## Looking into the future with

# Vik Rao, Halliburton

**By Linda Hsieh, associate editor**

VIK RAO IS senior vice president of technology for Halliburton.

**DC:** How do you envision rigs of the future considering the drilling challenges they will encounter?

**RAO:** One, there will be more automation — not mechanical automation but automation of information handling and decision making. There will be more high-bandwidth connections to rigs, and rigs will have more real-time controls from onshore. I believe we will eventually have fewer people on rigs due to real-time decision-making onshore. Up to now, technology hasn't reduced the number of people, but it's heading in that direction.

Vik Rao

**DC:** What kinds of capabilities will rigs have in order to enable efficient drilling?

**RAO:** I think there will be more — and I'm using the term loosely — artificial intelligence, meaning more networks, more heuristics and reasoning installed into software that will make drilling more efficient.

**DC:** With the need for these capabilities and technologies, do you think they will push a trend towards bigger or smaller rigs?

**RAO:** My view is that if technologies such as expandables and mono-diameters take hold, rigs will become smaller. With these technologies, operators could drill with second-generation vessels instead of fifth-generation vessels. Of course, this is an if-then prediction.

**DC:** Will we continue to drill deeper and deeper?

**RAO:** Without question. The most interesting part is the lower tertiary rock we are penetrating now. In the past, deepwater drilling has always been in young formations because deepwater by definition was younger sediment. Now we're going after the deeper horizon, greater than 20,000 ft below the mudline, and we're finding great untapped resources.

Many people had been concerned about permeability because old rock tends to be very compact. That appears not to be the case in Jack, which may be the harbinger of many good tidings for ultra-deep.

**DC:** How much deeper can we go?

**RAO:** In my view, that is limited by only one thing — materials.

**DC:** Why is that? Why is it not limited by other things?

**RAO:** Because of mono-diameter. Mono-diameter wells can take you to unlimited depths because you do not lose hole size upon hitting and encountering an overpressured zone. The only issue is, at some point, it gets too hot and too heavy in pressure. However, we're ways away from that. Now we are drilling to 32,000 ft and making it. Materials likely won't become a serious issue until 40,000 ft or beyond.

**DC:** What will the new upcoming technologies mean for rig crews and for safety?

**RAO:** Because future rigs will incorporate real-time decision-making, safety will be improved because more experts will be able to participate. There are only so many people you can put on a rig, but now you can have experts onshore looking at the same data and working problems. There's no doubt in my mind that safety will be improved singularly by real-time decision-making.

**DC:** What will be the characteristics of future reservoirs? Considering those characteristics, what are the areas of innovation we need to focus on in terms of equipment and technologies?

**RAO:** One is unconventional hydrocarbons in 3 forms — heavy oil, shale oil and tight gas. Reputable estimates put recoverable reserves of heavy and shale oil at over 2 trillion BOE. To give you an idea of what 2 trillion BOE means — the world has consumed about 1 trillion from the beginning of time up to now.

In the near term, tight gas is the most important unconventional resource. There are a number of tight gas prospects we wouldn't have thought prospective before. If you look at these rocks, you wouldn't dream of producing gas from it. But we do, and we do that by fracturing. It's a significant play already.

Next is heavy oil, which still only makes up less than 2% of the world's production. Many people, including me, believe that more than 10% of the world's production will be heavy by 2020. I believe it will take off in 5-10 years, mainly because there won't be enough conventional oil.

Finally, deepwater and deeper horizons within deepwater will be important. Improved recovery will become critical. Recovery averages around 30% in primary production now. Taking that to 60-70% will be a goal.

For shale oil, it needs to be "cooked" to convert it into useful hydrocarbon, so we need temperature and pressure. We can accelerate that cooking process, which nature did in a million years or more — but we'll have to put it underground. It would be uneconomical to bring it up and "cook" it on the surface. To have shale oil in an economical form, we'll need underground refineries so we can effect molecular transformations downhole. I don't see this happening within 10

**Q: What will future reservoirs look like?**

**A: Unconventionals in the forms of heavy oil, shale oil and tight gas. Deepwater and deeper horizons will also be important.**

years — perhaps 15 — but it's an exciting possibility.

The bottom line is that these are the new reservoirs of the future; therefore technologies will be needed to address them.

**DC:** What will it take for rotary steerables to be more widely adopted?

**RAO:** Rotary steerables is one of the most significant advances in drilling — maybe the most significant — in the last decade. It has enabled efficiencies like I never thought it could before. What we need now is higher reliability and lower cost. I believe that will happen in the next 5 years.

**DC:** What about intelligent completions?

**Q:** *What stands in the way of intelligent completions?*

**A:** *It can be difficult to take the long-term view of spending on CAPEX today to reduce OPEX tomorrow.*

**RAO:** Buyers have to take the long-term view, which often isn't easy to do. It's a classic case of spending on CAPEX today to reduce OPEX tomorrow. With intelligent completions, it even goes beyond operation costs. If intelligent completions is used correctly in stacked reservoirs, operators can commingle and produce multiple reservoirs simultaneously as opposed to sequentially. Technology-wise, we do need improvements, but that won't happen if the volume is not there.

**DC:** How about drilling with casing and liner?

**RAO:** You have to take a systems view. It's a risk, and our risk-averse industry is generally slow to update. This applies to expandables as well. To this day, they are largely used for contingencies. The industry should look at risk from a probabilistic standpoint. Expandable liner hangers cost more, but they have virtually no failure because they have no moving parts. If you look at a given well, you don't get the answer. If you look at a compendium of wells, it's clear that spending more now will obviate the risk of rework. I think we need to take a probabilistic view of the value of the technology in order to move forward, particularly with casing drilling, expandables and underbalanced drilling.

**DC:** How will underbalanced drilling and managed pressure drilling factor into the industry's future?

**RAO:** MPD and underbalanced drilling are nearly the same; they use the same technologies. If you can drill closer to the pore pressure, you can cut the rock faster. Managed pressure drilling is drilling closer to balance, which has tremendous implications for rate of penetration and the quality of the hole. Underbalanced drilling is going to be important because it is essential when drilling through depleted intervals or through rock damaged by fluids. Drilling underbalanced increases production, no question. Of course underbalanced drilling has risks, but I believe real-time decision-making will help because it allows more experts to work on the well.

**DC:** What technologies or tools will be needed in order for the industry to optimize directional drilling and extended reach?

**RAO:** For extended reach, we need more reliable rotary steerables. For both directional and extended reach, the biggest advance will be the seamless integration of drilling and geophysics.

**Q:** *How long before we seamlessly integrate drilling and geophysics?*

**A:** *In terms of wider acceptance, in the 5- to 10-year time frame.*

In the past 20-30 years, the most critical advances that have allowed us to drill faster have been steerable motors and PDC cutters. Then we integrated measurement while drilling. We have already seamlessly integrated directional drilling with MWD, rotary steerables and formation evaluation. The future is seamlessly integrating drilling and geophysics. Currently we drill to a 3-dimensional space, and that point is arrived at from exploration and seismics. We realize that point is inexact because reservoir engineers don't know enough — there are salt sheets covering the resources underneath. Once we drill down, we can see in a way that seismic can't. If we update the earth model using that information, then we'll get startling clarity in those models, which we can use in real time to guide the bit. That's the future of directional drilling.

**DC:** How close are we to that?

**RAO:** I see something happening within 3 years, but in terms of wider acceptance, I see it in that 5- to 10-year time frame. The reason I put it that far out is because I saw how long it took for the industry to truly integrate petrophysics. It takes longer than one thinks because of human beings, not so much the technology. Integrating geophysics will require directional drillers to accept a different workflow.

**DC:** What areas of innovation should the industry focus on for deepwater drilling?

**RAO:** We still need better subsalt imaging. We're doing it better than we ever did it before, but it is still like looking through shattered glass as opposed to clear glass. More than 45% of the Gulf of Mexico and similar deepwater plays are salt-overlaid. We need greater advances in subsalt imaging for the big deepwater breakthroughs.

**DC:** And for multilaterals?

**RAO:** To take it to the next level, we need better junction integrity of level 4 multilaterals. Multilaterals work on levels, and level 5 is the most common. It requires metallic isolation between the motherbore and the sidebore because the junctions don't hold up, particularly

in deepwater with soft formations. If the integrity of the rock at the junction can be improved, then cost can be reduced by going to a level 4. That would dramatically increase the use of multilaterals.

We will need formation consolidation technology in order to achieve that, and I think it will happen in the next 5 years.

**DC:** What do you see in the future for HPHT?

**RAO:** The industry needs a better economic justification widescale: What is the real need? What temperature and what pressure? Some of the ultra-deep plays, like Jack, are high-pressure but not high-temperature. The cost of development, but more importantly, the cost of the tools for HPHT is very high. As in rigs, utilization is everything. I agree that we need HPHT, but in terms of the work we're doing, that's not the issue. To optimize the scenario, the industry must share what the challenges are, just like it did in deepwater, which transformed our ability to serve that market.

**Q:** ***What's the biggest advantage of mono-diameter?***

**A:** ***It's not necessarily the smaller footprint but the bigger conduit when you get there.***

**DC:** What have been some revolutionary advances in the industry over the past decade and what types of revolutionary advances do we need to see in the coming decade?

**RAO:** In the past decade, I would say subsalt imaging and rotary steerables are the 2 most significant advances that have enabled horizons to be penetrated. For the coming decade, I mentioned it before — coupling drilling with geophysics. That will be the great advance.

On production, it's estimated that by 2010, more than 50% of the production will be from prolific but sand-prone wells. A major advance would be preventing sand from coming in without requiring a lot of screen. That will require formation consolidation in a clever way, meaning consolidate the formation but not materially damage the permeability.

Then there's mono-diameter. Many people think of mono-diameter as a way to go to unlimited depths, but I think the really big advantage is not necessarily the smaller footprint but the bigger conduit when you get there.

Finally, for unconventionals, the revolution will be in-situ molecular transformations as mentioned earlier. Whether that will happen in a decade, no one knows, but it's absolutely on the way.

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