Multifunctional rack and pinion technology takes shape in oilfield as versatile, mobile rigs

By Katie Mazerov, contributing editor

THERE’S AN OLD adage that says, “Necessity is the mother of invention.” Nowhere is that more true than the oil and gas industry, where the need for better ways to tap resources is pushing innovation and retooling of old technologies.

Rack and pinion technology, which has been around in one form or another for more than a century in such well-known applications as cog railways, elevators and automobiles, is now finding a niche in drilling, expedited by the ever-increasing need for horizontal and directional drilling.

“Rack and pinion technology is really going to revolutionize where oil and gas is going to go in the next few years,” said Rob Foster, marketing manager for American Augers, which has five prototype models, at a capacity of 330,000 lbs of hook load, operating in Texas, Pennsylvania and Oklahoma.

The West Salem, Ohio, company expects to introduce its VR 500 model, offering 500,000 lbs of hook load, this fall. In this model, the pinion is housed in the top-head drive, which travels up and down the rack that is positioned on the derrick.

While designs vary, rack and pinion rigs can both pull and push, utilizing thrust, not gravity. Because no wire is used, a direct connection between the hoisting system and the vertical movement of the drillstring is established, offering accurate positioning and control of the drillstring along the well path.

The rigs can be easily mobilized, require fewer personnel to operate, are quieter and leave a smaller footprint. They are ideal for land drilling and some offshore applications, but not deepwater exploration.

“The technology has always been out there,” Mr Foster said, noting that American Augers developed its first HDD rack and pinion rig in 1988 with a hook load of 100,000 lbs. The company was the first to eliminate chain drive systems. “Where it’s starting to take hold now is in the more shallow oil and gas formations, which have often been off-limits with conventional drill rigs.

“Rack and pinion allows you to go more shallow, but it also allows you to get more pay zone because you have the ability to back out horizontally instead of just having a true vertical well. You can drill that well down vertically, make your bend and then go out horizontally, which exposes casing into your total pay zone. Rack and pinion increases the probability of success on the job site.”

Mr Foster touts safety as a huge benefit in rack and pinion technology. “With a conventional rig, you’ve got four or five workers who are slinging chains, standing in the fall zone of the pipe and working with the rotary table,” he said. “Here, you don’t have anything. You’ve got two workers basically operating the
Drilling rig using an electric-over-hydraulic operating control panel. You’ve got one man running the controls, moving the top drive up and down, the other operating the pipe-loading system, getting the pipe in and out of the carriage.

“We’re hoping to really show that this is going to take a lot people out of harm’s way.”

Cost and maintenance are other advantages, he continued. American Augers’ basic drilling rig runs about $2.95 million, compared with $5 million for a conventional rig. And because the rack and pinion has fewer parts, it is easier and less expensive to maintain, he said.

“Chains, cables and other parts can snap or break,” he said. “Here, you’ve got a whole mechanically controlled system, which means you’re going to get a longer system life out of it. You don’t have complicated parts that have to be consistently replaced.”

Environmentally, the rack and pinion allows an operator to drill fewer holes and get in and out faster. “Let’s say you have a large plot of land with multiple adjacent wells,” he said. “On a traditional rig, you’re going to drill each well individually to get into the pay zone. With a rack and pinion rig, you’re only going to drill one hole to get into all the formations, and you’re going to expose the entire pay zone because you were able to drill out and get casing through the whole area.”

Given the apparent strengths and advantages of rack and pinion rigs, why has this decades-old technology taken so long to be embraced by the drilling industry? Rolf Gullaksen, vice president of sales and marketing for TTS Sense (formerly Sense EDM) believes the issue is twofold.

“Initially, the economy wouldn’t support it,” he said. “Drilling contractors really struggled with making their business profitable, and they weren’t willing or able to invest.

“Also,” he continued, “this industry is very conservative. New ideas take a long time to make their way to the marketplace.”

The surge in horizontal and directional drilling was the catalyst to bring rack and pinion technology to the forefront, Mr Gullaksen suggested. “We need the tools to drill these wells, and rack and pinion is an excellent choice.”

TTS Sense, based in Kristiansand, Norway, has several multi-functional land rigs on the market, with 125-250 tons of hook load capacity for drilling, underbalanced drilling, slimhole drilling workovers, well intervention, snubbing operations, re-entry and sidetracking.

Instead of the conventional open derrick or mast design, the rigs feature a closed mast design that houses the rack and pinion system. The pinion, or wheel, located in the mast, turns the rack modules, which move the rack upward for hoisting and downward for lowering.

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TTS Sense recently entered into a contract with Weatherford Drilling to deliver seven Ultrasingle 150-ton rack and pinion trailer-mounted land rigs. Above is a 150-ton rack and pinion rig in Canada’s Yukon manufactured by TTS Sense.
The push/pull capability is ideal for managed pressure drilling, top hole drilling, casing drilling, long horizontal wells and snubbing operations.

• The center of gravity stays low as the rack, not the machinery, moves.

• There is no requirement for cutting and slipping the drill line.

• The rack and pinion system offers a longer lifespan than a conventional rig.

“The rigs can quickly switch between workover, drilling and snubbing operations,” Mr Gullaksen said. They also can be delivered with a “drop-in” injector head, adding coiled tubing. Several versions of the rig can be delivered with automated pipe handling and a fully integrated control system.

“The rigs are very versatile and adapt easily to different operations,” he continued. “They are automated, safe and quiet, very quick to move and rig up, and the excellent control of the drillstring enables new and exciting opportunities with regards to downhole operations. We believe this type of multifunctionality will be very attractive to rig owners going forward.”

The company’s foray into the technology dates back to the late 1990s, when its predecessor, Engineering and Drilling Machinery (EDM), developed a rack and pinion-operated workover machine that facilitated faster and simpler rig-up and rig-down, reduced weight and improved safety, as fewer people were needed to operate the machine.

In 2001, EDM sold a rack and pinion rig to Breitburn Energy, which needed a quiet, compact, multifunctional rig for its operation in downtown Los Angeles. The rig, which is still operating, is housed in a church-like building that is mobile and services about 40 wells. The rig is TTS Sense’s only rack and pinion model operating in the United States.

In 2005, the company designed a rack and pinion rig for the European market that was also equipped with a robotic pipe handling system and an AC-driven top drive system, permanently mounted to the mast by a retractable dolly.

TTS Sense has sold 40 rack and pinion rigs and has 17 operating worldwide in Canada, Hungary, Australia, Jordan, Tunisia, Thailand, India, Mexico and offshore in Liverpool Bay, UK.

In July, the company’s Canadian division entered into a contract with
Weatherford Drilling to deliver seven Ultrasingle 150-ton rack and pinion trailer-mounted land rigs, starting operation in 2009.

Horizontal Well Drillers (HWD), a subsidiary of Akerman Construction in Purcell, Okla., has seven rigs operating in the United States, including Texas, Pennsylvania, Ohio and Indiana. The rigs are working at 330,000 lbs of hook load but are designed to go as high as 440,000 lbs, which the company expects to do this fall.

“This rig is automated, so you don’t need workers and derrick hands,” said founder and president Steve Akerman. “There is no one on the drill floor when the rig is making a connection. The rig does it by itself.” The rack and pinion mechanism is housed in a closed mast and is top-head driven.

Mr Akerman’s rack and pinion design was initially developed for the horizontal river crossing business operated through his construction company. Two years ago, he modified it for the oilfield.

“We’re putting one rig per month out in the field,” he said. In addition to the United States, the company has had inquiries from Mexico, Brazil, Russia, Kuwait and other Middle East countries, and Canada. “These rigs are ideal for the oil sands in Canada.”

One operator wants to put the rack and pinion rigs on barges in the Louisiana swamps. “They’re very simple to put on anything,” he said. “As a rig size, they are very, very light and compact, with a huge amount of power.” The rig also is designed to fit into small locations, making it ideal for areas where there is a large urban infrastructure.

Central Basin Oil Investments, South Lake Texas, is operating a HWD rack and pinion rig in central Texas, including the Barnett Shale near Fort Worth. “The rig is very compatible and conducive to drilling in metro areas because it leaves such a small footprint and because of the low noise factor,” said Hoby Urich, director of drilling operations. “It is extremely community-friendly.”

Mr Akerman said a key advantage of his rig is the elimination of the block and tackle mechanism. “A conventional rig can’t apply any downward pressure. With a conventional rig, you’ve got to have some vertical hole before you have any weight to be able to make your curve,” he explained. “But our rig will not only pull, it will push. The top drive actually does the pushing itself and will therefore apply the downward force on the drill pipe as needed.”

He also said that his rig reduces the drilling area to about a quarter of what’s needed with a conventional rig, about 22,500 sq ft (150 ft x 150 ft). And in terms of mobility, the costs are minimal because it only takes eight trucks to move this rig.

Fuel savings is another advantage. “Our rig uses 40-50% of what a conventional rig uses,” he said. “That wasn’t significant in the past, but with gas prices as high as $4 per gallon, you’re saving $2,000 to $4,000 a day.”

Mr Akerman also noted that while he developed his rig for horizontal and directional drilling, he has utilized it for vertical wells, going as deep as 13,000 ft. “There is a misconception that our rigs
are designed only for shallow oil and gas wells. But, according to my own research, these rigs could drill 92% of all the wells drilled in the United States last year.”

German company Max Streicher also discovered the benefits of rack and pinion technology for vertical rigs after designing a prototype originally intended for the horizontal drilling market. The company’s current focus is on the European vertical market.

“The need for the technology came from the horizontal market, but in 2004, we proved that the concept also works for vertical drilling,” said Rupert Koeckeis, a director for the company, headquartered in Deggendorf, Germany.

In early 2005, Streicher completed its first-generation vertical directional drilling rig through its subsidiary Drill Tec. “We proved there is good technology for vertical drilling,” he said. The rig can drill to a depth of 5,000 m (16,000 ft).

“A key advantage,” Mr Koeckeis continued, “is that our rig is extremely modular. You can transport this rig anywhere within Europe on any road, using trucks. The concept works.”

A key feature is the rig’s ability to push and pull, eliminating the need for drill wire and other components. “With a wire, you can only pull,” he said.

Streicher has three rigs operating in Europe, one in The Netherlands and two in Germany, including on a geothermal well near Munich. The Netherlands operation is a gas project for NAM, a subsidiary of Shell and ExxonMobil.

The rig operates with two racks on each side of a closed mast, he explained. Inside the top drive are six hydraulic motors, three on each side, which drive the pinion, which in turn delivers power to the stationary racks. “The motors, which are driving the top drive up and down, are integrated into the top drive itself,” he said. “When the pinion moves, the top drive moves up and down. Hydraulic energy is provided by the drag chain.”

Streicher plans to introduce two models of its second-generation vertical rack and pinion rig in early 2009. One will be a land rig, the other an offshore unit. “This design is an even tighter concept, more modular and leaves a smaller footprint,” Mr Koeckeis said. “It is highly automated and highly mobile.”

“Our intention is to build highly automated rigs with a higher safety standards that can operate with low labor costs,” Mr Koeckeis said. The safety aspect of the rig, along with its modular design and mobility, has “opened up another market for drilling. We are able to relocate these rigs within five days. I don’t know a rig that can move so quickly.”

Videos demonstrating rack and pinion technology are available under the Sept/Oct 2008 issue at www.drillingcontractor.org.