OES, Australia, describes getting a grip on the pipeline trenching business.

ROCK TRENCHING VISION BECOMES A REALITY

OES is an international Engineering Procurement and Construction (EPC) firm with offices and/or facilities in Australia, Korea, Singapore, Indonesia and Brazil. OES specialises in onshore and offshore pipelines, cables installation and marine terminals, and is a world leader in subsea pipeline and cable trenching, having completed over 120 lines. Among these are many world firsts, including deepest water (400 m), deepest trench (7 m), first DP vessel trenching, first diverless trenching, first successful trenching by liquefaction method, first post trenching through heavy seas and first live gas pipeline trenching.

The company started in 1982 in Perth and was called Ocean Engineering Systems (OES) where the current majority shareholder and founder John Lincoln had worked with Woodside on the North West Shelf Pipelines and Bechtel Clough on the Harriet field for Bond Petroleum pipelines.

Lincoln was an innovative and pioneering subsea pipeline engineer and helped engineer the new and unique stability methodologies using jetting, ploughing, cutter suction, blasting and rock dumping for NW Shelf seabed conditions.

Prior to forming Ocean Engineering Systems, Lincoln spent many years in the 1970s with Gulf of Mexico offshore contractors helping develop 'second generation' trenching systems, which were lightweight buoyancy-stabilised jet machines - a much lighter and safer system to use for smaller diameter pipelines. The tool of the day had been the Jet Sled which was the 'first generation' trenching device. These were very heavy, often weighing up to 50 t, and powered by large powerhouse barges, often having up to 20 000 hp jet engines providing 2000 psi. They would cut the occasional hard clay in the Gulf very well but failed miserably in sand, especially in the North Sea. They also were notorious for damaging small pipelines or else pulling them sideways many metres out of their approved right of way.

The new jet machines could easily and safely cater for the smaller diameter pipelines. Lincoln experimented with his jet machines and found he could also cut hard clay much more efficiently with only 1000 psi and precision engineering at a fraction of the big jet barge costs. In fact, today OES trenches 48 in. pipelines in hard clay off DP boats at less than 10% of the cost of the old jet barges.

After immigrating to Australia, working for Woodside and Esso Bass strait, Lincoln was put to work helping develop the European answer to the expensive jet barge: the 'third generation' trenching device - the plow. The post trenching plow was a success at first, often achieving progress in sand up to 20 km/day. Unfortunately, you needed a large derrick barge to deploy the 150 - 300 t monster and an even bigger barge to pull it with pull loads up to 500 t at times. It was also not safe as you had to pick up the pipeline. The plows could only be designed for a narrow range of soil properties. A sand plow owned by Hyundai once took over 700 t to pull it through hard clay. The Woodside plow weighed 300 t, was designed to cut soft rock but would barely scratch the rock. A plow off New Zealand for Maui B got stuck in clay and when it finally broke free because of the elasticity in the tow

wire, which behaved like a spring, it lunged forward 90 m and ended up on top of the pipeline. Shell would not let it be used any more. This is when OES got its start and invented the lead keel stabilised jetting machine, of which OES owns and operates 12 different systems, all named after tigers.

As years went by, many other problems were discovered with plows, jet sleds and other seabed supported devices. The problem is, the seabed can become very soft in areas, causing the device to sink excessively, like the Woodside plow and a 90 t tracked wheel cutter vehicle operated in West Australia by Hadson Energy. Both devices failed.

Another problem on many projects with seabed supported devices in silts and some sands is when the seabed skid, plow share, or track passes the soil, pressure is released and it soaks up water like a sponge. The soil liquefies causing it to collapse, filling in the trench before pipe touch down. OES has witnessed this problem with an ROV on one of its own sleds, which it uses for cables or piggyback pipelines and will never use one on a rigid pipeline.

A combination of seabed supporting problems and the fact that no jet sled, machine or plow can cut even soft rock and the knowledge that seabed soils can change frequently, spurred the development of a new concept - the 'fourth generation' pipeline trenching device. The 'Tiger Shark' is a mechanical cutter jet machine that can cater for all soils up to 35 mpa UCS hardness, which is 17 000 kpa shear strength. The hardest known clay is only 250 kpa shear strength.

Figure 1. Tiger Shark Jet, mechanical trencher.

Some of the key milestones that led to the development of the Tiger Shark are presented herein.

In 1985, Lincoln invented, patented, built and exhibited at Perth's first Oil and Gas Exposition a one-fifth scale model of his newly created Pipeline Post Rock Trenching Machine. He was confident it would work for 95% of all the seabeds he had seen while diving on the NW Shelf. The concept proved very successful and the machine cut limestone very well.

Lincoln moved his business to Melbourne in 1987 as here there was much more demand in the engineering business, designing power plants, marine terminals, oil refineries and other liquid processes and mining facilities. He kept up with progress on the NW Shelf and tendered to provide a subsea rock trencher for WAPET, Apache and Western Mining oil company pipeline projects.

Confidence in the machine

Although nothing was to come of these effects, Lincoln felt that there was little faith shown by companies when they realised that this subsea rock trencher was an Australian designed and built machine, as these companies seemed to favour European inventions. Lincoln needed millions of dollars to build and test a machine and could not find a backer. Having worked with European firms, he knew their failure rate for trenchers (80%), and he had already developed three innovative trenchers in the USA and one for a European company that had trenched over 80 pipelines, so he had confidence and remained positive.

In 1987, several West Australian companies joined forces to develop the world's first Post Rock Trenching System, later jokingly referred to as Mad Max. Lincoln was not invited to assist. The companies adapted a bulldozer to work underwater and put a horizontal shaft wheel cutter where the ripper arm would normally be. However, the design proved to be unsuccessful in a number of areas. But what it did do was cut calcarenite rock - and it did that well.

By 1996, OES had become a world leader in trenching subsea pipelines globally. The company also operated a successful consulting engineering firm called Lincoln Consulting, which purchased the Mad Max in 1996, and with it came additional engineering and 'know how' to trench rock seabeds.

Almost everything was scrapped except the cutting wheel, cutting teeth and hydraulic drives. A multi pass rock trencher called 'Rock Eater' was designed to post trench a 48 in. pipeline for the new Woodside second North West shelf trunkline. Most of the European contractors, including Allseas, Saipem, Brown and Root and Ham Dredging all nominated the OES 'Rock Eater' in their submissions.

However, the project was cancelled and when it was picked up a few years later, post trenching was not considered as there was not sufficient time to develop a trencher. OES, a little daunted, kept busy developing new technology overseas and was trenching more pipelines per year around the world than had ever been installed in Australia's 200 year history.

Rock Eater

In 2004, when work slowed down, OES, now having sufficient funds to develop its own rock trencher, started to design and full scale test rock cutters meant for 'Rock Eater'. 'Rock Eater' was for a large pipeline multi pass and had four cutters. It also had the advantage that if a hydraulic drive or cutter failed, you could easily recover the machine to repair.

This methodology was very expensive, however, as you had to dig a pipe trench twice as wide as the pipeline, which was a lot of wasted energy, time and equipment wear.

OES believed the next pipeline for Western Australia would be a 20 or 24 in. line and so a new machine was designed, built and tested and was named the 'Tiger Shark'. The 'Tiger Shark' has tested successfully in 35 mpa UCS rock (concrete). WP