Hydraulic Fracturing Using GOHFER

Complete Course

Detailed outline based on the 12 course sessions. The categories below distinguish intended learning, software workflow, supporting engineering theory, and hands-on work.

Course progression: The instruction moved from foundational fracture-model assumptions to a complete vertical-well workflow, then to a single horizontal lateral, then to a full 3D multiwell pad with depletion and zipper-frac sequencing, and concluded with independent production-data analysis.

Session 1 — Course Framework, GOHFER Fundamentals, and Project Setup

Learning objectives

- Understand the course structure, example progression, and production-focused design philosophy.
- Differentiate GOHFER's measured, laboratory-validated approach from conventional linear-elastic fracture models.
- Recognize the distinction between a numerical simulator and the earth/well model supplied by the engineer.
- Create and configure the initial vertical tight-gas project.

GOHFER features demonstrated

- Software startup, version/build and license information, recent-project list, and local project storage.
- New-project creation; oilfield versus metric units; multiple-treatment-well option with transverse fractures.
- Project tree, treatment and reference wells, well survey, tubular data, well information, coordinate systems, and LAS/CSV input paths.
- High-level tour of petrophysics, DFIT calibration, treatment design, simulation output, production forecasting, production analysis, stress shadowing, 3D geomodel exchange, and batch/cloud execution.

Engineering theory discussed

- Limitations of linear-elastic fracture mechanics, PKN/KGD and pseudo-3D assumptions, compliance, fracture closure, net pressure, and fracture toughness.
- Process-zone stress as a reservoir-condition fracture-extension criterion measurable from DFIT data.
- Nonlinear and inelastic rock behavior; stress shadow evolution; poroelastic stress components and the role of pore pressure.
- Coupled fluid/proppant transport, realistic proppant conductivity, near-wellbore screenout, production transients, drainage volume, and effective versus gross fracture length.

Practical exercises performed

- Create the "Vertical Tight Gas" project in a local working folder.
- Select project units and the multiple-well/transverse-fracture configuration.
- Use the treatment well as both treatment and reference well; delete the redundant reference well.
- Review the default survey, enter the treatment-string ID, inspect tubular data, and begin importing the well log.

Session 2 — Vertical-Well Log Processing and Petrophysical Model Construction

Learning objectives

- Resume and manage an existing project efficiently.
- Understand how imported log curves are mapped, checked, corrected, and converted into modeled reservoir properties.
- Identify the minimum useful log suite and the uncertainty introduced by limited or indirect measurements.

GOHFER features demonstrated

- Opening recent projects, closing individual screens, map and directional-survey views, depth-scale controls, and automated log processing.
- LAS curve assignments and QC of density porosity, bulk density, neutron porosity, gamma ray, resistivity, and derived GOHFER curves.
- Synthetic corrected gamma ray and cascading recalculation of gamma-ray-dependent properties.
- Log display, curve editing, correlations, cutoffs, net-pay definition, and geologic-section inputs.

Engineering theory discussed

- Gamma-ray response, uranium correction, clay-volume estimation, lithology and matrix grain density.
- Effective versus total porosity; saturation and permeability correlations; Biot coefficient.
- Dynamic-to-static elastic-property conversion, Young’s modulus, Poisson’s ratio, stress estimation, and process-zone stress.
- Why logs are indirect, vertically averaged measurements and why DFIT calibration is still required.

Practical exercises performed

- Reopen the vertical tight-gas project and review well orientation assumptions.
- QC the imported LAS data and align density-porosity and matrix-density assumptions.
- Correct the gamma-ray response below the pay interval and regenerate dependent curves.
- Work through the log-analysis tree and prepare reservoir, rock-mechanical, and pay-property curves for gridding.

Session 3 — Grid Construction, Treatment Schedule, and Initial Simulation

Learning objectives

- Convert processed log data into a discretized fracture-model grid.
- Build design and actual treatment schedules and understand the project directory structure.
- Prepare a simulation suitable for later diagnostic calibration and pressure matching.

GOHFER features demonstrated

- Grid Setup, asymmetric fracture grid, node height/width, top and bottom boundaries, and graphical lithology/property displays.
- Averaging log data into grid cells and inspecting grid-property curves.
- Treatment-well setup, perforations, wellbore/reservoir fluids, pumping-schedule tables, and schedule import/editing.
- Run Engine controls and initial engine-output displays.

Engineering theory discussed

- Cartesian discretization, spatial resolution, numerical averaging, and the resolution limits of logging tools.
- Relationship among grid size, computational effort, fracture geometry, and heterogeneous rock properties.
- Fluid volumes, slurry versus clean rate, proppant concentration, pipe/perforation friction, tortuosity, and pressure components.
- Differences between a planned design schedule and the field-recorded pumping history.

Practical exercises performed

- Build the vertical X–Z grid around the target interval and verify pay and bounding layers.
- Enter perforations and reservoir/wellbore fluid properties.
- Create a design pumping schedule, then import and map the actual field schedule.
- Run the treatment and review preliminary pressure and geometry output in preparation for DFIT calibration.

Session 4 — DFIT Analysis and Pressure-Match Calibration

Learning objectives

- Extract measurable reservoir and fracture parameters from an injection/falloff test.
- Use diagnostic results to calibrate the geomechanical model and interpret a field pressure match.
- Distinguish instantaneous shut-in pressure from fracture-extension pressure.

GOHFER features demonstrated

- Diagnostics creation; import and mapping of time, pressure, and rate data; event-line placement and synchronization.
- Test Events, logarithmic-time displays, step-rate/step-down analysis, G-function analysis, closure selection, and after-closure analysis.
- Derived wellhead and bottomhole pressure, fluid and well-configuration inputs, perforation efficiency, and tortuosity estimates.
- Transfer of diagnostic results into the model and comparison of simulated versus measured treatment pressure.

Engineering theory discussed

- Wellbore storage/blowdown, compressibility, fracture extension, closure stress, and pressure-dependent leakoff.
- G-function normalization, injected fracture volume, leakoff behavior, after-closure flow, permeability, and initial pore pressure.
- Relationship between fracture-extension and closure pressure as a measure of process-zone stress.
- Importance of a clean first injection and why repeated pre-frac injections can invalidate falloff interpretation.

Practical exercises performed

- Import the diagnostic dataset and set pretest, extension, shut-in, and falloff events.
- Estimate effective open perforations and near-wellbore losses from the step-down response.
- Pick closure and analyze after-closure data for reservoir parameters.
- Update stresses and related inputs, rerun the vertical treatment, and begin matching measured pressure behavior.

Session 5 — Final Vertical-Well Match, Sensitivities, and Production Forecasting

Learning objectives

- Complete and judge a post-job pressure match without overfitting uncertain data.
- Evaluate how selected calibration parameters change pressure, geometry, and placement.
- Convert simulated fracture geometry into a realistic production forecast.

GOHFER features demonstrated

- Engine composite plots, legend/display controls, schedule and fluid editing, reruns, and case comparison.
- Calibration inputs including sand exponent, transmissibility-related controls, and fluid-friction assumptions.
- Production task creation, well/reservoir/completion inputs, forecast controls, and comparison with actual production.
- Copying treatment cases and running job-size or parameter sensitivities.

Engineering theory discussed

- Uncertainty in post-job ISIP caused by supercharge, altered pore pressure, proppant placement, and residual deformation.
- Fluid friction, perforation friction, tortuosity, near-well effects, pressure matching, and non-uniqueness.
- Proppant-pack damage, multiphase and non-Darcy effects, effective conductivity, drainage geometry, and transient flow.
- Optimization against predicted production and economics rather than maximum created fracture dimensions.

Practical exercises performed

- Refine the final pressure match by revising flush-fluid and friction assumptions.
- Review proppant distribution and fracture geometry after the calibrated run.
- Create a production forecast for the vertical well and compare forecasted and field production.
- Run comparative treatment-size/sensitivity cases and interpret why larger treatments do not always create proportional production gains.

Session 6 — Single-Lateral Horizontal Project and 3D Grid Setup

Learning objectives

- Transition from a vertical-well model to a single horizontal lateral with transverse fractures.
- Understand fracture-flow sensitivity to transmissibility and fracture-width exponent.
- Build a spatially oriented horizontal-well earth model from survey, log, and structure data.

GOHFER features demonstrated

- Copying/closing projects and creating a new single-lateral project.
- Importing the reference and treatment-well surveys, setting locations/elevations, and checking map orientation and stress azimuth.
- Log import and accelerated QC using the workflow learned in the vertical example.
- Longitudinal and transverse grid construction, geologic structure/geosteering, and stage setup.
- Run-parameter controls for transmissibility and width exponent.

Engineering theory discussed

- Node-to-node flow, harmonic-average fracture width, Navier–Stokes-based transmissibility, and apparent slurry viscosity.
- Effect of rough fracture walls and width exponent on pressure gradient, width, height, and length.
- Stress orientation, well azimuth, transverse versus longitudinal fractures, and heterogeneous structure along a lateral.
- Why rate and viscosity influence flowing pressure gradients but do not alone “hold” a fracture open.

Practical exercises performed

- Review a width-exponent sensitivity from the vertical-well project.
- Create the single-horizontal-shale project and import directional and reference data.
- Verify well/stress orientation and process the logs for the new model.
- Build longitudinal and transverse grids, establish structure along the lateral, and prepare the first stage.

Session 7 — Horizontal-Well Perforations, Acid Fracturing, and Multistage Design

Learning objectives

- Design stages and perforation clusters for a transverse horizontal well.
- Construct and interpret an acid-fracture schedule.
- Understand how staged treatments and fluid/proppant choices are represented.

GOHFER features demonstrated

- Grid display options and export of 3D earth-model properties in GSLib format for other applications.
- Perforation entry, cluster placement, stage creation, schedule table, flush calculation, and wellbore-fluid definition.
- Acid-job types and inputs for straight, emulsified, and gelled acid; acid concentration and reaction modeling.
- Stage copying, output review, and preparation of subsequent horizontal stages.

Engineering theory discussed

- Acid mass transfer versus reaction-rate limitation, diffusion, kinetics, and changing reaction-product properties.
- Carbonate dissolution, calcium/magnesium products, carbon dioxide generation, density change, and convective mixing.
- Perforation allocation, fracture initiation, transverse/longitudinal growth, and the role of anisotropy.
- Grid resolution and the interpretation/export of spatial petrophysical and geomechanical properties.

Practical exercises performed

- Export selected grid properties and review interoperability with Petrel, DecisionSpace, CMG, and related tools.
- Place a near-toe perforation cluster for the first stage.
- Build and run a non-propped acid-fracture schedule.
- Create additional plug-and-perf stages with multiple clusters and examine treatment results.

Session 8 — Sequential Stress Shadowing and Horizontal Production

Learning objectives

- Understand how earlier stages alter later-stage fracture initiation, allocation, and geometry.
- Build repeatable sequential stages with correct perforation and shadow references.
- Evaluate production from a multistage horizontal completion.

GOHFER features demonstrated

- Copy Design/Job, perforation-table editing and sorting, automatic flush-volume calculation, and stage-shadow selection.
- Shadow files, cumulative shadow history, engine-run options, and multidimensional stage-output displays.
- Horizontal production setup and aggregation of stage/fracture contributions.
- Comparison of stage geometries and production consequences.

Engineering theory discussed

- Stress superposition, stress-shadow stabilization after successive stages, cluster competition, and perforation erosion.
- Longitudinal fracture initiation from a pressurized horizontal wellbore and subsequent transverse growth.
- Low stress anisotropy, tangential stress, lithologic variation, random breakdown, and plugged/inactive perforations.
- Current-model treatment of stored shadow states versus a continuously evolving poroelastic/thermal stress field.

Practical exercises performed

- Copy Stage 3 to create Stage 4 and reposition clusters at the next measured-depth interval.
- Sort perforations before calculating flush volume and verify shallowest-to-deepest order.
- Reference the prior stage shadow and run the next stage in sequence.
- Review fracture interference and create/review a horizontal production forecast.

Session 9 — Five-Well 3D Pad Model and Geomodel Integration

Learning objectives

- Create a multiwell pad in a common 3D coordinate system.
- Integrate well locations, directional surveys, surface/structure data, logs, and a 3D property cube.
- QC vertical and spatial alignment before modeling well-to-well interaction.

GOHFER features demonstrated

- Multiple-well project creation by pasting well names from Excel.
- Site Location and Well Construction tools; UTM/state-plane coordinates; KB elevations; survey imports; map view.
- Context-sensitive Help and coordinate/location conversion tools.
- Reference-well LAS import, surface map, GSLib property cube, geomodel/core mapping, and 3D visualization.

Engineering theory discussed

- Coordinate reference systems, projection consistency, elevation datums, MD/TVD relationships, and trajectory placement.
- Using a reference well to anchor a spatially variable mechanical-earth model.
- Interpolation/resampling, lithologic and mechanical-property variability, and the need for common spatial coordinates.
- Why accurate well spacing and azimuth are prerequisites for interference and depletion modeling.

Practical exercises performed

- Create the “3D Training Pad” with five treatment wells and one reference well.
- Paste well names and import wellhead coordinates, elevations, and directional surveys.
- Import and align the reference log, map, and three-dimensional GSLib earth model.
- Create the geomodel core/pseudo-log, map its properties into GOHFER curves, and QC the wells inside the model volume.

Session 10 — Geomodel QC, Depletion, and Interwell Fracture Interaction

Learning objectives

- Validate imported 3D properties and reject physically inconsistent model inputs.
- Represent parent-well depletion and assess its effect on child-well fracture growth.
- Build reusable stage designs for a multiwell pad.

GOHFER features demonstrated

- All-treatment-wells view and geomodel extent check.
- GOHFER geologic-model curve distributions, heat maps, and overlays of reference-well curves on 3D-property populations.
- GSLib viewer and selective mapping of geomodel properties into the simulation grid.
- Pore-pressure editing/depletion setup, multiwell stage creation, design templates, and initial shadowed runs.

Engineering theory discussed

- Hydrostatic gradients and why pore pressure cannot be assigned independently of depth/gravity.
- Matrix versus stimulated-system permeability and realistic depletion extent around hydraulic fractures.
- Effective stress response to depletion and the tendency of child-well fractures to grow toward lower-pressure/lower-stress regions.
- Quality control of reservoir-simulator outputs before coupling them to fracture models.

Practical exercises performed

- Confirm that the five laterals and pay interval lie within the geomodel volume.
- Compare Poisson's ratio, saturation, and other 3D distributions with the reference-well curves.
- Identify and reject an imported pore-pressure model lacking a physical vertical gradient.
- Create a corrected depletion representation, run parent/child interaction cases, and begin a common stage-design template.

Session 11 — Zipper-Frac Sequencing, Shadow Groups, and Batch Execution

Learning objectives

- Define chronological stage order for a zipper-frac treatment across multiple wells.
- Understand how alternative sequencing strategies change the cumulative stress field and stimulated volume.
- Automate large groups of dependent simulation runs.

GOHFER features demonstrated

- Design templates for repeated perforation and pumping-schedule creation.
- Stage Shadowing map, graphical sequencing, list-based reordering, shadow groups, and Save Order.
- Automatic assignment of each stage to the preceding cumulative shadow state.
- Batch Queue/server execution, sequential dependency handling, progress review, and multi-stage output comparison.

Engineering theory discussed

- Cumulative superposition of stress and strain from all previously pumped stages.
- Outside-in, inside-out, and one-direction zipper sequencing; confinement and diversion caused by bounding stress fields.
- Stage-order effects on geometry, allocation, overlap, interwell communication, and development efficiency.
- Why dependent shadow groups must run chronologically and why earlier stages may need to be regenerated consistently.

Practical exercises performed

- Create four stages on each of Wells 3, 4, and 5 from a design template.
- Set a 14-stage chronological shadow order beginning with the two previously modeled stages on Well 2.
- Use both the map and list controls to correct and save the sequence.
- Submit the shadow group to the batch queue and review the resulting multiwell fracture pattern.

Session 12 — GOHFER Production Analysis: Decline Curves and Transient Interpretation

Learning objectives

- Use production data to estimate deliverability, connected reservoir volume, and ultimate recovery.
- Distinguish empirical decline-curve extrapolation from physics-based pressure/rate transient analysis.
- Recognize when available production history is sufficient—or insufficient—for a defensible forecast.

GOHFER features demonstrated

- Standalone Production Analyses independent of the fracture-model grid.
- Gas- or oil-well setup, CSV import/preprocessing, column inclusion, time conversion, and data mapping.
- Decline-curve fitting, rate/cumulative displays, square-root-of-time/linear-flow diagnostics, and forecast controls.
- Production-history matching using reservoir, wellbore, completion, pressure, and fracture inputs.

Engineering theory discussed

- Enhanced-permeability/stimulated reservoir volume surrounded by lower-permeability storage rock.
- Pressure-transient propagation, recharge after shut-in, boundary-dominated flow, reservoir linear flow, and pseudo-radial flow.
- Difference between gross created/propped length and effective producing fracture length.
- Decline-curve uncertainty with short histories; drainage boundaries, connected volume, EUR, and economic interpretation.

Practical exercises performed

- Open the production-analysis input workbook and create a new gas-well analysis.
- Import enhanced-area datasets representing 180 days, one year, ten years, and fifty years; compare how forecast confidence changes with history length.
- Analyze the tight-gas case and compare decline-curve and transient/history-matched results.
- Work through additional gas and multistage horizontal oil-well case studies, including square-root-of-time behavior, drainage interpretation, and deliverability limits.
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