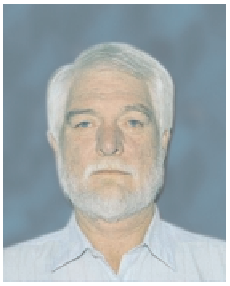
ProTechnics

Expert's Corner

INTERVIEWS AND DISCUSSIONS WITH INDUSTRY EXPERTS

REALITIES AND MYTHS OF CREATED FRACTURE LENGTH VERSUS EFFECTIVE FRACTURE LENGTH

Interview with Dr. Michael Conway



In this interview, Dr. Michael Conway shared his rich background in the area of fracturing fluids, proppant conductivity and fracture design modeling. He has specifically addressed the issue of created fracture length versus effective fracture length. This issue is currently at the center of debate and concern by fracturing experts across the industry. Answers to the questions in this interview will help the engineering professional understand and mitigate the negative impact this difference has on fracture performance

Q: ProTechnics
Anyone who is even remotely involved in hydraulic fracturing is very familiar with the terms "created fracture length" and "effective fracture length." Would you take a moment to define these two terms and discuss how they are commonly determined?

A: Dr. Conway
Created length is that length actually generated from the actual fracturing operation. Fracture treatment design models are the most used means of estimating created fracture length. Other technologies such as microseismic fracture mapping have the ability to actually measure this length. With better understanding of fracture height coupled with microseismic mapping, a fairly good estimate of created fracture length can be made.

Effective fracture length, that length contributing to stimulated production is more difficult to arrive at. First, we have to decide how we are going to describe that length. If we have an independent estimate of fracture conductivity, then we can describe it as a flowing length with a finite conductivity of some value. If not, we are probably better served to describe it as an equivalent infinite conductivity fracture.

Two methods are commonly used to estimate effective length: Post-frac buildup tests and production analysis. The biggest problem with buildup tests is the long shut-in time required to achieve pseudoradial flow so that permeability can be unambiguously determined. With a successful test, the analysis will typically suggest a longer fracture length than production analysis. This occurs because the dynamic effects die out very quickly after shut-in and the pressure transient measured in buildup tests sees much more of the created fracture length. This can easily be confirmed by attempting to use the buildup reservoir permeability and fracture length to model the production history. Often the buildup derived characteristics lead to estimated production rates much higher than were actually observed.

Production analysis has its own limitations. The biggest is the estimation of reservoir permeability. All analysis techniques have a challenge to separate reservoir permeability from fracture length and conductivity, and production analysis is no different. The success of this methodology depends on the additional diagnostics available to help identify the correct permeability and fracture length. We continue to see cases where the estimated reservoir permeability leads to highly suspect fracture length estimates. Non-Darcy flow and relative permeability effects are major dynamic factors that tend to limit the effective fracture length and are not sensed by the buildup tests.

The real caution here is that none of the analytical techniques are infallible and are subject to non-uniqueness problems

Q: ProTechnics
What are the specific major causes that account for the difference between created fracture length and effective fracture length?

A: Dr. Conway
In all cases where the two are not the same, some form of damage of the fracture conductivity is at play. The cause of this damage is either from gel not cleaned up and/or fluid damage or from mechanical damage to the proppant pack from crushing and plugging by fines production.

After the fracture is placed and cleanup is started, one of two cleanup profiles will occur. The one that we hope occurs is that the fracture begins to clean up from the tip. If this occurs, 80% of total gas flow will occur from the tip and the created fracture length should be nearly equal to the effective fracture length.

continued on page 2

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In most cases, we suspect that this is not what occurs. We believe that there is an early gas breakthrough near the wellbore due to the unfavorable viscosity ratio and the cleanup occurs only for some limited distance into the fracture. Once this production equilibrium is established in the fracture, the well ceases to further clean up and the effective fracture length is for all practical purposes set. Data shows that some, but very little additional, cleanup and increase in effective fracture length continues as the well is produced. The low permeability to water due to the gas saturation limits the depth of cleanup and leaves a substantial part of the fracture water and gel filled and does not contribute to production.

Q: ProTechnics

In your opinion, what are the major misunderstandings or "Myths" concerning created fracture length as it relates to a post-treatment pressure history match of the fracture geometry and production performance?

A: Dr. Conway

A post-treatment history match of a treatment certainly gives one possible fracture geometry and can rule out some geometries that clearly are unlikely. It does not however, provide a unique answer unless other independent information is available to help guide the match such as tracer results or microsesimic fracture mapping. A history match by itself unsupported by any other evidence which, for example, suggests massive height growth is suspect and not unique and thus will likely be a poor indicator of post frac production

The desired fracture geometry is a necessary, but not a sufficient condition for the desired stimulation. The fracture has to clean up to take advantage of the created length and lack of cleanup is generally the production limiting factor.

Q: ProTechnics

I hear all the time from production engineers that "my post-treatment pressure build-up or production analysis indicates that I have a much shorter fracture length than I designed, therefore, I must have had uncontrollable frac height to account for the discrepancy in this mass balance. What would you recommend doing to try and identify the causes of these mass balance discrepancies to better calibrate the frac models?

A: Dr. Conway

My recommendation would be to employ a more systematic program for fracture geometry determination. These diagnostics have been very instructive in a number of mature reservoirs where they have identified fracture geometries not generally expected by operators.

Experience is that fracture height growth has been a convenient explanation for the observed short effective fracture length. Contained fractures were always inferred to have created excessive length as a means to mass balance the process. However, the fracture height generally seen in fracture mapping studies and from tracer studies suggests that uncontrolled fracture height growth is rare. This puts the burden for fracture cleanup back on the shoulders of the service company to provide breaker systems and additives to promote cleanup. I expect this to be a major research and development effort as we go into the future.

Q: ProTechnics

Your background as chief fluids researcher at Halliburton for 10 years and as a principle scientist at Stim-Lab for another 15 years has made you uniquely qualified to comment on fluid/rock and fluid/proppant interactions. Would you share some of the major concepts of fluid damage that result in a less than optimum performance of the fracture?

A: Dr. Conway

The interaction of a foreign fluid with the reservoir may or may not be production limiting. If the reservoir has enough flow capacity to overcome the threshold pressure to initiate gas flow in the invaded region, then the fracturing fluid/reservoir interaction should have no adverse impact on production. This is, however, clearly a problem in many low permeability reservoirs where high capillary pressure creates a very high threshold pressure and gas permeability is difficult to re-establish. This will result in a much reduced relative permeability to gas and impaired production.

The other problem with viscous fluids is in reservoirs that are naturally fractured. If the natural fractures are a major production pathway, they are very susceptible to damage from the stimulation fluid. Whole gel can invade these fractures and form a filter cake which is very difficult to break. When the natural fracture closes it is basically cemented. Overcoring has recovered such unpropped fractures which are so strongly cemented that they can be recovered intact

Proppant/fluid interactions are generally far more important. Laboratory tests continue to show that it is very difficult to clean up a fracture when high viscosity fluids are used. The desire to have enough viscosity stability to guarantee good proppant transport often leads to recommended fluids, supported by Model 50 rheology testing, that just will not clean up adequately and thus result in very short effective fracture lengths.

Q: ProTechnics

Based on your statements to the above question concerning fluid damage to the formation and the proppant pack, what prudent strategies and operational procedures should an operator take to understand and mitigate the negative effects of this damage?

A: Dr. Conway
Aggressive break schedules are the most obvious. Two things are very important. The first is to have a reasonable estimate of the fluid thermal history and design the fluid stages based on the expected temperature profile and not bottom hole temperature. The second is to aggressively try to reduce fluid leak-off. When the fluid leaks off into the reservoir, it leaves a concentrated gel filter cake on the fracture face. The filter cake is very difficult to break and less filter cake is a real benefit for cleanup. Chemical tracers studies can be very useful in identifying stages that do not clean up well. This information has been used to help modify the fluid formulation and optimize the fluid design for more effective cleanup.

Q: ProTechnics
Would you share a real-world case history that would showcase the effects of gel damage on effective fracture length?

A: Dr. Conway
Our cleanest examples are on wells where remedial treatments significantly improve production. The most convincing was a well in Australia that produced less after four frac stages than one zone flowed pre-frac. After on and off testing over a year and a half, a high rate CO_2 remedial treatment was performed. An extensive post treatment flow test program was conducted and one morning at 3 a.m. the flowing pressure doubled and the rate doubled. A rather unique post frac fluid had been recovered during the original flowback and it was suddenly being seen again. We interpreted this to mean that one stage had never flowed after the fracturing treatment and finally cleaned up and began flowing. Production profile logging confirmed that a zone that previously had shown no gas inflow was now a principal gas productive zone.

Q: ProTechnics
In closing, I would very much like to thank you for your time spent with this Expert's Corner interview. For our readers, would you list any industry works, groups or other forums that are currently addressing the issue of improving effective fracture length?

A: Dr. Conway
Certainly, all of the major service companies are acutely aware of the need to improve fracture effectiveness especially in ultra low permeability reservoirs. They continue to develop and offer new solutions.

The Stim-Lab Inc. Proppant Consortium has been ongoing since 1986 and continues to develop information to support improved practices in hydraulic fracturing. Currently, fracture dewatering and relative permeability effects, fluid loss characteristics and proppant pack cleanup are major areas of study.

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