Subsea cracking underwater repairs

What impact will new wet spot-welding techniques have on the market?

Despite advances in remote technology, there is often no realistic alternative to diver intervention when conducting subsea repairs. Customarily, oil industry divers have to perform an extensive array of tasks, ranging from inspection and metrology to cleaning and repairing. The divers themselves therefore, need to possess a significant expertise in a broad variety of underwater skills, however welding tends to be a specialist business.

Surface testing of the welding system

A number of underwater welding methods have been devised, including training divers to be welders (which is both expensive and presently the subject of a skills shortage) or if the operation is big enough, getting surface welders to the underwater site by enclosing them in some sort of enclosed habitat and allowing them to carry out the welding processes in the dry.

An alternative initiative has been proposed by the UK-based Speciality Welds. They reason that the best approach is to develop a welding system that is so simple, that experienced divers, but inexperienced welders, can easily carry out high quality wet-welding tasks safely and quickly.

'The new system, which has been named Hammerhead in keeping with the company's branded 'fish' names, answers the problems of obtaining high quality wet welds without the need for experienced, trained and or qualified welder-divers,' says managing director of Speciality Welds, David Keats.

'This system will enable diving contractors, who might normally decide against bidding on some welding projects, to rethink their policy.'

HAMMERHEAD

The Hammerhead wet spot-welding process, is a quick and reliable joining method of a spot/plug weld, comprising a standard three-phase DC welding power source and a Piranha II control unit. In designing it, Speciality Welds had to re-appraise the fundamental approach to underwater wet-welding.

'By removing the actual welding skills from the operation, there's no need for the diver-welder to control parameters such as travel speed, electrode angles, or arc length,' says Keats. 'There's even no need to have good visibility, as the diver doesn't need to see or control an arc in the conventional sense, so even in poor visibility conditions high, repeatable quality welds are produced.'

HOW IT WORKS

Keats' premise is that it is considerably easier to create a spot/plug weld, rather than deposit a fillet weld within a specified joint.

The Piranah II surface control console

At the centre of the design therefore is a welding electrode. It penetrates the two materials to be joined by piercing a hole directly through both materials. The hole is then filled, resulting in a spot/plug weld, similar in principle to a rivet. Other than the control system/electrodes, all other equipment is exactly the same as conventional 'stick' welding.

Typically the shear strength for plain carbon steel is generally assumed to be 80% of the ultimate tensile strength. The Hammerhead electrode offers a tensile strength of 650N/mm² and therefore, will offer a shear strength of approximately 520N/mm². Consequently, a 10.0mm (3/8in) diameter weld nugget will produce a max load capability of 40.840 kN (9181 lb/force) per spot.

The weld strength offers improvements over ferritic steel electrodes and generally the heat-affected zone (HAZ) hardness is improved. The electrodes have a 22.5Cr and 14.45Ni equivalents, thereby, allowing for high percentage dilutions up to 50%.

The benefits of this system are many. There is no need for specific joint configurations and all the preparation that goes with them. There is no need even for cleaning the joint area or for chipping off slag, before laying down additional passes. In fact, there's no need for additional passes, as the process is a one-shot process – one electrode produces one complete spot/plug weld,' states Keats.

CONTROL UNIT

The Hammerhead control module, which is fitted into the Piranha II safety switch system, sits above water and controls the primary and secondary current values selected in accordance with a set of guideline tables. These calculate the average weld/time cycles used for that particular size of electrode and thickness of material. The operator can then make any minor adjustments to ensure adequate weld quality on site.

Laboratory analysis of a subsea spot-weld

The control unit is connected to the welding power source via the remote control facility and is powered by a 110v supply. All welding leads pass through the 400A Piranha safety switch, before going to the diver.

It first switches to a high current setting, allowing the electrode to pierce through the materials, thereby creating a hole through which both materials are joined together. The control unit also has a timer, which has the function of limiting the depth of this penetration, so as to avoid bursting through the base (back) material.

After the first weld cycle is completed and depth of penetration achieved, a second, lower current is automatically initiated. It is this current that fills the hole, creating a spot/plug weld that has penetrated both sections of material, creating a weld nugget.

During the operation the diver need only apply sufficient pressure to the electrode to push it through the material while welding.

The guidelines shown below provide basic benchmark settings for selecting current and timer.

3.2mm / 1/8" Electrode	Timer	High Current	Low Current
Plate thickness:			
8-8mm (16mm) 5/8 inch	4-6 Sec	250-260	150-160
10-10mm (20mm) inch	5-8 Sec	260-270	150-170
12–12mm (24mm) 1 inch	7-9 Sec	270-280	160-180

The selection of electrode size is matched to material thickness, with two sizes of electrode available: 3.2 and 4mm. These two electrodes will comfortably join combined steel thickness of up to 32mm.

'The process is not completely automatic, however the skills necessary for a diver to produce a weld have been removed, as have many of the traditional preparations and environmental factors, which normally have such an influence on welding underwater.

'If this wasn't enough the final weld quality is also improved,' claims Keats, 'with the majority of the weld being confined within the through thickness of the material, factors such as erosion, corrosion are less of a concern.'

The National Metals Technology Centre (NAMTEC) have also expressed an interest in evaluating this system for crack repairs. It is particularly interested in initial findings, which indicate the elimination of most of the gouging, grinding and removal of material normally required prior to repair welding, as well as the ability to produce a fully penetrating weld working from one side of the material only.