Application and Needs for Advanced Multilateral Technologies and Strategies

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Abstract

Horizontal well, coiled tubing, multilateral, underbalanced drilling, extended reach technologies as well as other emerging technologies have and are providing new tools for engineers. Economics and risk must be considered on the implementation of such new technologies within companies and the industry. Both economic and risk analysis should help management in making capital decisions which will enhance results and make the company more profitable, while monitoring actual results during the company's learning curve. Too often a one-time, high risk project view is taken within the company's ranks versus establishing new technology within the company with a longer term commitment. This paper will look at new technology implementation and ties to multilateral technology. The paper will forward concepts that a total system approach must be uses in multilateral technology application. One of the problems which will be discussed will be management of the parent hole to multilaterals which may or may not be completed for isolation purposes.

Risk Considerations Within Industry

New and emerging technologies like 3-D seismic, 4-D seismic, horizontal drilling, coiled tubing operations, extended reach, slimhole, monobore, underbalanced drilling and multiple lateral technologies all are impacted by firms opting to stay with older techniques. In high cost environments, a low risk strategy can result in a lose-lose proposition for industry. Where companies have successfully risked the implementation of new technologies within their organization, costs have been reduced and capital preserved, while improving overall results with a new or emerging technology. There have been exceptions where the company had no success with a new or emerging technology.

In operator studies carried out by Philip C. Crouse and Associates, Inc. involving horizontal well and extended reach technologies, corporate philosophies could be seen as having impact on implementation rate relative to asset size. Also, disagreement in advantage on a particular process or application dictated usage of a particular technology. In one instance, two or more large companies had very different views regarding isolation in horizontal wells. One corporate position was that horizontal wells could not be cemented effectively, partly because of hole cleaning and filter cake removal issues. Companies in this position used external casing packers for isolation options. On the other side, corporate position was that isolation could be achieved with a case, cement an perforate approach, and many more wells were completed with this technology. Others offered the view that external casing packers were ineffective in isolation. The above described positions points to the need for the operator to properly understand risks.

Risk comes to each player in the oil industry by different variables. These variables can be either dependent or independent in nature. L.T. Stanley[1] defined the independent or dependent nature of variables are obtained by determining whether a significant relationship exits by correlation analysis. Risk can involve the following:

1. **Process Risk -** Process risk is the risk associated with the implementation of a technique or process. It is generally mechanical and procedural in nature. An example of process risk is the procedure and system used for drilling with coiled tubing beyond 1000'.

2. **Production or Reservoir Risk -** Production risk is the risk associated with the estimation of how the reservoir and production will respond to the process employed. This risk may be dependent on process risk. An example is underbalanced drilling in which formation damage benefits are determined as a reason for implementing the process. Here there would be an effort to quantify the production enhancement or reduction risks. Production and reservoir risks are also independent of process risks in that the geological and reservoir description and understanding is a separate risk. For example, drilling a horizontal well through an oil-water contact because of unknowns in the reservoir is both a reservoir and production risk which is independent generally of the process risk.

3. **Financial Risk -** Financial risk is the risk caused by oil and gas price fluctuations, costs estimate fluctuations, and dependent risks of production. The success of a project could be determined by capital outlay, revenues from production, prices received for production, and costs (both recurring and maintenance costs). Inflation, market conditions and interest rates also affect financial risks. In a capital allocation situation, firms may seek to minimize financial risk by eliminating those projects which have high capital encumbrances. Capital encumbrances are defined as negative cashflows.

4. **Technology Risk -** Technology risk is the risk of understanding and properly developing a successful technique, piece of equipment, or management of technology. A good example of technology being risky is one company may implement the successful drilling of horizontal wells in a fractured carbonate while another company with high technology capabilities fails in the implementation of the same technology. This situation has been seen in the Austin Chalk in South Texas.

For the manufacturing/service company, investment in equipment and associated R&D costs for new technology requires the company have a certain amount of confidence that the new rig or unit will at least pay out and hopefully have a suitable return on investment. An example here would be the manufacture of a hybrid rig. The key to making a return for such a rig as well as any equipment in general will be utility rates. If the rig is 100% employed, very good returns are generally achieved, while anything under 50% utility rates results in substantial loss of capital return and losses.

Activity for Rig Types with New Technologies

As of December 1996, multilateral, horizontal, high angle and vertical, underbalanced, and extended reach drillings have been accomplished with jointed pipe operations with 99% of the wells drilled using conventional drilling equipment.

1996 preliminary world activity in percents among types of rigs and implementation is as follows:

Well Geometry	Rig Type	Overbalanced	Underbalanced
Vertical	Jointed Pipe	99%	95%
	Snubbing	<.1%	<1%
	Coiled Tubing	<1%	<5%
	Hybrid	New	New
High Angle	Jointed Pipe	99%	98%
	Snubbing	<.1%	<1%
	Coiled Tubing	<1%	<1%
	Hybrid	New	New
Horizontal	Jointed Pipe	99%	93%
	Snubbing	<.1%	<1%
	Coiled Tubing	<1%	<7%
	Hybrid	New	New
Multilateral	Jointed Pipe	99%	99%
	Snubbing	<.1%	<.1%
	Coiled Tubing	<1%	<1%
	Hybrid	New	New
Extended Reach	Jointed Pipe	>99%	New
	Snubbing	<.1%	New
	Coiled Tubing	<.1%	New
	Hybrid	New	New

While the activity for number of wells drilled in 1996 will be about 60,000 wells, horizontal, multilateral, extended reach technologies account for about 5% of all well activity and less than 10% of all well expenditures despite the massive amount of information pointing to advantages of these new technologies. Underbalanced technologies (including flowdrilling and mudcap drilling techniques) are less than 2% of world wells drilled in 1996. This points to the fact that the most significant companies (i.e. companies which drill over 20 wells per year) continue to monitor new and emerging technologies (some of which have been proven for over 10 years!) instead of broadly implement the these technologies within their asset base. Because of poor asset implementation of these technologies, one can clearly see why companies are beginning to establish job roles in which a champion of a particular technology will be responsible for its promotion and implementation on the company assets. Bennion[6] as well as others have described another risk is career and political risk. Most in industry have opted to keep this type risk minimum as the overall industry has reduced in size from 1985-95 and failures are more visible in engineering ranks.

It is important to note that countries like Canada are using a higher percentage of wells drilled with coiled tubing, although the percentage is still low relative to the potential market.

Coiled Tubing Drilling - The Future for Multilateral Well Drilling?

Modern coiled tubing drilling traces its roots to Bowen Tools coiled tubing rigs used for workover operations in 1964. Modern CT rigs use much of the same equipment as the Bowen Tools rig of 1964. Their limitations include the inability to set casing, which requires a hydraulic workover unit. While this industry is still quite small in relation to overall industry expenditures, coiled tubing drilling development and R&D dedication continues at companies like Canadian Fracmaster, Halliburton, Schlumberger, Baker Hughes Inteq, Nowsco, and others. This interest has been focused and emerging as the CT drilling well count expands to increasing levels and interest and job inquiries continue to CT rig operator companies. In Canada, it has been reported that if good CT drilling rigs were available, the activity rate of CT drilling could be double based on job requests. In the United States a hot bed area of activity has been the use of CT drilling rigs for the Prudhoe Bay Unit. In 1997 BP and Arco have about 40 wells budgeted to be drilled for the year. BP is drilling and completing their reentries in 11-13 days including cementing a liner and perforating. These companies are now exceeding the 2000' horizontal lateral barrier and seeing productivities up and super cement jobs. 2162' with a 100 degree turn in it and Arco is drilling towards 2500' horizontal departures. The following information shows the emergence of the CT drilling market over time (History through 1994 is based on Schlumberger with 1995 forward based on Philip C. Crouse and Associates values):

Year	Job Count	Underbalance	Overbalance	Directional
1991	3	2	1	2
1992	14	4	10	5
1993	30	6	24	7
1994	150	25	125	18
1995	300	100	200	80
1996	420	130	290	105
1997 Est.	540	180	360	160
2000 Est.	800	320	480	350

Barriers in increasing this marketplace for CT drilling is and will be training of personnel, bringing on new generation equipment which is cost competitive, and continued desire by operators to identify opportunities for this technology. Again, it is important to note that even in the year 2000, CT would just constitute over 1% of all wells drilled.

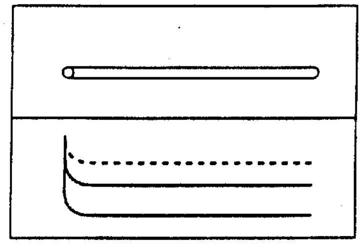
Multilateral Wells - Applications

Patents dealing with multilateral concepts have been around long before the recent patent flurry, although the word multilateral or multibranch may not have been used. Most experience with multilateral wells have been situations where the wells have been completed open hole, making the ideal candidate reservoirs in competent, fractured reservoirs. Well over of all multilaterals have been drilled in Texas and Louisiana in the Austin Chalk and geographically related formations. Over the last four year period, manufacturing and service companies have been working with operators and other entities in developing completion strategies for multilateral wells. The industry is currently arguing the classification of multilateral wells along with the jargon (including whether multilateral, multibranch, and other similar words should be used). Major operators are meeting overseas in March 1997 to discuss ideas on standardization of definitions referring to the wells by completion type.

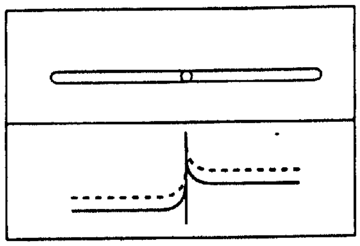
Multilateral well can be defined as any well where a number of sidetracks are made into the reservoir in order to maintain or increase productivity. Peden and others have defined a multilateral well as a well which has more than one horizontal or near horizontal lateral well drilled from a single site and connected back to a single wellbore. Likewise a multibranch well would be a well which has more than one branch well drilled from a single site and connected back to a single wellbore. In this definition, multibranch wells may be vertical, horizontal or angled or in combination. Multilateral wells would be multibranch wells.

The configuration of multilateral wells deals with being stacked, over/under, planar, and/or opposed. Complex configurations have been given names like herringbone, chicken foot, star pattern, radial, Y well. The number of laterals are generally referred to as dual lateral, trilateral, quad, etc.

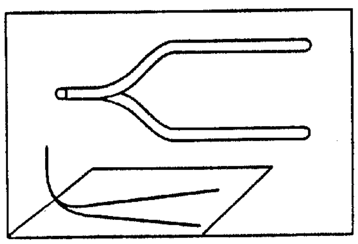
On the following page are figures of well strategies:



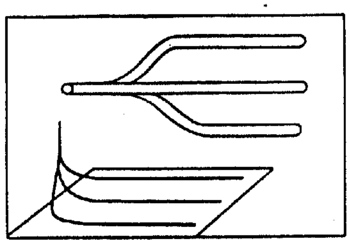
Stacked Dual-Lateral and TriLateral.



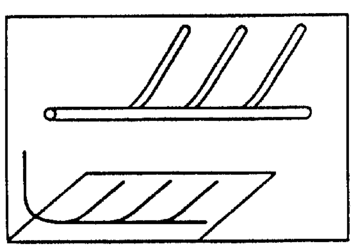
Dual-Opposed Lateral and Stacked/Opposed Quadrilateral



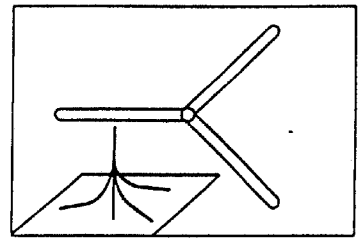
Planar Dual-Lateral



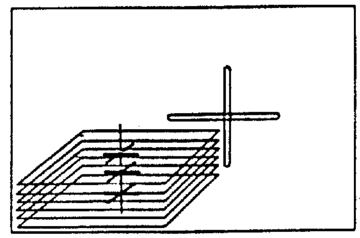
Planar Tri-lateral



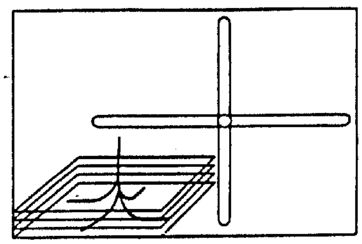
Planar Offset Quadrilateral



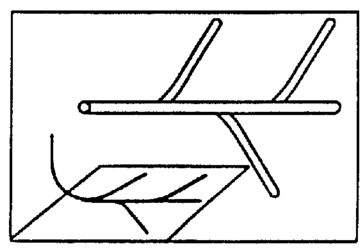
Radial Tri-lateral Extending From Primary Vertical Wellbore



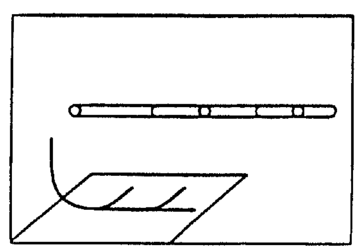
Stacked Radial Quadrilaterals



Radial Quadrilateral



Planar Opposed Quadrilateral



Stacked/Inclined Tri-lateral

Some of the completion type classification proposed would be:

Level 1- Open Hole
Level 2- Cased trunk or main bore and open hole lateral
Level 3- Mechanical integrity at junction like the Sperry LTBS or Baker Hook Systems
Level 4- Pressure integrity at the junction like the Baker Root System and Halliburton System 3000.

Some operators are proposing the systems be identified by junction type, sealability, reenterability, and smart well (i.e. can control on surface or say a choke built in type system).

Completion systems on the market come from BHI (Selective Reentry System, Root System, Hook Liner Hanger System, Splitter System, and Kick Plate Dual Lateral System), Speery-Sun (LTBS, RMLS, LRS, NAML and DSML systems), Halliburton (System 3000), Texas Iron Works (ML Access System, TTR, USR), Elf/IDS (Multidrain System, Rapid Seal Multidrain System), Shell Canada/Canadian Toolmaster System, and the Red Baron System.

Benefits

Motivations by operators for this technology will be due to:

1. Drilling footage to primary target area is drilled only once.
2. More production or payzone exposure
3. Reduction of platform costs
4. Better utility of existing platform slots and existing wells
5. Extend life in marginal fields
6. Environmental concerns lessened

However, this comes at potential costs of risking loss of a parent hole and significant production if the well goes down. Also, to date there have not been many wells completed in the level 3 and 4 categories. The reality is that multilaterals are in the open hole environment. The intervention side of a level 3 and 4 wells does not have a history yet.

Issues

Well control requires additional precautions and measures compared to well control used in single bore wells. Also, impairment and cleanup of individual laterals or branches is an issue in industry.

Future Focus of R&D Efforts

Once a multilateral has been completed as either type 3 or type 4 (achieving some degree of isolation), there are still significant issues regarding the optimization of production and reserves. Crossflows from one lateral to another is an issue which could cause the loss of production and reserves. Situations can exist in which one lateral may be at significantly higher pressures and would be the only lateral really contributing production. If we drill a well with 4 laterals/branches into different reservoirs with different pressures, when do we complete? The industry must look at full well strategy which includes the capability to tie back a lateral to surface (like vertical duals). The problem becomes "What well branches are tied back?". Some operators are looking at "big hole" concepts for multilateral, multibranch applications. A "big hole" could allow running tubing completions to particular laterals.

References

1. L. T. Stanley, Practical Statistics for Petroleum Engineers, Petroleum Publishing Company, Tulsa, Oklahoma, 1973.

2. P. C. Crouse, Philip C. Crouse and Associates, Inc., Dallas, TX, "Economic and Risk Considerations for Coiled Tubing", PNEC 2nd International Management Conference on Coiled Tubing Technology and Applications, February 1994.

3. P. C. Crouse, "Screening and Economic Criteria for Horizontal Well Technology", SPE 23617, March 8-11, 1992, 2nd Latin American Petroleum Engineering Conference.

4. P. C. Crouse, The Economics of Horizontal Drilling, Training Manual, Gulf Publishing Company, Houston, Texas.

5. P.C. Crouse, Philip C. Crouse and Associates, Inc., Internal memos for Client Research from 1993-1996.

6. D.B. Bennion, Underbalanced Drilling Operations and Technology Short Course by Bennion, Lunan, and Crouse, Petroleum Network Education Conferences Publishers, Section 13, page 20.