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Welding developments for Speciality Welds Limited

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Contents	Page
1. Background	1
2. Portability and application	1
3. Work undertaken by Corus	3
4. Results for a variety of thickness and orientation	5
5. Suggestions for modification of welding kit	10
6. Replacement of bolts with welds	10
7. Conclusions	10
8. Recommendations	11
9. Further work	11
10. Reference	11

Summary

Welding developments for Speciality Welds Limited

Author(s): A M Thompson, Knowledge Group Leader, Joining Technology

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David Keats of Speciality Welds Limited, came to the 'Meet the Experts' event at STC. This event was organised within the TWI Joining Forces Programme, funded by Yorkshire Forward. David Keats came to explain the Hammerhead underwater welding process and ask whether Corus could evaluate and develop the process for use in air.

Corus undertook to test the process in air and assess its suitability for use in both the down-hand and vertical orientations to join a range of steel thickness from 1.6 mm to 15 mm. The evaluation revealed the following:

1. The Hammerhead welding process offers a rapid method of joining plates or sheets of a wide variety of thickness, in either the down-hand or vertical orientation.
2. Joints using the Hammerhead process can be made from one side only.
3. The correct degree of penetration can easily be achieved to ensure a weld of sufficient quality.
4. In certain cases connections, presently made by bolting, could be made by welding from one side.
5. Conventional stainless steel electrodes appear to be suitable for welding.
6. Small electrodes of approximately 2 mm need to be used for plate of a thickness below 4 mm.
7. Welds in thick materials in the vertical orientation will probably contain some defects, but would still be suitable for certain applications.

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Welding developments for Speciality Welds Limited

1. Background

David Keats of Speciality Welds Ltd, of the address below, came to the 'Meet the Experts' event at STC. This event was organised within the Joining Forces Programme, funded by Yorkshire Forward. David Keats came to explain the Hammerhead underwater welding process and ask whether we could evaluate and develop the process for use in air. The system was designed to be very user friendly and capable of use in conditions of very poor visibility. The welds were essentially modified MMA plug welds, which provide the ability to weld from one side only*.

2. Portability and application

Speciality Welds developed the Hammerhead single sided welding process, to require only a very low level of skill and to be very portable. The equipment comprises an 8 kg attachment to a MMA welding machine (DC). In essence, a MMA electrode is forced through a front plate into the backing plate, at high current and then withdrawn slowly at a lower current, such that the hole created by the arc is re-filled. The steady pressures required can be taught very easily to a non-skilled operator and the machine is preset with the current levels and welding duration time settings, depending on the thickness of materials to be welded. Even changing the numbers and symbols on the knob to talk the language of plate thickness rather than amps and seconds has been considered.

The standard machine is built around the Mahe 360A, weighs approximately 16.5 kg in total and will cost approximately £3000.

This is shown in Fig. 1.

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(a) Mahe welding power source



(b) Hammerhead control unit



(c) Operator making a vertical weld

Fig. 1(a-c): Hammerhead welding equipment and operation

The process was developed for underwater welding and as such could easily be undertaken in either the down-hand or vertical position. The vertical position was facilitated by the effect of the metal freezing on contact with the water below the weld and hence, the metal was held in the weld. Also, the surrounding water kept the electrode cool during welding at high current.

3. Work undertaken by Corus

Until Corus undertook the evaluation, the Hammerhead process had only been developed for use underwater. Corus undertook to test the process in air and assess its suitability for use in both the down-hand and vertical orientations to join a range of steel thickness.

The potential for extending the thickness range of steels that can be welded was evaluated according to Table 1. All weld numbers were done under the Corus QA code 5WH73, such that the full codes were 5WH73-D1 for Downhand 1 etc.

Table 1: Evaluation undertaken by Corus

Welding position	Back plate (mm)	Front plate (mm)	Electrode	Weld QA number 5WH73
Downhand	15	8	Hammer-head 3.25	D1
	8	8	Hammer-head 3.25	D2
	4	4	Avesta 316/SKR 2.5	D3
	4	1.6 (G)	Avesta 316/SKR 2.5	D4
	2	2	Avesta 309L 2.0	D5
	1.6 (G)	1.6 (G)	Avesta 309L 2.0	D6
Vertical	15	8	Hammer-head 3.25	V1
	8	8	Hammer-head 3.25	V2
	4	4	Avesta 316/SKR 2.5	V3
	4	1.6 (G)	Avesta 316/SKR 2.5	V4
	2	2	Avesta 316/SKR 2.5	V5
	1.6 (G)	1.6 (G)	Avesta 309L 2.0	V6

(G) - galvanised

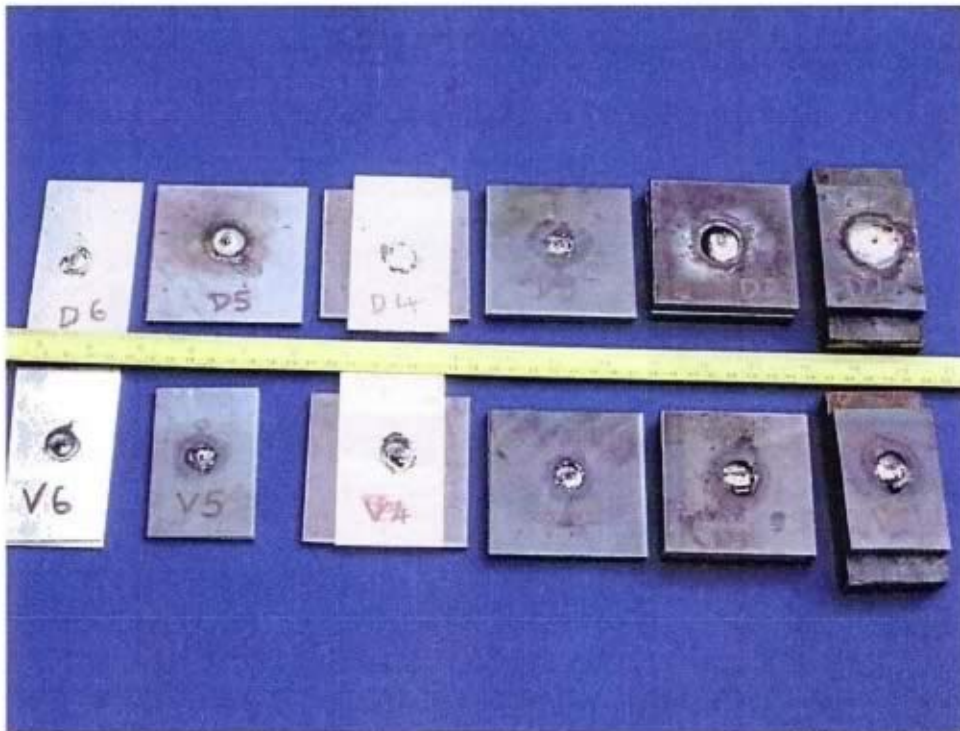


Fig. 2: Photograph of welds made

The back plate is that onto which the front plate is welded. Hence, required penetration is approximately the sum of the front plate and several millimetres of the back plate. The range of materials welded is shown in Fig. 2. This is a significant extension to tests of the existing Hammerhead process, which to date have only used 3.2 mm electrodes to weld steels in the thickness range of 8 mm to 15 mm. To facilitate welds in the thinner plates a 2.0 mm or 2.5 mm stainless steel electrode was used. (Table 1, column 3.)

Also, Corus, which has knowledge of general fabrication procedures, undertook to make recommendations for enhancements, such as pressure switches, guides and shrouds.

4. Results for a variety of thickness and orientation

The twelve welds described in Table 1 were all welded without insurmountable problems. The problems that did arise were as follows:

- Weld metal tended to run out of the welds made in the vertical position. However, this was not expected to significantly reduce the strength.
- The current needed to be very low for the thin material and at such power levels the controller was not stable. This is because it was designed for higher currents and it is believed that the sensitivity can be improved.
- The thicker welds made in the vertical position contained porosity and lack of fusion unless the electrode was manipulated to force the arc to the top of the molten pool.

All results of the evaluation, including photographs are shown in Table 2. It is evident that the range of thickness, which can be welded using this process could easily be extended down to 1.6 mm thick steel. Plates were not cleaned, nor was the surface removed from the galvanised plates. Hence, the process was robust and demonstrated that it was capable of welding through scale, light rust or a galvanised surface.

The results of the Hammerhead welding process trials are shown in Table 2.

The Hammerhead process, generally produced welds of high quality in the downhand position. No defects were discovered in these welds.

In the vertical orientation weld quality was variable. The most consistent problem was the tendency for the molten steel to run out of the weld. At the greater thickness of 8 mm front plate, there is also a tendency for the formation of voids. Generally however all joints contained large fused regions providing what would be expected to be a strong joint.






The 1.6 mm galvanised steel could be welded to produce joints with high mechanical integrity. Indeed, the photograph for weld 5WH73-V6 shown in Fig. 3, shows how the weld nugget has pulled out of the parent material, with significant plastic deformation.













Fig. 3: High weld integrity of a typical weld





There was insufficient time to study the size of gaps between plates that could be accommodated by 'bridging' with the weld, but a couple of welds where imperfect fit up had been achieved, creating a gap of approximately 1 mm, did not appear to lack weld quality.

Table 2: Results of Hammerhead welding trials

Welding position	Back plate (mm)	Front plate (mm)	Electrode/diameter (mm)	Weld number	Photographs top and cross-section	Welding parameters 1. High current (Amps) 2. Duration high current (sec) 3. Low current (Amps)
Downhand	15	8	Hammer-head 3.25	5WH73-D1		1. 300 2. 8 3. 210
	8	8	Hammer-head 3.25	5WH73-D2		1. 300 2. 8 3. 170
	4	4	Avesta 316/SKR 2.5	5WH73-D3		1. 180 2. 3 3. 80
	4	1.6 (G)	Avesta 316/SKR 2.5	5WH73-D4		1. 141 2. 3 3. 80
	2	2	Avesta 309L 2.0	5WH73-D5		1. 131 2. 3 3. 60

	1.6 (G)	1.6 (G)	Avesta 309L 2.0	5WH73-D6	 	<p>1. 109 2. 2 3. 62</p>
Vertical	15	8	Hammer-head 3.25	5WH73-V1	 	<p>1. 292 2. 5 3. 120</p>
	8	8	Hammer-head 3.25	5WH73-V2	 	<p>1. 292 2. 5 3. 120</p>
	4	4	Avesta 316/SKR 2.5	5WH73-V3	 	<p>1. 190 2. 3 3. 80</p>
	4	1.6 (G)	Avesta 316/SKR 2.5	5WH73-V4	 	<p>1. 140 2. 3 3. 80</p>

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	2	2	Avesta 316/SKR 2.5	5WH73-V5	 	 	<p>1. 130 2. 2 3. 60</p>	
	1.6 (G)	1.6 (G)	Avesta 309L 2.0	5WH73-V6			<p>1. 109 2. 2 3. 50</p>	

5. Suggestions for modification of welding kit

The Hammerhead process is currently an open arc process and for many applications open arc welding is perceived to be dangerous and dirty. Corus suggests that Specialist Welds should consider enclosing the arc within a shroud, with an extraction system attached. This could also be fitted with a safety contact so that the shroud needs to be in place before welding can commence. Such a system would be less likely to have perceived disadvantages in comparison with mechanical riveting to clinching. However, it would have a great advantage from only requiring access from one side. Such a development may be of particular interest for applications involving plate less than 8 mm thick.

A further development could be to automate the pressure by means of a pneumatic or hydraulic ram. Such a development would result in operators merely placing the system in the correct location and pressing a button. The skill level would become very low indeed, safety very high and the quality and consistency of weld very high.

6. Replacement of bolts with welds

For certain applications there is a desire to be able to fix a component from one side only. In such cases, a bolted assembly requires advanced planning and precise alignment. The Hammerhead technique facilitates a rapid, single sided attachment without precise alignment. Also, in many instances a weld would be quicker to make than a bolted assembly joint.

Testing had been undertaken, previously, to demonstrate good mechanical properties from typical welds in 15 mm thick plate made underwater and the results are recorded [1]. Hence, in this evaluation only the weld profiles were examined to assess whether a weld, of at least comparable quality to with those tested could be produced.

The weld profiles generally contained a high proportion of fused interface and the assessments made suggested that the welds should be of equal mechanical performance to those previously tested [1].

7. Conclusions

1. The Hammerhead welding process offers a rapid method of joining plates or sheets of a wide variety of thickness, in either the down-hand or vertical orientation.
2. Joints using the Hammerhead process can be made from one side only.
3. The correct degree of penetration can easily be achieved to ensure a weld of sufficient quality.
4. In certain cases connections, presently made by bolting, could be made by welding from one side.
5. Conventional stainless steel electrodes appear to be suitable for welding.
6. Small electrodes of approximately 2 mm need to be used for plate of a thickness below 4 mm.

7. Welds in thick materials in the vertical orientation will probably contain some defects, but would still be suitable for certain applications.

8. Recommendations

1. The Hammerhead welding process should be evaluated for a range of applications and especially those where single sided joining is required, but precise fit up cannot be achieved easily.
2. Use of a shrouding mechanism should be considered, to fully enclose the welding and prevent the escape of fumes.

9. Further work

1. Trials should be undertaken using conventional steel electrodes on plates within the same range of thickness.
2. The maximum gaps that can be 'bridged' between plates should be evaluated.
3. A shrouding device should be designed to enable the welding to be fully enclosed.

10. Reference

1. Keats, D J: Feasibility study for Hammerhead spot welding process (wet and dry), versus conventional fillet welding (wet and dry), using barracuda underwater electrodes, Smart Award Communication, Speciality Welds Ltd, 2004.