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Multiphase Pumping Comes of Age With Incremental Gains In Equipment Reliability, Industry Experience In Variety of Applications

By Sven Olson

ALLENDALE, N.J.–From Chevron's plans for long-distance power and multiphase boosting at the sanctioned Jack/St. Malo development in the Gulf of Mexico Lower Tertiary trend to a Shell-led program to develop a high-boost multiphase pump and electric motor system for deepwater applications, subsea boosting in deep- and ultradeepwater fields is a major future driver of multiphase pumping technology.

However, multiphase pump technology has come of age over the past decade onshore as well as offshore as an oil and gas field production tool. Both helicoaxial and the twin screw pump designs have been installed onshore in a number of oil and gas production and enhanced recovery projects as well as offshore in both topside and subsea applications in a range of water depths.

Multiphase pumping allows the entire production stream from wells to be gathered and boosted to a central processing facility without requiring separate flowlines, separators, heater treaters, intermediate storage tanks, gas flares, compressors or dedicated pumping facilities for oil, gas and water. Eliminating this equipment means substantially reduced facilities and a much more economical installation for pressure boosting production so it can move farther downstream for processing.

The principle of flowing the untreated well stream in a pipeline before separation and processing provides a simplified and economical means to transport hydrocarbons over longer distances from the producing well. That would be ideal and works as long as the energy in the reservoir can overcome the pressure drop created by drag losses, terrain obstacles and the arrival pressure in the first-stage separator. When that no longer can be achieved, artificial lift and boosting become a necessity. There are many principles and alternatives for artificial lift boosting, although most require separating liquids and gases, and are more focused on liquid production.

Building on the total system approach of integrating multiphase pumps into the production process, manufacturers are offering turnkey multiphase pumping solutions such as those pictured here. This allows manufacturers to extend pump operations to very high gas fractions and pressure ranges.

Unique Solution

Multiphase pumping offers the unique solution to boost both gas and liquids in a single process with a single piece of machinery. This feature is becoming increasingly familiar to operators as an additional tool to economically produce oil and gas, especially in marginal and deepwater fields.

The technology behind multiphase pumping has been known for many years, with certain types of pumps proving more gas tolerant than others. In the early 1990s, this knowledge was put to the test in theoretical studies at universities, mostly in Europe. It showed that such a pump could be built successfully.

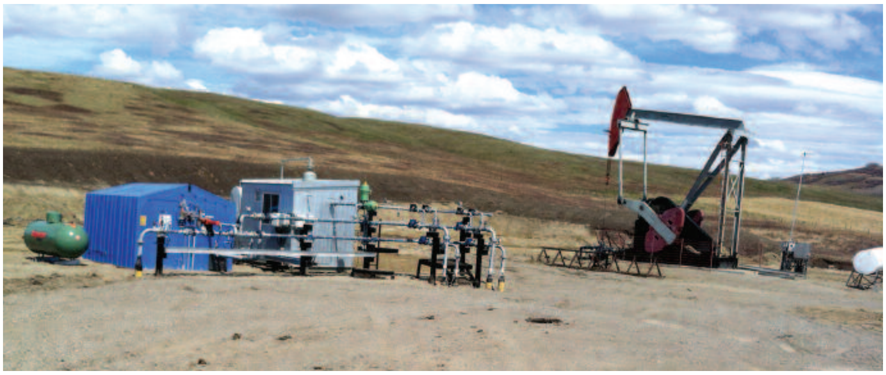
Prototypes were designed and tested at several testing facilities in Europe and the United States, and pumps were offered to oil and gas companies for testing by manufacturers. Test facilities such as Texaco's facility in Humble, Tx., and Total's facility in Solaise, France, offered unique opportunities for manufacturers to run and collect data from pumps working with actual crude, water and natural gas.

In the latter half of the 1990s, pumps were installed by operators in actual field tests at sites in Indonesia, Canada and the North Sea. A forum for users of such pumps was created with the annual Multiphase Pump User Roundtable meetings, the first of which was held in 1999 in Houston. The event has since been alternating between Calgary and Houston, and also has been held in Europe and South America. As time passed, the number of pumps installed grew rapidly from these initial field tests, serving onshore, offshore and subsea producing fields all over the world.

At the same time, pumps grew in size from a couple hundred horsepower initially to several thousand horsepower as they were installed in ever-larger gathering and boosting facilities. Process technologies became integral with the pumps, creating large packages especially for subsea deployment. The experience gained from the field was turned into product improvements, and multiphase pumps have emerged as a reliable piece of machinery under even the most difficult operating conditions.

The principles used in multiphase pumping turned out to be different, with certain technologies better suited than others for a given operating scenario. Typically, twin-screw pumps became the choice in heavier crude and higher gas fraction applications, while helicoaxial and electric submersible-type pumps designs were used with lighter crudes, high-volume and low gas fraction applications. The demand for higher boost pressures, especially subsea, has called for developing new products and using hybrid pump technology. In smaller ca-

Multiphase pumping offers the unique ability to boost both gas and liquids in a single process with a single piece of machinery in both onshore and offshore applications. Shown here is a typical multiphase pumping unit in on onshore installation.



Multiphase pumps eliminate the need to separate associated gas, enabling the entire production stream to be moved to a processing facility without flaring or venting, or a separate gas gathering system. Shown here is a multiphase pump installation for casinghead gas.

pacities, progressing cavity pumps and piston pumps have found niches where the simplicity of the designs could be employed.

Today, twin-screw pumps dominate the installed base of approximately 500 pumps, with helicoaxial a distant second, and a limited amount of other technologies also installed around the world.

Increased Reliability

The most important steps for all these technologies have been the dramatic increase in reliability and availability. "Infancy" problems, such as mechanical seals and bearings, have been improved dramatically as pump and component manufacturers worked together closely. The experience gained by operators has been put to use in a remarkable fashion, and the "book of lessons learned" from the field has been the source of many product improvements. What today are regarded as obvious and necessary for reliable operations of these pumps in the field were often novelties or uncharted waters 15 years ago.

Examples of such improvements are diamond-faced mechanical seals, and stellite and other coatings used on rotors and wear parts. Also important is the addition of instrumentation and monitoring of pump operations. Standard specifications were created using the experiences from the past, resulting in efficient and cost-saving equipment monitoring. Process control with variable speed electric motors or torque converters has increased the operational window of the pump and allowed it to respond easily to changes in reservoir conditions.

The "total system" approach has gained additional market response as multiphase pumps have been integrated into the complete production process. Manufacturers have added to their knowledge in system design and integration, and today can offer complete turnkey multiphase pumping installations. This also allows manufacturers to extend pump operations to very high gas fractions and pressure ranges.

Shown here is a complete system delivery for an offshore platform. One of the advantages of installing multiphase pumps topside is a reduced footprint and eliminating vessels, tanks, pumps, compressors and other production equipment.

The drivers behind multiphase technology have remained basically unchanged over the years. The obvious advantage of boosting allows producers to accelerate production, increase total recovery and delay the abandonment of mature assets. This has proved to be correct in cases where there was a good understanding of the reservoir.

However, the results can be less obvious in tight formations. Using multiphase pumps to lower annulus gas pressure has shown to be effective to increase production. In these cases, pumpjacks are on pump-off control and have responded with greatly increased uptime. Here, the economic return is instant and a very tangible proof of the advantage of multiphase pump technology.

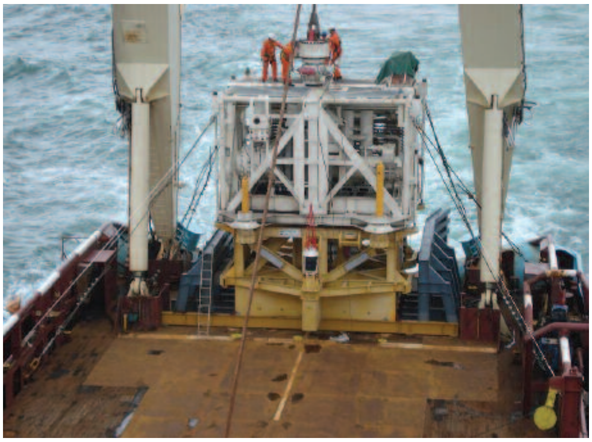
A second important driver is the ability to use multiphase pumps to reduce facility requirements, particularly in newly developed fields with central processing instead of processing at satellites or batteries. A multiphase pump is able to transport the untreated well stream over great distances, significantly reducing the capital and operating costs of decentralized processing.

With the addition of multiphase metering for well testing, the production operations also can be simplified. This approach has been used by operators of new field developments in remote areas, and provides a way to rationalize separating and treating oil and gas in existing facilities. In one example, an operator eliminated a complete dehydration plant with separate heater-treaters and stock tanks with three multiphase pumps that moved the production to an underutilized facility for processing.

Environmental Attributes

The environmental attributes of multiphase pumping also have become a very important driving force. Flaring or venting associated gas during oil production is no longer an option in most producing regions around the globe. With multiphase pumps, the need to separate the gas is eliminated, since the entire production can be moved to a facility for processing.

The lower pressure at the wellhead also frees additional gas and the pump manages the entire production in a controlled process without the need for flaring, venting or a separate gas gathering system. Moreover, the gas added to the liquid stream reduces drag losses in flowlines, and the energy of the associated gas is not wasted and can be used for local power generation, which should be favorable on sites with underdeveloped



Subsea boosting is emerging as a major growth area for multiphase pumping, and is a key driver for future advancements in multiphase technology. A sharp rise is expected in subsea multiphase boosting installations in deep- and ultradeepwater fields, some of which cannot be produced without boosting from the first day of production. This photo shows a pump as it is being prepared for deployment in subsea service.

electricity grids.

Eliminating large vessels, tanks, pumps and compressors also must be added to the environmental aspects. A multiphase pump has a reduced footprint compared with conventional separation, which should benefit production in ecologically-sensitive areas.

In addition, developments in multiphase technology also make it more possible to use the pumps instead of compressors in wet gas compression, but without liquid scrubbers and blow cases. Wet gas compression is used in rapidly growing unconventional gas production as well as in subsea compression directly at the well on the mud line. For twin-screw pumps, screws with various rotor leads or so-called digressive screws can be used, while contra-rotating impellors have been developed and are being field-tested in hydrodynamic machines.

In shale gas installations, wet gas compression enables water-logged wells to be freed and water to be brought to a more convenient site for reclamation. In cyclical steam stimulation, multiphase pumps gather the annulus gas (mostly vapors with some hydrocarbons) and commingle it with the bitumen. This not only reduces equipment requirements substantially, but also has a very positive environmental impact. More than 100 multiphase pumps are supporting this application in Canada alone.

Subsea Boosting

That said, the most exciting area for multiphase boosting probably is in subsea development. A sharp rise is expected in subsea multiphase boosting installations from relatively modest numbers of installations over the past 15 years, driven by the deep- and ultradeepwater plays with enormous amounts of recoverable hydrocarbons. Some of these fields, especially those with heavier oil reserves, cannot be produced without boosting from the first day of production.

Subsea boosting is being tied with subsea processing, and sand and gas removal at the mud line. The demand for higher boosting pressures and gas handling capability has sparked the development of ESPs inside caissons or installed horizontally. Twin-screw pumps are designed with twice the pressure rise compared with only a few years ago, and hybrid pumps now provide improved gas handling and boosting, with an array of advancements in subsea power distribution, controls and tools facilitating these pumps.

Taking the "helicopter view," it seems that multiphase pumping technology is heading in different directions, with each application area having its own merits. This includes small-scale casing gas compression, full-scale field development using multiphase pumps and flowlines, large offshore topside installations in mature fields, and subsea boosting.

The technology has stood the test of time and now is getting the recognition it deserves from operators in fields around the world. Manufacturers have waited patiently for this to happen, steadily improving reliability and performance to the point where the benefits are uncontested.

Has it gone as fast as many had initially hoped and expected? The answer is no, of course. However, with the optimism for the potential of multiphase pumping finally turning into realism, the future looks very bright for multiphase pump technology. ❐

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