Long Distance Step-Outs

ABB has recently published a white paper on long step-out systems. The aim is to stimulate discussions about future projects that can benefit from this technology.

In recent years, the industry has made considerable advances in developing pumps, separators and compressors designed for installation on the seabed.

Individually, these may be considered as tools to satisfy specific applications such as optimising production and extending the life of existing fields. Alternatively, companies such as Statoil have envisaged the strategic concept of a subsea factory, relocating equipment that had been traditionally considered the domain of offshore platforms.

"During early field life, its reservoir pressure is often sufficient to drive the wellstream to the surface," said Knut Riinge, Global Product Manager for subsea in ABB.

"Over time, however, pumps and compressors have to be installed on oil platforms to boost the pressure in the wellstream and consequently, extend the field’s life to 2032.”

"Statoil found that by deploying compression or pumping systems on the seabed on the Asgard project, it could increase overall costs per unit. This could enable an additional 306 million barrels of oil equivalent, and extend the field’s life to 2032." Obviating the use of a platform and relocating the systems to the seabed, however, allows another strategy that potentially makes marginal fields economic – extending the tieback length.

"There may be discoveries in remote locations, considerable distances from existing infrastructure. These would remain untapped because they could not economically support a production platform. If it were possible install a remote subsea pump/compression station many kilometres from the host platform, and tie it back by pipeline, however, this could potentially unlock the development."

One issue limiting the tieback distance, is the power used to drive the rotary equipment. This is supplied back at the offshore platform or an onshore facility.

In a typical application, power from the grid is fed into input transformers, frequency converters and then step-up transformers to raise the voltage level. At the subsea end of the line, the power enters a step-down transformer installed close to the subsea load.

"The distance from the surface facilities to the subsea pump or compressor, and the power that can be transmitted, has been increasing over the years," said Knut. "The first system delivered by ABB was rated approximately 1 MW with a step-out distance of around 7 km (Topacio and Ceiba subsea projects)."

Nowadays, long step-out systems such as that on Asgard, are delivering up to 20 MVA electric power to subsea loads and at a distance up to 43 km. Power system studies have shown that feeding 20 MVA up to a significantly longer distance of 120 km is feasible.

When pumping oil or compressing gas such long distances, it is natural to experience sometimes considerable variations in flow, both during operation as wellstream passes through the pipe, and throughout the field’s Metline. This means that the speed of the pump or compressor driving the flow also changes. For this to happen, the motors require a variable speed drive (VSD).

There are two options to deliver electric power (variable voltage and frequency) to subsea multiphase pumping and gas boosting loads for completed wells. One is locating the VSD on the platform. There is now a greater demand to locate the VSDs close to the subsea load.

"Long step-out systems were originally designed to avoid having advanced equipment, such as VSDs located subsea. While 90% of the existing demand for brownfield long step-out solutions is within 40-50 km, feasibility studies have revealed that systems in excess of 120km are attainable, albeit considerably more challenging.” ABB predicts that there will be a significant rise in interest for super-sized long step-outs in the future.

"We have already been investigating the interconnected complexities relating to subsea motor starting conditions, control and protection, breakaway torque, higher required VSD rating power, higher topology feeding voltages, voltage drop along cable, transformer saturation and harmonic resonance points for super-size long step out for several years."

ABB also formed a joint industry development program (JIP) in 2013 with Statoil and partners to develop new subsea power solutions which will be able to transmit power (from shore) up to 100MW over distances up to 600km and to power equipment at depths of up to 3000m.

The target is to develop subsea power distribution, meaning all power system components (transformer, switchgear and MV drive) are located subsea. It is anticipated that this solution will be ready for the market by 2019, enabling operators to extract oil and gas in considerably longer and deeper areas than currently achievable.

Technical Challenges

There are a number of technical challenges faced by a long step-out system. These include:

• Distance Between the VSD and subsea loads.
• Frequency Increasing the frequency raises cable losses significantly. This influences the physical size of equipment and sensitivity to load variations.
• Harmonics These introduce high frequency components and create waveform distortions in currents and voltages.

Harmonics can cause problems ranging from telephone transmission interference (electromagnetic compatibility problems) to an increase in power losses and winding temperature in motors and transformers.

Consequently, degradation of conductors and insulating material of the components is accelerated.

• Resonance point. These resonance points can be excited by harmonics since the long step-out system is equivalent to an electrical circuit comprising inductors and capacitors.

One of the most important aspects is managing and mitigating these resonance points. The importance of avoiding these resonance points is vital to ensure correct system performance.

Exciting the resonance points means voltage escalation, torque oscillations and reduced lifetime and system performance.

• Current and voltage At receiving point, ABB has developed an algorithm that estimates the current and voltage on a subsea motor and allows the machine to be optimised by controlling the output power of the subsea load. It tunes the voltage modulation of the frequency converter.