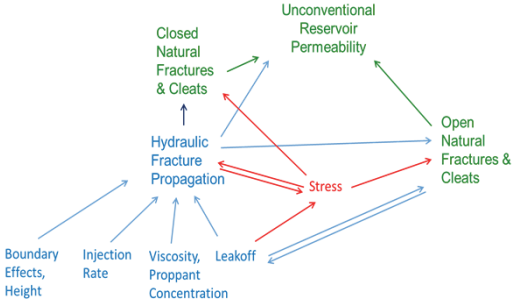
capable | Some capabilities | Limited or no capabilities

Conclusions

- Existing advanced hydraulic fracture models and codes are improving their capabilities in handling multi-stage fracturing in naturally fractured unconventional reservoirs. Most recent upgrades offer new features that are mostly applicable to stimulation of shales. This is particularly the case for North America where a normal stress regime is prevalent.
- Explicit inclusion of natural fractures in hydraulic fracture modelling becomes difficult because of uncertainties in the characterisation of natural fracture networks.
- There are substantial time and computational costs in effectively managing dynamic spatial discretisation. This includes Hydraulic Fracturing Naturally Fractured Reservoir (HF-NFR) interactions and closely-spaced, simultaneously growing fractures.
- New generation simulators or codes that are fully or partially-based on particle-based numerical methods demonstrate improved capabilities in handling these complexities, notwithstanding concerns on computational costs and time.

Recommendations

Further research is required to enhance the ability of existing commercial and new generation hydraulic fracture models for stimulation of coals, especially for low permeability coals in the Surat and Bowen basins of Eastern Australia. These studies should include a better understanding of the interrelationships between factors affecting the hydraulic fracture.



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