Underwater welding with your eyes closed

Will a new wet spot-welding system revolutionise hull repair?

Until now a diver-welder has had to take into consideration countless factors such as travel speed, electrode angle, arc length and accurate deposition in order to produce high quality welds, all of which are dependent on so many different parameters in medium to good visibility. However, the Hammerhead wet welding system, which can be used both above and underwater (and was recently awarded the UK's Department of Trade and Industry's SMART Award) is said to allow for high-quality repeatable welds to be produced in near zero visibility. This is accomplished by automating as many aspects of the welding process as possible in an effort to minimise the burden placed on the diver, who only has to press the electrode on to the surface of the material to produce a weld.

According to David Keats of Speciality Welds Ltd, the company behind the technology, the system is highly suited to operations on structures where a complete sealing weld is not necessary, such as securing anodes, anchor plates, doubler plates and patches. In certain situations, it can also be employed in place of bolts and securing lifting lugs. The electrode can be used for welding dissimilar materials, such as stainless to mild steel.

A simplified weld

'We have redefined stick welding by creating a spot/plug weld rather than having to deposit a fillet weld within a specified joint,' Keats told *MER*. 'Moreover, doing away with fillet weld deposits brings other benefits: it simplifies the joint configuration (simple lap joint) and hence makes the associated preparation work unnecessary. The electrode can even be used on rusty, dirty or painted steel as the only preparation needed is for a small clean contact area to ensure easy arc ignition.' The chore of chipping off metres of slag prior to additional passes is said to be completely eradicated because the 'one-shot design philosophy' of the Hammerhead system makes additional passes redundant: one electrode produces one spot/plug weld.

Control system housed in 400A safety switch/control unit

Apart from the control unit and electrodes, the equipment is indistinguishable from conventional stick welding apparatus. The control unit is connected to the welding power source via the remote control facility and is powered by a 110V supply. As a safeguard against accidents, all welding leads pass through a 400A Piranha safety switch before reaching the weld operator.

Plate shows piercing effect and the hole created by the first high current

Automatic current management

The electrodes can be used nakedly with nothing more than a standard MMA/SMAW power source, but in such cases the quality and repeatability of the weld cannot be guaranteed. For optimum results, the manufacturers advocate the use of their proprietary Piranha II control unit, which is programmed with a preset sequence of current and weld cycles for maintaining a consistent weld quality.

The chief function of the control system is managing first peak/high and second background/low current settings. The high current setting allows the electrode to pierce through the materials and create a hole through which both materials are joined. An integrated timer limits the depth of this penetration so as to avoid bursting through the base (back) material.

'After the first weld cycle is completed and the correct depth of penetration achieved, the control system automatically switches to the second current,' explains Keats. 'This lower current is responsible for filling the hole and producing a spot/plug weld that penetrates both sections of the material and creating a weld nugget.'

During the operation the diver or indeed robot need only apply sufficient pressure to the electrode to push it through the material while welding. The diver can then make any minor adjustments necessary to ensure adequate weld quality.

Currently, Speciality Welds only supplies a 3.2mm (1/8in) electrode, but the company says that even this is capable of handling a wide range of material thicknesses (see Table).

3.2mm/1/8 in Electrode	Timer	High Current	Low Current
Plate thickness:			
8-8mm (16mm) 5/8 in	4-6 Sec	250-260	150-160
10-10mm (20mm) 3/4 in	5-8 Sec	260-270	150-170
12–12mm (24mm) 1 in	7-9 Sec	270-280	160-180

The Table provides basic benchmark settings for selecting current and timer

A spot weld and flash cut through the centre and macro polished

The shear strength for plain carbon steel is generally assumed to be 80% the ultimate tensile strength. Since the Hammerhead electrode offers a tensile strength of 650N/mm^2, it will offer a shear strength of approximately 520 N/mm^2. Therefore, a 10mm (3/8in) diameter weld nugget will have a maximum load capability of 40.840 kN per spot.

The weld strength is touted as being superior to ferritic steel electrodes and the hardness of the heat-affected zone (HAZ) is improved. The electrodes have 22.5Cr and 14.45Ni equivalents, thereby, allowing for high percentage dilutions up to 50%.

According to Keats, tests have demonstrated that a spot weld with a total area of 65mm^2 took 40kN to fail and the ultimate tensile strength was calculated to be 606 N/mm^2. 'In comparison to a defect-free single pass fillet weld failing at 259kN, but having a total area of 746mm^2 with an ultimate tensile strength of 347N/mm^2, these tests clearly show that the spot weld possesses nearly twice the strength capability.'

Commercial applications

Although the Hammer head system cannot fully automate welding operations and that the process is not entirely defect free, it 'substantially reduces the skill-set that a diver must attain before undertaking and producing high quality welds,' adds Keats. 'Furthermore, it offers a convincing solution to the long-standing problem of working in low-level visibility, while virtually eliminating time-consuming material preparations.'

The Hammerhead system has already been tested in its first real-life application following a request from Quest Underwater Services Ltd, to undertake repairs to a slipway in Poole, Dorset. After discussing the assignment with Gifford, the consulting engineers, the new system was approved and the job began of spot welding 15mm steel sections to existing piles that had suffered damage caused by ferry chains.

For Keats the tests provided an absolute vindication of the technology: 'Since the divers involved had no previous wet welding experience and were working in reduced visibility and difficult tidal conditions, the assignment demonstrated that after a short period familiarising himself with the process, a good diver equipped with the Hammerhead system could produce an acceptable weld within a matter of minutes rather than the hours typically called for by conventional methods.'