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Enabling Change with New Technology and Integrated Operations

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Abstract

The introduction of a new downhole digital technology has the potential to revolutionize well intervention operations through performance management, faster decision cycles and organizational change. The new system has the ability to send real-time downhole data from well intervention operations to the surface, and from there to data centers anywhere in the world. The system facilitates collaborative work by engaging a broader spectrum of specialists than has been traditionally available at the wellsite.

A major benefit is the technology's capability as the catalyst for bringing about the significant organizational change required to replace currently aging offshore personnel with an adequate supply of competent employees within the context of the existing management and supply chain systems. Case studies are presented taken from over 20 field runs conducted during field integration testing.

Introduction

This discourse concerns the metamorphosis of traditional oilfield working methodologies into a new way of working enabled by the introduction of a new technology into a new market.

The discussion investigates:

- what the technology does and how it works
- the implications for collaborative work
- one solution to the "graying workforce" issue

This example is set in the field of well intervention, a substantial sector of the industry. In this case it is specifically within the context of wellbore intervention; those operations concerned solely with downhole operations such as service tools, casing exits and fishing operations, services most of which are generally delivered by pipe-conveyed downhole tools, and in some instances, by coiled tubing. Wellbore intervention can be properly defined as "the often unplanned act of intervening in an unacceptable downhole situation to modify it to a satisfactory condition."

Enabling Change

Step changes in technology such as this are often accompanied in their introduction by requirements for new skills and for higher levels of education or training. Always, however, they are accompanied by changes in working practices and require adaptation by the people "at the sharp end." In this instance, this process of change breaks entirely with traditional models of work and reconstructs an entirely new model of collaboration that has implications for all who work in the energy sector.

Performance: A Break with the Traditional Model

Before any break with tradition can be explained, the traditional model must be examined. The tools and techniques used in wellbore intervention originated in the earliest days of oil well drilling. For most people the term "drilling" conjures up an image of a rotating element, such as a twist drill or a spiraled rod of steel with a sharp tip, being pressed into a workpiece. For oil industry insiders, the term usually suggests an image of a drilling assembly, with drill pipe rotating inside a tapered rig structure or derrick built from steel spars. While the image may be familiar and convenient, it is not necessarily so, as in the origins of the industry the hole was “drilled” or rather “made” by impact tools run down on lengths of cable, or “line.” Often the tools would break and an operator would have to go “fishing” for the broken pieces with some form of “bait” on the end of the line. If progress was halted, then a wooden railroad tie, or sleeper, could be dropped down the well. When impact drilling operations recommenced, the well would take a new track along the angled timber baulk at the bottom and would be “side-tracked.” This feature is the origin of “whipstock” and casing exits. As wells became deeper and more complex over the next hundred years, operators grew in skill as they manipulated all forms of downhole tools, aided only by surface observations and intuition gained through experience.

As the new era of ultra-deep wells dawned, with their high friction and high torque, new factors came into play. It became much more difficult to see, deduce or imagine what was happening to the fishing or other intervention tools at the bottom of the well. The only information available was very limited: the rotary speed and torque, the hook load, a few other tell-tale indicators. The behavior of tool systems at the bottom of the hole was becoming less predictable and widely variant from what was happening at the top of the hole.

The same situation exists today. Most well intervention jobs that get into difficulty do so because of a lack of accurate downhole information. Because any uncertainty or confusion in downhole well intervention operations can cause very significant non-productive time (NPT) costs, the need for skilled, experienced Tool Service Technicians (TSTs) is greater than ever before.

As with traditional upper management, TSTs often take a very long time to mature, and by inference, to replace. They are in the upper, older quartile of energy industry demographics. They often require at least 10 years of oilfield experience before they start training, and many have 15 to 40 years of post-training service. Traditionally, there were never any fast-track routes to becoming a TST, but at a time when industry costs are escalating rapidly, innovative methods of collaboration and organizational change can provide a new paradigm.

Description of Applied Technologies

Until now, true downhole conditions such as push, pull or torque on an intervention tool could not be evaluated accurately from the surface. The results of an operation were unknown until the tools were retrieved to surface. A smart system for well intervention work now provides new levels of closed-loop control with real-time decision-making capabilities, and by doing so, elevates the system, and well intervention operations, to the realm of process control.

Based upon a conventional intervention bottom hole assembly (BHA), the system adds an intervention performance sub, a measure-while-drilling (MWD) tool, and a rig floor smart box and cabling to provide parametric information at surface that physically characterizes the true downhole environment in real time. Downhole information is presented in an easily understandable format on a rig floor monitor. By then transmitting that data to a remote data center or client operating center, collaborative work is enabled with an expanded world-wide well team, one that can contain as many and as diverse specialists as necessary. By immediately understanding what is happening to the tools at the bottom of the hole, well intervention teams can optimize operations consistently and reliability. This performance feature greatly reduces uncertainty and risk by combining good risk management with real-time decision making. The real-time advantage is particularly beneficial for remote or offshore rig sites.

A smart intervention system requires a number of primary components. From bottom to top, they are:

1. A sensor array to measure true downhole parameters
2. A signal processor to digitize the sensor outputs and quantify the results
3. A data processor to process the results downhole and compute critical and useful data
4. A memory module for storing raw data for later analysis
5. A data encoding module to encode data for uphole transmission
6. A power module
7. A downhole signal transmitter
8. A surface signal receiver
9. A surface signal decoder
10. A surface data processor
11. A surface visual display for converting data to an easy-to-understand format
12. A transmission system to forward the data to a remote team
13. A competent rigsite employee to interpret the data
14. A remote team of specialists to observe and assist the operation

This technology list can be conveniently summarized and packaged into the following systems:
Items 1-5: intervention performance sub
Items 6-7: MWD sub
Items 8-12: surface system
Items 13-14: personnel

Management of Data

The current use of MWD tools for data transmission includes the apparently inherent drawback of limited bandwidth. To overcome that inconvenience, all the data is processed downhole by a digital signal processor (DSP) in the intervention performance sub, and only the data most pertinent to that particular operation is selected for transmission to surface by the MWD tool. By using only selected data, the refresh rate is high and the MWD transmission channel is fully utilized. The MWD transmission system is bi-directional, that is, it can downlink as well as uplink data. The surface smart box interprets the data and a visual display unit presents the downhole parameters in the most meaningful format. Further refinements can extend the capabilities of selectable data transmission.

Case Studies

System integration testing in a deepwater Gulf of Mexico environment generated and analyzed real-time data streams. The smart system provided answers to questions that have been asked on well intervention jobs for decades: What's the weight on mill? Have we got the fish? How much torque are we applying downhole? How much tension are we pulling on the overshot? How straight is the exit window? What's the dogleg like? Many of these questions were answered through real-time collaboration.

Many casing exit jobs have been performed with very encouraging results. The system has successfully identified detrimental conditions on several of these jobs, some of them serious. These conditions fall into two primary categories: dynamic and bending. In the dynamic category are destructive conditions, such as stick-slip, whirl, or torsional vibration, which left unchecked can lead to connection twist-off, fatigue, or severe cutter damage, conditions that increase the duration and cost of a section. In the bending category, component fatigue appears again, together with window profile, window ledges, and unacceptable doglegs. On fishing operations, objects ranging from 250 to 260 lbs were confirmed at great depth. On well cleanup operations, small changes in BHA weight indicated capture chambers being filled with debris as intended, but these conditions never before were seen or indicated in real time. Figure A shows a map of bending data received at surface in real time during a casing exit operation.

In many of these operations, data relayed to remote real-time operating centers enabled collaborative work through the extension of traditional well teams. In all of these operations, poor operating parameters were detected in real time, acted upon rapidly and optimized for positive outcomes.

Collaboration

In the traditional model, the success of a well intervention job is very much dependent upon the experience of the rigsite TST. Although surface data can be sent to remote data centers and client operating centers, most decision-making is done at the rigsite where the TST and local operations team must have the "feel" for what is going on downhole.

The smart intervention concept is changing that situation. Decisions can be made based upon facts instead of "feel." On many of the initial jobs, the downhole data and the surface data sent to the client's remote operating center allowed team decisions on crucial operations at a level not previously available on well intervention operations.

On some of the jobs, data was sent both to the client's and the service company's data centers, allowing timely access to wellsite data and to teams of skilled professionals when crucial decisions were required. Of particular value were instances of maximum collaboration and utilization of the team resources when clients and service companies were widely separated by geography; something that would apply to time zones also.

Organizational Change

Here again, we must break with tradition. The traditional model of recruiting and training TSTs is a long, slow-moving process, especially for those being recruited directly for more advanced positions.

A traditional model based upon industry experience posits a technician with pre-hire experience of 10 to 12 years.

This figure reflects the hiring pool and experience preference for drillers, toolpushers, or exceptionally talented individuals with in-depth experience of downhole activity, that is, an understanding of how a drilling rig and ancillary systems work as a whole machine. For such an individual, a typical training program including theory and field experience on increasingly difficult and complex jobs may last up to 2 years.

For example, an individual starting at age 21 and gathering 14 years of experience and training produces a competent high-level TST at age 35. With typical service periods ranging from 15 to 40 years, it is not difficult to see that replacement for the average individual by another competent employee may be required in about 10 years. The key word is competent. How they get there does not have to be the same route. Much past experience has been gathered by nothing more than the passage of time and an individual being subjected to enough good and bad situational experience to be able to develop an unfavorable situation into a favorable one.

Today's more technical industry has very different personnel requirements, with a college or university degree often being a minimum standard of education. This elevated requirement brings with it significant pitfalls as well as benefits. The first pitfall is that the potential pool of employees has been reduced significantly, and these more highly educated candidates may not necessarily view the energy sector as the most appealing arena in which to begin their careers. However, the core issue of an aging workforce brings with it a very appealing possibility of an accelerated career for many with the right motivation and drive.

Another facet that has changed is the long period of situational experience. If training programs are targeted specifically at developing the precise skills sets required, the training portion of career development becomes more efficient. In conjunction with proprietary knowledge management tools and resources, the whole training experience can be compressed dramatically. How these well-educated, well-trained individuals actually perform in the real world remains the "acid test."

By using the smart intervention system, existing and new TSTs are getting instant feedback on the results of their decisions and actions. The well intervention process is vastly more immersive, and because the immersive experience takes place in real time, the lessons learned are accelerated rapidly. Further, much of the data on smart intervention jobs is recorded, so the real world jobs can be taken into the classroom and used as training simulations. The level of complexity of a real job is much greater than can be invented for a simulator because the additional real job data and performance anomalies, whether dramatic or subtle, further test and accelerate trainee knowledge and decision-making abilities.

As the technology itself is only now just coming on the market, the new training model is only a proposal at this time. Conceivably, the typical period of acquiring competency could be compressed from as much as 14 years to as little as 3 years. Following the current stage of technology commercialization, candidates will have to be trained following new accelerated models. The next step in the process will be the development of credibility of the "new model" Tool Service Technicians in the very real world of well intervention operations.

Conclusions: Challenges and the Way Forward

The key challenges to be faced are as follows:

- Technical success of the new smart system in a myriad of well conditions
- Commercial acceptance of the new smart system
- Recruitment of the right people to run the new systems
- Creation of an accelerated training program utilizing the attributes of the new system
- Rig floor credibility of a new generation of tool technicians

The new technology is a huge step forward and will revolutionize well intervention as it is known today, particularly in deep, problematic and high-risk wells. By using the downhole data in a collaborative environment founded upon knowledge transfer, uncertainty is dramatically reduced and risk becomes a known and manageable entity. The training concepts described will dramatically accelerate the learning experience regarding downhole tools and operations, especially when used in conjunction with knowledge management tools.

References

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Figure A
PLOT OF REAL TIME CASING EXIT BENDING (y) AGAINST DEPTH (x)