The New Technology Frontier: Moving Oil and Gas Production to the Seabed

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World demand for oil and gas shows no signs of diminishing. In fact, the U.S. Energy Information Administration reports that world-marketed energy consumption is projected to increase by 49 percent from 2007 to 2035. Production of crude oil, however, may have a difficult time keeping up with the pace of demand. According to the International Energy Agency’s 2009 World Energy Outlook, crude oil production from existing fields will drop by almost two-thirds by the year 2030. In addition, it is anticipated that oil and gas companies will need an additional 2,700 billion cubic meters (BCM) of natural gas capacity just to keep up with the ever-increasing demand for this type of energy resource.

To compound the problem, there is simply no such thing as “easy oil” anymore. As a recent article in Slate by Daniel Gross explained, the exhaustion of onshore and shallow water reserves have pushed exploration and production further and further out to sea. By moving further offshore, producers face fields in increased depths technological and mechanical challenges. According to Wikinvest, rigs capable of deepwater production are in low supply and high demand, and it can take up to 10 years for a deepwater field to start producing.

There are additional environmental and safety risks production as well. For example, deep-water platforms often require helicopter transportation for supplies and staff, which have relatively high risks of fatal accidents, according to the International Association of Oil and Gas Producers’ risk assessment data.

In addition, production platforms in deep water are particularly vulnerable to potentially catastrophic events ranging from explosions to ship collisions, and are capital intensive. It typically costs more than $1 billion to operate a production platform over a 10 to 20-year life cycle.
Subsea Could Be the Answer

As operations move further offshore, not only do the potential risks compound, but also the potential gain. Due to the loss of pressure caused by the extraction process, some hydrocarbons are simply non-recoverable – there is not enough natural pressure to push oil and gas to the surface. It is estimated that by moving production to the seabed and thus decreasing the amount of pressure needed to extract resources from the earth, oil and gas companies could recover up to 20 percent more resources from producing fields. In addition, subsea production facilities can cost up to 50 percent less to operate than surface platforms due to the decrease in topside staff and supplies.

The implications for the boost in recovery combined with the reduction in capital investment are huge. Companies could explore smaller, deeper fields that might not have been economically viable previously. They could mine reserves located in arctic environments not conducive to a topside production platform. In short, oil and gas companies could potentially have access to the additional resources necessary to serve the enormous global demand.

Technology Challenges

While companies have long anticipated the potential benefits of subsea production, reality has prevented it from happening. Until recently, the idea of building an entire production facility thousands of feet under the sea probably didn’t seem much different than building one on the moon. While many could see the opportunity, the technology was not available to produce in an unmanned, complex environment 3,000 meters below the surface.

However, over the last ten years, oil and gas producers around the globe have started developing pilot subsea compression stations. If these pilot projects prove successful, the reality of subsea compression has the potential to change the landscape of future offshore production, increase exploration and production efforts and eliminate the need for – and risks associated with – a topside production platform.

Companies participating in various pilot projects understand the potentially vast economic, safety and environmental benefits that subsea production represents. At the same time, cutting-edge compression technology has matured to the point that it is ready to be marinized, miniaturized and ruggedized for the pressure constraints, corrosive environment and frigid temperatures that existed subsea.

The latest subsea compression systems typically measure 12 meters high, 35 meters wide and 49 meters long, and are roughly the size of a football field. A platform of this size is required in order to allow room for a remote-operated vehicle (ROV) to assist in maintenance of the system.

The complexities of the system also require some of the most technologically advanced equipment available. Equipment on the systems include multiple compressor trains, variable speed motors, separate vessels and coolers, pump and level controls, transformers, electronics and liquid slug and MEG handling – each thoroughly tested and designed specifically for the harsh subsea environment.
The Brains Behind the Brawn

To control giant subsea platforms, oil and gas companies need closed-loop controllers to help protect against dangerous pressure surges that could cause catastrophic failures in the expensive compressors. This type of system also requires a controller that matches the Eurocard circuit board format that fits in existing subsea-qualified enclosures, to save the time and expense associated with designing and testing an entirely new enclosure usable at extreme depths.

These platforms typically use machinery and components from a large number of vendors in order to test as many potential components as possible. This helps the company using the platform to produce oil to identify best-in-class solutions most likely to hold up in such intense conditions prior to installing the system subsea. In order to communicate with a variety of devices, it is critical that the control system leverage a standard programming environment. The end user also requires that the control solution feature simplex, redundant or triple modular redundancy levels to meet each supplier’s needs.

As companies look toward executing this cutting-edge approach, it’s important to look for a control architecture that offers dual, closed-loop independent subsea electronics modules (SEMs), each with a redundant central processing unit (CPU) for improved availability to help boost throughput. This also provides physical separation to minimize loss of contact during safety events, along with multiple Ethernet channels to onshore operations. The control system should support online reconfiguration, such as adjustment of input thresholds, without necessitating a process shutdown, and be built for IEC-61131 compliance with integral support for all five programming languages.

The AADvance controller from Rockwell Automation has been implemented in several subsea compressor control applications to provide the multiple redundancy levels required. Its scalable design allows oil and gas producers to add up to 48 I/O modules if necessary and is based on commercially available, off-the-shelf technology. This allows the end user – and the many companies involved in a project – the ability to focus on cutting-edge design rather than time-consuming customized programming and engineering.

An automation engineering team also modifies the electronics to fit a Eurocard circuit board format, which fits in subsea-rated enclosures rated to a depth of 3,000 meters. The modification then receives thermal testing ranging from -20 to 70 degrees C, as well as severe vibration testing on special test jigs.
Success

Oil and gas companies involved in the development of subsea technology estimate that in addition to increasing overall field recovery by up to 20 percent, subsea production solutions like the pilot compressor platforms offer the potential to reduce capital expenditures by 30 to 40 percent, and overall operating costs by up to 50 percent.

Because subsea platforms are designed to pump gas directly to onshore production facilities, oil and gas producers will not require any topside structure whatsoever. As a result, they will improve safety by reducing the number of personnel needed to operate the platform production facilities and reduce any negative impact from weather. They also will be able to expand exploration and production into even less hospitable arctic regions.

While the pilot projects currently underway focus primarily on compressor control, many leading oil and gas companies see potential for similar control systems to be used for a wide range of future subsea applications, including gas separation, high integrity pressure protection system (HIPPS) control and water disposal.

This new breed of best-in-class technology is allowing companies to explore and produce in areas never thought possible, perhaps providing the much-sought after answer to the question of where do we go from here?