StimPlan News
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StimPlan Adds "A's" – After Closure & Acidizing

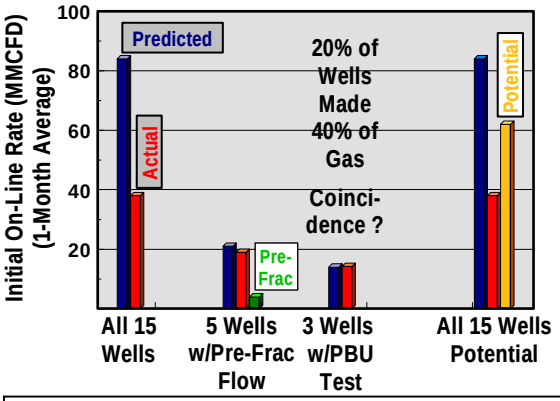
StimPlan is adding something old (Acid Fracturing) and something new (After Closure Analysis, or ACA, for formation permeability) to the basic functions of the package.

Permeability (from Fracturing Data?)

Formation permeability is the MAJOR variable for hydraulic fracture treatment design since this variable determines "Design Goals" for a treatment. That is, do we need a loooong fracture, or a short "fat" fracture? As one example, consider the post-analysis of 15 treatments summarized in the figure.

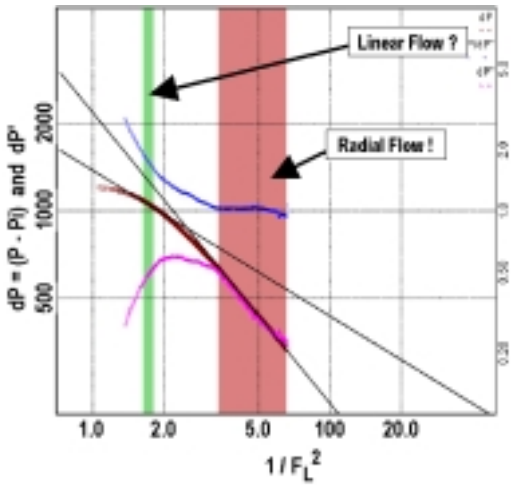
The treatments were conducted in wells covering 7 fields and 3 formations, with formation permeability ranging from 0.3 to 2.70 md. Five of the wells had a pre-frac flow, and 3 of these 5 had a pre-frac PBU test. All 15 treatments were placed exactly as designed (following traditional mini-frac testing), including a predicted TSO (tip screenout) behavior in several of the treatments.

Despite placing the treatments as designed, overall post-frac production was about ½ the predicted rates. However, for the 5 wells with a pre-frac flow (giving at least some idea of formation flow capacity), post-frac rates were 95% of the predictions. For the 3 wells with "real" data, i.e., a pre-frac PBU tests, actual post-frac rates were 102% of the predicted rates. THAT IS, when the treatment design was for the correct (as opposed to estimated) permeability, post-frac performance was: a) much better, and b) matched design expectations. In fact, the observed behavior where 20% of the wells made 40% of the gas suggests that post-frac production could have been doubled from the actual rates.



This was probably not achievable. However, a post-frac analysis based on using the same overall total proppant type/volume, showed that revised fracture designs could have increased the post-frac rates by 50% to 62 MMCFD – an increase of 22 MMCFD. Permeability is a major design variable!

While one might recognize the importance of this, the fact remains that pre-frac flow tests and/or pre-frac pressure build-up tests can be quite time consuming and often expensive. So, where do we get this critical data? The answer may come from the important work of Nolte [Nolte, K. G., "Background for After-Closure Analysis of Fracture Calibration Tests", SPE 39407]. This analysis has been fully implemented in StimPlan Version 5.20, including detailed "Flow Regime Identification" plots as seen below along with "Analysis Plots" **for determining formation permeability to gas & oil**.



FIVE Functions! – StimPlan™ is designed around a "Five Function" approach to fracture design. These 5 functions, that should form the basis of any fracturing software, are:

- ***Data Analysis*** including the ability to handle and analyze the multiple data types associated with fracture design (logs, pre-frac well tests, fracturing pressure data and post-frac production data),
- ***Fracture Geometry Model*** (while an important part, it is only one of the 5 essential functions),
- ***Economic Analysis*** in order to determine what type of treatment is desired based on realistic data and numerical fracture/reservoir/economic simulations,
- ***Automatic Pump Schedule*** generation to eliminate wasted trial & error data input to arrive at a final pump schedule, and
- ***Production Analysis*** (type curve analysis and numerical reservoir simulator production history matching) for post-frac oil/gas rate production analysis.

If you are interested in hosting/attending one of NSI's interactive user courses, please contact us at StimPlan@nsitech.com.

Acid Fracturing Research See Next Page

NSI TECHNOLOGIES, INC.

StimPlan News

NSI Tulsa/Houston

StimPlan / E-StimPlan Development Features & Plans

Development	Status	Target
Build database files of "Formation Types", properties, etc.	Version 5.00	
E-StimPlan – Upgrade to "Fully" 3-D Geometry Model	Version 5.00	
3D Reservoir Production Simulation including Non-Darcy Flow & Stress Dependent Permeability/Fracture k_fw	Version 5.10	
Multiple Log Track Handling	Version 5.10	
Increase Modeling to 100 Geo-Mechanical Layers	Version 5.20	
E-StimPlan – Completely Coupled Fracture Geometry/Reservoir Model including Poro- & Thermo-elasticity effects	Version 5.20	
E-StimPlan Acid Fracturing	Version 5.20	
Fracturing Pressure Decline Analysis for Permeability, "k" ("Pre-Closure", Ispas, et al and "Post-Closure", Nolte, et al)	ACA – Nolte Version 5.20	Pre-Closure 2004
Extend ACA Using Type Curve Techniques	Beta	2nd Qtr, 2004
Upgrade "k" Analysis above by coupling to Frac Geometry Model to Allow Time/Pressure "Stiffness" Variation	Future	
Expand Production Decline Analysis to Agarwal-Gardner	Future	2004

Acid-Fracturing Conductivity

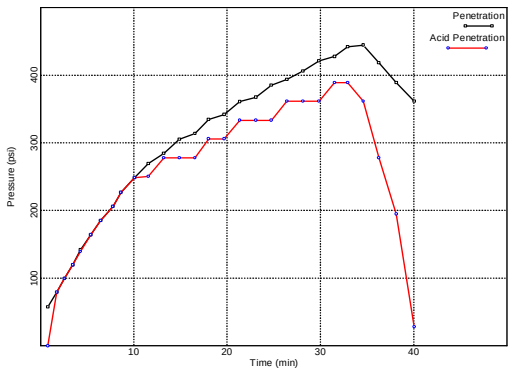
NSI is proud to assist Professors Dan Hill & Ding Zhu with the creation of an important U. Texas Joint Industry Project. This project aims at developing quantitative techniques for predicting acid fracture k_fw for individual formations. Lack of such capability is the major weakness in acid fracture design, and this project will be a significant step.

Check NSI's web site — www.nsitech.com – or our booth at the SPE Annual Meeting in Denver (October 2003) for more information.

Fracture Acidizing

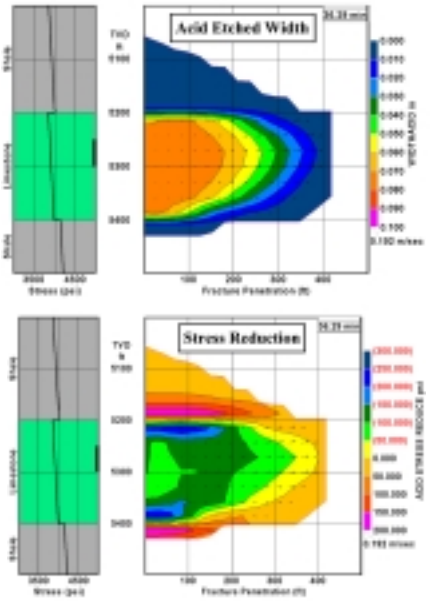
The oldest form of "hydraulic fracturing" is almost certainly fracture acidizing. Despite this, acidizing has not been part of the StimPlan package. With version 5.20, this is no longer the case. StimPlan 5.20 introduces acid fracturing as part of the E-StimPlan/E-StimPlan 3D simulation package. E-StimPlan was chosen as the "vehicle" for this new model since it was felt some of the simulation capabilities of E-StimPlan were of critical importance to a rigorous simulation of acid fracturing. Particular features considered in making this decision included:

- ***Rigorous Fluid Flow Solution*** – As the acid flows along a fracture, acid reactions create an additional fracture width (above the normal, hydraulic pressure, width). As this extra width is created, it becomes easier for fluid to flow along the wider path. Thus, more acid flows in that direction, creating more width, etc. This could be a major factor in acid fracture design, and is not included in current acid fracture simulations. For example, this rigorous flow simulation allows new design output such as the Acid Penetration plot below. This shows that after about 30 minutes of pumping, live acid penetration is beginning to lag behind fracture penetration. Thus, additional pumping will create minimal additional etched fracture length!



- ***Multiple Zone Initiations*** – Acid fracturing, more so than propped hydraulic fracturing, uses limited entry techniques for treating multiple, and/or long intervals. The E-StimPlan solution implicitly includes a wellbore model to allow for rigorous simulation of such cases. Future versions will also include modeling of wellbore diversion.
- ***Closure Stress Reduction*** – When hydraulic pressure in a hydraulic fracture returns to equal "closure pressure", fracture width returns to "0" (ignoring any propped width of course). However, when fluid pressure in an acid etched fracture declines back to closure pressure, there will still be some positive, etched width (as seen in the figure below).

Then, as fluid pressure further declines, this acid etched width closes – reducing stress acting on the fracture face (as seen below). This could have a significant impact on predicted acid etched conductivity, particularly for very soluble formations such as soft chalks.



StimPlan™

The most rigorous simulations around – and SO MUCH MORE!