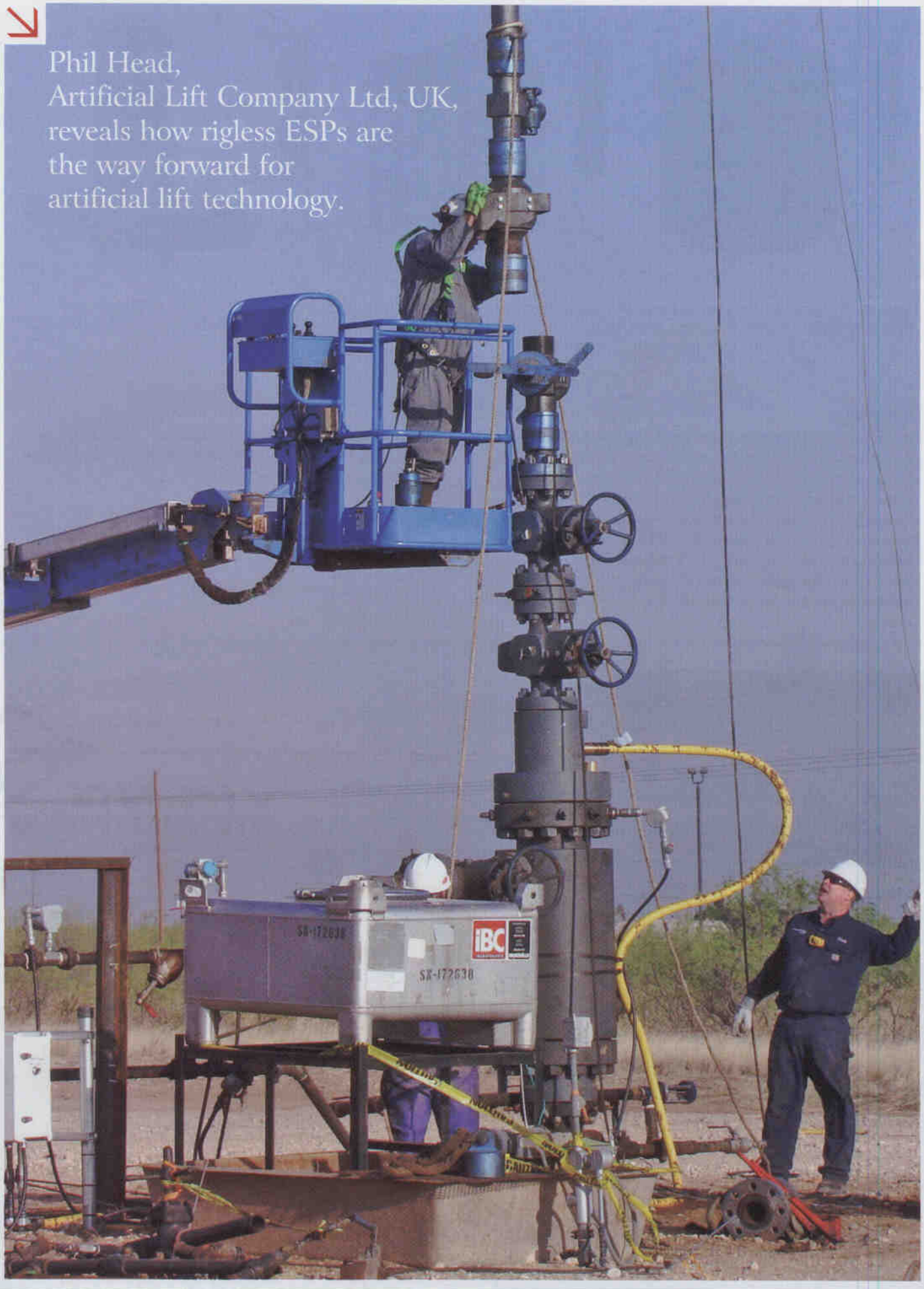
Phil Head,
Artificial Lift Company Ltd, UK,
reveals how rigless ESPs are
the way forward for
artificial lift technology.



Lightening THE LOAD

Electrical submersible pumps (ESPs) are the most efficient form of artificially boosting the production of fluid from the reservoir. Positioning the pump at depth in a well ensures the pump only has to remove the fluid in a liquid state, be it single (oil) or two phase (oil and water). This is particularly advantageous in subsea applications, as it eliminates the need for complex seabed multiphase boosting systems.

Traditionally, ESPs have been deployed on the end of production tubing. This requires a rig for installation and removal. New rigless systems, including one developed by UK-based Artificial Lift Company (ALC), require a rig initially to deploy the production tubing and outer completion, to which is attached one half of a three phase electrical wet connector. All the other ESP hardware is deployed and recovered on slickline, internal to the production tubing. This means that once a well has been made 'future proof' for the technology, the rig is no longer required to disturb the tubing and completion equipment.

Rigless ESP benefits

The most important benefits are financial and production related. The rigless ESP eliminates the need to schedule highly sought after rigs and their escalating rental rates. This can literally save hundreds of thousands of dollars, as well as shorten the project's completion timeline. What's more, production from the well is maintained with minimum downtime, maximising cashflow and revenue for the operator.

Another benefit is the fact that the well does not have to be killed during installation, as all the internal tubing components can be worked over on slickline using conventional live well intervention techniques. This is particularly well suited for the recently developed subsea workover systems operated from light well intervention vessels.

A further advantage of the ALC wet connector is that it is located in a side pocket window (similar to a gas lift valve). When the ESP hardware is removed from the well, full wellbore access is possible. This enables any remedial work to be performed on the reservoir, including wellbore cleanouts, coiled tubing drilling for well deepening or new lateral drilling, perforating, zonal isolation or stimulation.

Plus, because the side pocket wet connector is out of the main bore, it cannot be covered in debris or wellbore particulates, or damaged by tools intervening the well.

Figure 1. Live well installation of rigless ESP using slickline unit, lubricator and crane (rigless ESP inside lubricator).

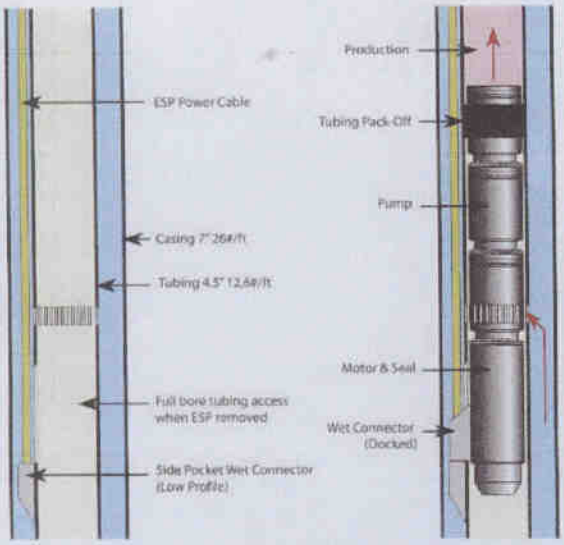


Figure 2. Illustration of well completion on left and internal rigless ESP components installed on right.

Figure 3. Motor, seal and wet connector assembly prior to being installed into lubricator.

Ideal circumstances for a rigless ESP

The rigless ESP is not for every ESP well. For example, if rig rates are extremely discounted or rig availability is not an issue, the costs might be prohibitive. From a well standpoint, if the well is benign (meaning there is a good local track record of ESP life), it would be very hard to justify the additional hardware and cost of a rigless ESP. However, many situations merit evaluating the use of a rigless ESP system:

Offshore

- Subsea: if a rigless ESP is combined with new subsea light well intervention vessels, cost-effective access to a subsea ESP is now viable. This will extend the effective productive life of a subsea well and maximise the hydrocarbons produced from it. The subsea well has to be designed at the initial stage to have the necessary power line and completion hardware installed to accept a rigless ESP system. This way, as the reservoir pressure declines, the well is ready to accept the rigless ESP.
- Satellite platform: these minimum facility platforms generally require a jackup to access the well. The rigless ESP slickline and pressure control equipment could be helilifted to the platform, enabling low cost change out.
- Full facility platform: in the North Sea, for example, if the operator installs a rigless ESP, it could keep the rig clear for more heavy duty well work such as re-entry drilling, well deepening and milling.

Onshore

- Tough environmental regions: areas such as the Arctic, desert, jungle or mountains make it extremely difficult to move a rig or heavy equipment. Additionally, significant cost can be saved by not having to maintain access roads suitable for heavy equipment.
- Urban areas: wells located in sensitive urban areas are excellent candidates for a rigless ESP system. These locations create awkward, even hostile community relations issues if a rig is required.

Enabling technology

The critical components of an ALC rigless ESP system include the following:

Compact side pocket three phase electrical wet connector

The well is a hot and high pressure environment, with a sometimes aggressive combination of chemical compositions, either originating from the reservoir or introduced by the operator as part of the well maintenance programme. The permanent half of a wet connector has to be extremely simple to ensure it has a long life. The rigless ESP system has the advantage of always recovering the deployed half of the electrical wet connector, therefore, all the 'clever' technology to provide a rugged and reliable electrical wet connector system are incorporated in the retrieved slickline equipment.

It is important for the wet connector to enable full wellbore access and work with standard wellbore sizes. For the sake of completeness, the connector has the same electrical rating as a packer or wellhead feedthroughs.

Permanent magnet motor (PMM)

To ensure practical deployment of a rigless ESP system, a compact permanent magnet motor was developed. The rigless ESP motor technology has been around for years in such premium applications as in aerospace, where size, weight and reliability are essential, as

Figure 4. *Rigless ESP synergy with light well intervention technology enables ESPs to be cost-effectively exploited in the subsea arena.*

well as mass produced applications such as the cooling fan motor in laptop PCs.

ESPs traditionally have used induction motor technology. For a performance comparison, a 3.75 in. standard oilfield induction motor develops 50 kW (67 hp.) from a length of 14.45 m (47.4 ft) and weighs 600 kg (1542 lbs). The ALC 3.8 in. PPM produces 50 kW (67 hp.) from a length of 1.4 m (4.6 ft) and weighs 52 kg (112 lbs).

This difference in performance can be explained very simply: a permanent magnet motor has its excitation provided by a permanent magnet rotor and all the current in its armature is torque producing. Induction machines get their excitation from the armature current directly. For an induction motor, part of the current fed to the motor magnetises the circuit and is not torque producing.

Furthermore, induction machines require more cooling because of the significant electrical losses in the rotor due to current circulating in the squirrel cage in the AC nature of the field in the rotor laminations. Permanent magnet motors have very small electrical losses in the rotor due to the broadly DC nature of the field in the rotor structure.

Because of their efficiency, permanent magnet motors achieve much higher performance than induction motors and can have up to eight times the power output to a similar sized induction motor.

The ALC PPM is fully compatible with industry standard drives, requires no special position feedback such as an encoder or resolver, and does not require any special sensorless algorithms. This is an important characteristic, as other PPM motors require either a special drive or feedback sensors adding to the installation cost.

Typical installation

Two types of installation that are common for a rigless ESP include a rig installation and a live well installation.

Rig installation of completion

The first installation of the rigless ESP system requires a rig to install the production tubing and bottomhole outer completion.

The outer completion generally consists of a re-entry guide, an orientation and side pocket electrical wet connector, motor shrouds and a power cable that is clamped to the outside of the production tubing all the way back to surface. The slickline deployed rigless ESP equipment is then installed through the tubing.

Live well installation of ESP equipment

During subsequent workovers, the well can be accessed using proven and practiced live well intervention techniques. This requires a lubricator (extends the well pressure vessel to above the Christmas tree) that is connected to a BOP, which in turn is connected to the crown flange of the Christmas tree. The rigless ESP system can be deployed in sections if there are length or weight issues. Slickline is then used to lower or retrieve the rigless ESP assembly into the well.

If the well is extended or deviated, coiled tubing or a wireline tractor can be used to walk the assemblies into the well and position at the required setting point. The rigless ESP system is fully compatible with the operation of either coiled tubing or a wireline tractor, and the lightweight motors assist with these deployment processes.

Similarly, the system is fully compatible with the various subsea well intervention systems currently in final development or in commercial use. This is a very exciting combination of technologies enabling cost-effective ESP systems to be exploited in subsea wells.

ESPs today

Efficient pump retrieval for reconfiguration, maintenance or replacement will be essential to the progress of ESP technology in deepwater projects. ESPs to be installed by Petrobras, with FMC, at the Gulf of Mexico Cascade and Chinook fields in 8800 ft of water will have horizontal caisson configurations and will be placed on the seafloor inside of cages. Retrieval and reinstallation will take place by means of a service boat deploying an ROV, with the cage and pump handled as a unit. Seabed pumping units that serve multiple wells are an effective deepwater boosting solution.

With the arrival of rigless ESP technology each individual well can have an ESP installed and placed at its optimum setting depth. For example, if a rigless ESP is placed in the well, providing a drawdown of 4000 psi, this additional lift might enable an extra 10 – 20% recovery of total oil in place. This is a significant benefit to the operator.

The future

The challenge the industry faces is to maximise the cost-effective recovery of oil in place. Rigless ESP technology will enable an economic means of installing and retrieving in-well pumps.

Wells will be prepared for rigless ESPs, and will involve a two-stage well production solution. In the first stage, high reservoir pressure will provide the natural drive for production from the well. In the second stage, as reservoir pressure declines and natural well flow diminishes, production will then be augmented by means of the rigless ESP system.

This technology is currently being installed and evaluated by both national oil companies and international operators globally. In addition, engineering for several large subsea projects is currently in progress. Given its practical and financial benefits, rigless ESP technology should become a standard requirement for certain large niche applications; one that can provide significant benefits for the operator in terms of reducing the overall project costs whilst assisting in achieving the maximum recovery of hydrocarbons from the well.