StimPlan News
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E-StimPlan / StimPlan 3-D

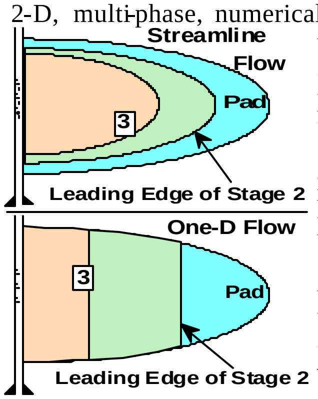
E-StimPlan 4.00

What is E-StimPlan? **When** should E-StimPlan be used? **How** do we know the answers are "good"? **Where** is E-StimPlan going? This newsletter briefly addresses these questions.

What is - E-StimPlan *enhances* traditional PC based fracture geometry calculations by including a rigorous numerical solution for 2-D flow and proppant transport inside a fracture. Since proppant placement is the end goal of all propped fracture treatments, ideally a rigorous proppant placement solution such as E-StimPlan should be used as a final "check" for all final treatment designs.

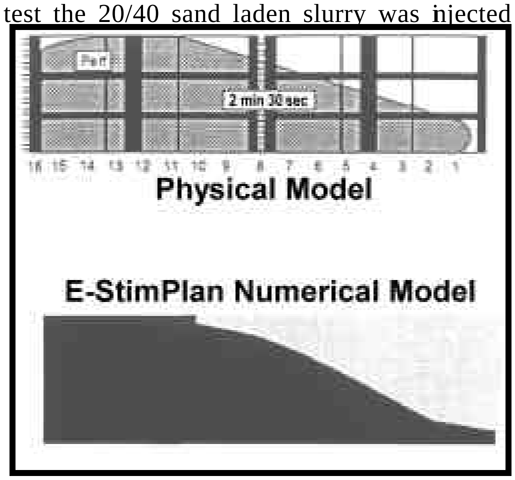
In addition, version 4.00 includes rigorous Finite Element calculations for elasticity & fracture width. Thus, a correct solution is possible for layered modulus formations. This is often critically important for "softer" formations where drastic variations in modulus are possible. This has a dramatic impact on the local fracture width, and thus on fluid flow and proppant placement. ***E-StimPlan is the only commercial fracture geometry model to include this advanced technology.***

How Do We Know - E-StimPlan uses a 2-D, multi-phase, numerical flow solution to track fluid flow and proppant placement in the fracture. Historically, fracture geometry models have used one of two simple flow solutions as pictured in the figure. Using "model definitions" (after Warpinski, N. R., et al. "Comparison Study of Fracture Models - ....," <u>SPE Production & Facilities</u>, Feb 1994), usually "lumped" (parametric or single-cell) models use a streamline flow approach; "cell type" (finite difference) models often use the 1-D approach.



Either approach has advantages and disadvantages. However, in both cases, we have long known that such fluid flow/proppant placement calculations were far too simple. It was "what we had", so the industry did it's best with those constraints. Considering the 50 year success of hydraulic fracturing, things didn't go to bad. Now, better tools are available allowing rigorous flow/proppant placement predictions and much better designs. In addition, due to the rigorous nature of these tools, the numerical models can be directly "checked" against laboratory experiments, i.e., physical models.

The first comparison (seen below) is with a large, by lab standards, slot flow test (after Barree, R. D. and Conway, M. W., "ExperImental and Numerical Modeling of Convective Proppant Transport," SPE 28564, 1994) In this test the 20/40 sand laden slurry was injected



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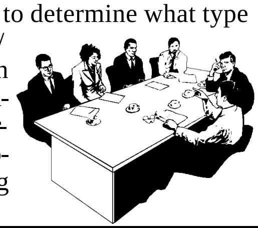
StimPlan User Courses are being presented. These one-day courses are designed as hands-on interactive instruction on the application of **StimPlan** and **E-StimPlan** to solve many of a petroleum engineer's stimulation design and analysis problems. The objective is to maximize our user's ability to solve completion and stimulation problems using the "**<u>Five Function</u>**" approach of the StimPlan software package. These ***5 functions***, which should form the basis of any fracturing software are: 1) **Data Analysis** including the ability to handle and analyze fracturing pressure data and post-frac production data, 2) **Fracture Geometry Model** (while this is an important part, it is only one of the 5 essential functions), 3) **Economic Analysis** in order to determine what type of treatment is desired based on realistic data and numerical fracture/reservoir/economic simulations, 4) **Automatic Pump Schedule** generation to eliminate wasted trial & error data input to arrive at a final pump schedule, and 5) **Production Analysis** (type curve analysis and numerical reservoir simulator production history matching) for post-frac oil/gas rate production analysis. If you or your company are interested in hosting/attending one of these interactive course, please contact us at info@nsitech.com.



StimPlan News NSI Tulsa/Houston

StimPlan/E-StimPlan Development Features & Plans

StimPlan	Status	Target
3-D Numerical Reservoir Simulator	Version 4.00	Released
Integrated (Fracture Geometry, Reservoir Model, Economics) Optimization	Version 4.00	Released
Post-Frac Production Analysis (Fetkovitch/Carter Analysis, History Match)	Version 4.00	Released
Production Decline Analysis (Agarwal-Gardner Type Curves)	Designing	
Horizontal well and multi-fractured horizontal well analysis/optimization	Beta	
Upgrade 3-D Numerical Reservoir Simulator to include non-Darcy flow	Ongoing	1st Quarter 2001
Graphical, Log Style input for Geo-Mechanical & Fluid Loss Layering	Beta	4th Quarter 2000
Measured Depth/TVD Option	Planning	
Enhanced Database Features (fluids & proppant)	Version 4.00	Released
Enhanced Database Features—Rock Mechanics, Pipe Friction	Planning	
Pre-Closure Frac Pressure Decline Analysis for Permeability (Ispas, et al)	Designing	
Post-Closure Frac Pressure Decline Analysis for Permeability (Nolte, at al)	Designing	
E-StimPlan		
Finite Element elasticity for layered modulus cases	Version 4.00	Released
"N" Frac Simulations (multiple fractures in separate vertical layers)	Beta	4th Quarter 2000
Upgrade to Planar 3-D Model — StimPlan 3-D	Beta	1st Quarter 2001
Upgrade Decline Permeability Analysis w/time & closure varying "stiffness"	Future	

StimPlan 3-D Info

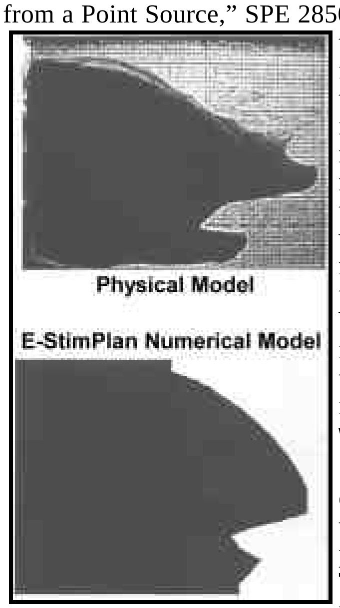
StimPlan and E-StimPlan soon to be joined by StimPlan 3-D, a planar 3-D model. This makes StimPlan the only package ever to offer a complete range of solutions (with common I/O) in one integrated, user friendly package. Thus, the exact level of simulation sophistication needed can be easily employed for every case.

Check our web site—www. nsitech.com–or visit our booth at the SPE Annual Meeting in Dallas (October, 2000) for more information.

(StimPlan 4.00 , Continued from page 1)

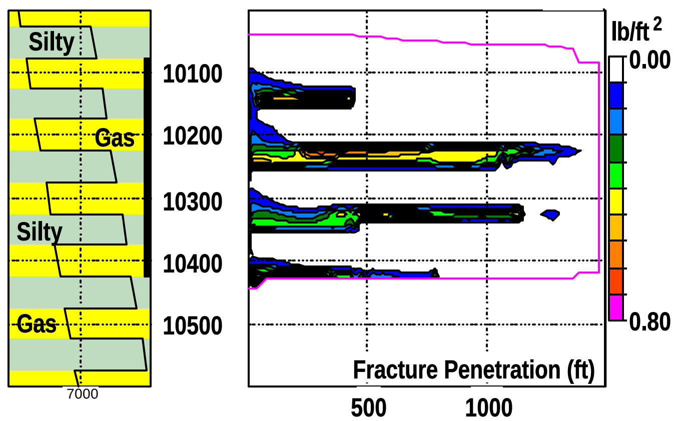
over the top 1/2 of the slot, with the heavier slurry immediately sinking to the bottom 1/2 of the simulated fracture. Clearly the 2-D flow solution gives good agreement with observed behavior — both for vertical flow and as to when proppant reaches the right hand end of the slot, i.e., the critical parameter of propped length.

The second comparison with a smaller scale test (after Clark, P. E. and Zhu, O., "Fluid Flow in Vertical Fractures from a Point Source," SPE 28509, 1994) illustrates the importance of fracture width to the fluid flow profile — as seen in the figure. Once again the solids laden slurry was injected near the top/left of the physical model. However, for this test there was a small, narrow width region of the fracture near the bottom. The effects of this width profile on the flow behavior is clear, as is the ability of the rigorous flow solution to correctly capture this important behavior.



When Should - E-StimPlan correctly models the effects of fracture width variations on fluid flow & proppant placement as seen above. These effects can be critical for layered formations, particularly when using low viscosity fluid such as a water.

This is clearly seen in a "water frac" simulation in the next figure. This case is an idealized version of an actual water frac in a layered, "tight" gas formation. Measured in-situ stress data shows "silty" zones to have ≈ 500 psi higher closure stress than relatively cleaner sands. This creates narrow fracture width over silty intervals, with most flow moving at high velocity down the wider fracture in the sand intervals



(where gas is located!). Thus, it is possible to get long, relatively well propped fracture fingers in the productive intervals using water and low proppant concentration. However, ***planning such treatments, knowing when or if to pump clean fluid "sweeps", understanding how many layers can be treated simultaneously, etc., all require designs based on rigorous flow modeling.***

In general, the need for such modeling is driven by the complexity of the geology. That is, multiple formation layers with differing properties for stress, modulus, fluid loss, etc., drastically alter final proppant placement. Since this unfortunately describes most geologic settings, ideally this should be used as a "final check" for all final propped treatment designs.

Where Is - E-StimPlan going? NSI is in the midst of the "2000 Development" including:

- use of Finite Element elasticity for layered modulus cases (released April, 2000)
- the ability to model multiple fractures in a vertical, "limited entry" sense (scheduled for release October, 2000), and
- full conversion to a Planar 3-D geometry model for complex layered geologies (scheduled for 1st Quarter, 2001)