IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	Numerical and experimental investigations of complex fracturing in shale	
Project Number	**IMURA0643**	
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Research Academy Themes:

Highlight which of the Academy's Theme(s) this project will address?
(*Feel free to nominate more than one. For more information, see www.iitbmonash.org)*

1. Advanced computational engineering, simulation and manufacture
2. Clean Energy
3. Infrastructure Engineering

The research problem

Shale is now commonly exploited as a hydrocarbon resource. Due to the high degree of geochemical and petrophysical heterogeneity in shale reservoirs, there is a growing need to find more efficient methods of extracting shale gas and petroleum compounds (crude oil, natural gas, bitumen) from potential source rocks.

Both experimental and simulation works are key to resolving the understanding of these rocks. Using the experiments, we can replicate the sub-surface conditions in the laboratory and monitor the initiation and the evolution of fractures in shale. Further, numerical modeling will enable us to upscale the conditions and provide with real time analysis and prediction capabilities.

A three dimensional fracture modeling using FEM methods and its analysis, for instance, variation in permeability of select Indian shale on treated with optimized hydraulic fracturing for augmenting

production, improving productivity and life of a well. It is worthy to note here that fracture analysis and permeability variation at the micro-level would assist us in ascertaining several complex rock fracture fluid flow behavioral patterns as it is possible to extrapolate the micro-scale results to explain the macro level phenomenon. Studies based on visco-elastic and plastic deformation of rocks deformation, fracture analysis and their mechanisms, testing based on micro-scale fracture have piqued my interest. With improved FEM and XFEM based modeling, the flow patterns and fluid rock interactive behavior patterns can be studied to predict ground permeability through rock mechanics and fluid dynamics. The applications of computer modeling in this area in form of constitutive models on micro-scale elemental analysis will truly aid in predicting the macro-level phenomenon by integrating the micro-effects along with inclusion of suggestive and suitable assumptions.

Numerical modeling can provide predictions of fractures, its multiplication probability, rock stresses and their and the fluid flow behavior and enables to estimate possible chances to trigger the influential parameter for optimized and safe production of gas or oil from the reservoir of shale. This study aims to predict the fracture growth and behavior over certain parametric changes in variable inputs controlling or affecting fracture growth and directions along with stability. It also focuses on study of multi-level and distributed fracture networks along with natural and hydraulically made fractures.

Project aims

1. To study the effect of porosity and permeability over distribution of fractures and fracture networks developed during hydraulic fracturing.

2. To study the stress distribution, deformations and developed fracture network of resulting from hydraulic pressures and their interaction with natural existing fractures.

3. To investigate the possible flow parameters' and fracturing input parameters' influence in growth and development of fractures in shale reservoirs.

4. To optimize the parameters and the growth of fractures for efficient production and flow back from the well and fractures.

Expected outcomes

1. Improved understanding of the mechanisms of flow properties of fluids and gas through porous and permeable reservoirs of shale.

2. Helps to improve the permeability for efficient injection of fluids for fracturing and controlled process.

3. Improved understanding of induced and relative stresses at the surface and around the wells and zone of interest due to migration of fractures and flow of fluids.

4. Gives a tool to predict controlled growth of fractures in shale reservoirs so that the zone of interest and the other zones of risk can be handled efficiently.

5. How much fluid can be injected into a well and amount of gas / oil released from that well for the same injected fluid, can be predicted.

6. Understanding of porosity nature of shale beds and multiphase Darcy flow with diffusion of gas in the natural fracture system.

How will the project address the Goals of the above Themes?

This project addresses the themes like unconventional resources of energy, petroleum and rock sciences, infrastructure engineering, environmental engineering and advanced computational engineering, simulation and manufacture.

The output of the project will result in the quantitative description of fractures generated with the hydraulic fracturing method and possibilities of any chances of hydraulic fracturing in newer untested reserves. Prediction of stresses and deformations induced in the shale beds/ reserves will help to control the inputs during hydraulic fracturing (avoiding any damage to the formation) during gas / oil production from shale reserves.

Capabilities and Degrees Required

Should demonstrate capability in numerical simulation. Experience and knowledge on rock fracturing and rock mechanics is desirable.

Potential Collaborators

Please provide a few key words relating to this project to make it easier for the students to apply.

Shale Gas, Hydraulic Fracturing, Numerical Modeling