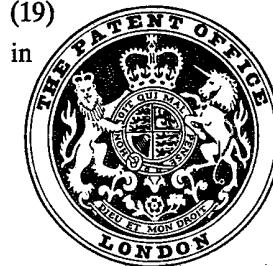


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(54) METHOD FOR TUBE WELDING

(71) We, ESAB Limited, a British Company, of Beechings Way, Gillingham, Kent, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is performed, to be particularly described in and by the following statement:-

5 The invention relates to methods for welding together tubular members in general and particularly to a method of butt welding a pair of vertically disposed ferrous, tubular members having a wall thickness of more than 12 mm in end-to-end relationship by multi-pass gas-shielded arc welding with a consumable electrode from the outside of the tubular members without using a backing member.

10 When drilling wells, e.g. offshore wells, vertically disposed tubes of substantial length are used to prevent materials such as water, soil etc. from being introduced into the well and to remove other materials such as oil from the drill hole.

The tube inserted into a drill hole consists of short tube sections welded together on site in end-to-end relationship. Until now manual welding methods were predominant requiring 15 much time and high-qualified workers. However, the manually made welds are not of uniform quality. Therefore great efforts have been made to automate the welding operation which is a requirement for a perfect weld.

20 It has been proposed to improve the weld quality by preparing the opposed edges of the tube sections in a special manner before welding. Accordingly, the edge of the upper tube is bevelled forming a conical surface inclined inwardly and downwardly at a bevel angle of appr. 45° to the tube axis. The lower tube has a square edge, or is beveled thereby forming a conical surface inclined inwardly at a bevel angle of appr. 15°. No root face is provided. The alignment of the two tubes is facilitated by the use of a backing member on the inner surface 25 of the tubes. The backing member is welded together with the tubes and forms an integral part of the weld thereby diminishing the inner section area of the tube. Submerged arc welding is used to join the tubes.

Disadvantages of the known welding methods are high costs, poor quality, binding 30 defects at the flanks of the groove and the root, and poor dimensional accuracy of the inner section area of the tube near the weld.

35 It is an object of the present invention to provide an improved method of butt welding a pair of vertically disposed tubular members. It is a further object of the invention to provide a method for depositing perfect welds with a consumable electrode without using a backing member on the inside of the tubes, thereby achieving a high dimensional accuracy and facilitating the welding operation.

35 The present invention consists of a method of butt welding together a pair of ferrous, tubular members disposed with axes vertical and having a wall thickness of more than 12 mm in end-to-end relationship by multi-pass gas-shielded arc welding with a consumable electrode from the outer side of the tubular members without using a backing member, comprising the steps of preparing the opposed edges of the tubular members by forming a 40 root face on each of the opposed edges the width of which root face being in the range of 0.5 to 3.0 mm, beveling each edge adjacent the root face to a bevel angle in the range of 40° to 50° with respect to the root face, coaxially aligning said tubular members so that the root faces of said tubular members are disposed in closely spaced relationship opposite to and facing one another, thereby forming a groove between the bevelled edges, the gap between 45 the root faces being not larger than 1.5 mm, performing a root pass by continuously feeding

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an electrode into the groove with its tip parallel with the root faces, the diameter of said electrode being not larger than 1.0 mm, supplying shielding gas consisting of 0.40% carbon dioxide with the balance being argon, energizing an arc between the electrode and the bottom of the groove, alternately changing the voltage supplied to the arc between a low 5 value and a high value at a frequency of alternation cycle in the range of 0.5 to 2.0 Hz, adjusting the low voltage to produce a dip transfer of the metal from the electrode into the groove during short-circuit periods, adjusting the high voltage to produce a spray transfer of the metal, adjusting the welding speed and the electrode feeding speed to deposit metal in the groove in the range of 0.15 to 0.35 grams per mm length of the pass, and successively 10 depositing overlapping passes for filling the groove.

The expressions "spray transfer" and "dip transfer" are here used with the meanings meanings defined in British Standard 499, Term Numbers 3294 and 3296.

It is advantageous to adjust the frequency of the voltage alternation and the welding speed in such a way that the length of the root pass deposited during one cycle of the voltage 15 alternation cycle is between 4 and 7 mm.

This invention will become clear from the following description taken in conjunction with the drawings illustrating a preferred application of the invention wherein:

Figure 1 shows a cross-sectional view of an edge preparation of a groove of this invention; Figures 2-4 show the groove after the deposit of the first, second and third pass, 20 respectively.

Figure 5 shows schematically a typical relationship of a welding unit to the tubular members for carrying out the invention in making butt welds.

Figure 1 shows a groove in the wall of two vertically disposed steel tubes 1, 2. The groove is symmetrical and provided with root faces 3 having a width c . Adjacent the root faces 3 an inner portion 4 of the edges is bevelled to an angle v . The inner portion is adjacent an outer portion 5 bevelled to an angle u and extending to the outside of the tube. The distance between the site of transition of the inner and outer portions of the edge and the plane defined by the square edge of each root face is designated by the letter d . A shallow chamfer 6 on the inside of the tubes facilitates the alignment of the tubes before welding, 30 especially when the tubes are not quite round or their wall thicknesses show a slight difference. The root faces of the tubes are disposed in closely spaced relationship and facing one another so that the gap between them is not larger than 1.5 mm.

The first pass 7 is deposited by shielded-gas arc welding. An electrode 14 is fed by a feeding unit 15 through a welding torch 16 into the groove. When depositing the first pass, 35 the tip 17 of the electrode is held in the plane of the square edge of the root faces 3. The welding power is supplied to the welding site by a welding cable 18 and a work connection 19 from a welding power source 20 provided with controlled rectifier valves. A shielding gas mixture is supplied to the welding torch 16 and the groove by hoses 31, 22 connected through valves 26, 27 to gas sources (not shown) for argon and carbon dioxide. The tubes 1, 40 2 are rotated by a schematically shown friction wheel 23 engaging the outside of tube 2 and driven by a motor 24. If the tubes cannot be rotated, the welding unit is moved along the periphery of the tubes.

The welding voltage is alternately changed between a high and a low level with the aid of an adjustable triggering unit 25 which supplies pulses to the controlled rectifier valves for 45 adjusting the welding voltage in a known manner. The frequency of the voltage alternation is in the range of 0.5 to 2.0 Hz. The high voltage is adjusted to produce a spray metal transfer between the electrode and the workpiece in form of droplets, and the low voltage is adjusted to produce a dip metal transfer only under short-circuit conditions between the electrode and the workpieces. These welding conditions result in a root pass of very quality. 50 The root penetration is quite sufficient to produce a flat weld face on the inside of the tubes. The weld face is practically in line with the inner surface and therefore the root pass does not diminish the inner sectional area of the tubes.

A second pass 8 and a third pass 9 are deposited adjacent the root bead 7. It has been shown that a very good penetration of these two passes can be achieved when only carbon 55 dioxide is used as shielding gas and the voltage is alternated in the same way as during the deposit of the root pass.

The filling passes 10, 11, 12, 13 are deposited in the named numeral order by using a known gas-shielded arc welding technique without voltage alternation.

The following examples are illustrative of the butt welding method of the invention 60 without in any way being limiting:-

Measurements of the groove:

c:	0.5 - 3.0 mm	
5 d:	not less than 3.5 mm	5
v:	40° - 50°	
10 u:	min. 10° but not more than v	10
root gap:	not more than 1.5 mm.	

15 Welding parameters for the first pass:

Frequency of voltage alternation cycle:	0.5 - 2.0 Hz	15
20 Low welding voltage level:	22 - 26 V D.C.	20
High welding voltage level:	36 - 40 V D.C.	
25 <i>Duration of the high voltage level per alternation cycle</i>	0.3 - 0.4	25
Duration of alternation cycle		
30 Shielding gas:	0 - 40% CO ₂ , preferably 5 - 40% CO ₂ , remainder Ar	30
Electrode diameter:	not more than 1.0 mm	
35 Deposition rate of metal:	0.15 - 0.35 grams/mm length of the pass	35

Optionally for the passes adjacent the root bead:

40 The same welding parameters as above are preferred. The shielding gas consists of 0-95% argon, the balance being carbon dioxide. Preferably, however, carbon dioxide is solely used as shielding gas. When welding steel tubes having an inner diameter of 100 mm and a wall thickness of 17 mm the following values have been preferred: 40

	Measurements of the groove:	$c = 1.5 \text{ mm}$, $d = 4.5 \text{ mm}$, $v = 45^\circ$, $u = 15^\circ$, root gap = 0 mm.
5	First pass:	
5	Frequency of voltage alternation cycle:	1.25 Hz
10	Low voltage level:	24 V D.C.
10	High voltage level:	38 V D.C.
15	Welding current:	appr. 190 A
15	Duration of alternation cycle:	0.8 seconds
15	Duration of high voltage level:	0.3 seconds
20	Shielding gas:	20% CO ₂ + 80% Ar
20	Electrode diameter:	0.8 mm
25	Electrode feeding speed:	17.5 m/min.
25	Welding speed:	350 mm/min.
25	Deposition rate of metal:	0.20 grams per mm length of the pass
30	Second and third pass:	
30	The same parameter as with the first pass using, however, 100 % CO ₂ as shielding gas.	
35	Filling passes:	
35	Short-circuit arc welding.	
35	Welding voltage:	24 V D.C.
40	Shielding gas:	20% CO ₂ + 80% Ar.
	WHAT WE CLAIM IS:	
45	1. A method of butt welding together a pair of ferrous, tubular members disposed with axes vertical and having a wall thickness of more than 12 mm in end-to-end relationship by multi-pass gas-shielded arc welding with a consumable electrode from the outer side of the tubular members without using a backing member, comprising the steps of preparing the opposed edges of the tubular members by forming a root face on each of the opposed edges the width of which root face being in the range of 0.5 to 3.0 mm, beveling each edge	45
50	adjacent the root face to a bevel angle in the range of 40° to 50° with respect to the root face, coaxially aligning said tubular members so that the root faces of said tubular members are disposed in closely spaced relationship opposite to and facing one another, thereby forming a groove between the bevelled edges, the gap between the root faces being not larger than 1.5 mm, performing a root pass by continuously feeding an electrode into the groove with	50
55	its tip parallel with the root faces, the diameter of said electrode being not larger than 1.0 mm, supplying shielding gas consisting of 0-40% carbon dioxide with the balance being argon, energizing an arc between the electrode and the bottom of the groove, alternately changing the voltage supplied to the arc between a low value and a high value at a frequency	55
60	of alternation cycle in the range of 0.5 to 2.0 Hz, adjusting the low voltage to produce a dip transfer of the metal from the electrode into the groove during short-circuit periods, adjusting the high voltage to produce a spray transfer of the metal, adjusting the welding speed and the electrode feeding speed to deposit metal in the groove in the range of 0.15 to 0.35 grams per mm length of the pass, and successively depositing overlapping passes for	60
65	filling the groove.	
65	2. A method according to Claim 1, wherein the frequency of the voltage alternation	65

cycle and the welding speed are adjusted in such a way that the length of the root pass deposited during one cycle of the voltage alternation cycle is between 4 and 7 mm.

3. A method according to Claim 1 wherein the high voltage is supplied during 30 to 40% of the duration time of one cycle of the voltage alternation.

5 4. A method according to Claim 3 wherein the duration for one cycle of the voltage alternation is 0.8 seconds and the high voltage is supplied during 0.3 seconds of the said cycle.

5 5. A method according to Claim 1 wherein the shielding gas consists of 5 - 40% carbon dioxide with the balance being argon.

10 6. A method according to Claim 1 wherein the low voltage is between 22 and 26 volts and the high voltage is between 36 and 40 volts.

15 7. A method according to Claim 1 wherein the passes adjacent the root pass are deposited by feeding an electrode having a diameter not larger than 1.0 mm into the groove, supplying shielding gas consisting of 0 - 95% argon with the balance being carbon dioxide, energizing an arc between the electrode and the root pass, alternately changing the voltage supplied to the arc between a low value and a high value at a frequency of alternation cycle between 0.5 and 2.0 Hz, adjusting the low voltage to produce a dip transfer of the metal from the electrode into the groove during short circuit periods and adjusting the high voltage to produce a spray transfer of the metal.

20 8. A method according to Claim 7 wherein the shielding gas consists essentially of carbon dioxide.

25 9. A method of butt welding together a pair of ferrous, tubular members disposed with axes vertical and having a wall thickness of more than 12 mm in end-to-end relationship by multi-pass gas-shielded arc welding with a consumable electrode from the outer side of the tubular members without using a backing member, comprising the steps of preparing the opposed edges of the tubular members by forming a root face on each of the opposed edges the width of which root face being in the range of 0.5 to 3.0 mm, beveling a first portion of each edge adjacent the root face to a bevel angle in the range of 40° to 50° with respect to the root face, and beveling a second portion of each edge adjacent the first portion to a bevel angle with respect to the root face not more than the bevel angle of the first portion but being not less than 10°, the vertical distance between the site of transition of the first and second portions of each edge and the plane of the root face being at least 3.5 mm, coaxially aligning said tubular members so that the root faces of said tubular members are disposed in closely spaced relationship opposite to and facing one another thereby forming a groove between the bevelled edges, the gap between the root faces being not larger than 1.5 mm, performing a root pass by continuously feeding an electrode into the groove with its tip parallel with the root faces, the diameter of said electrode being not larger than 1.0 mm, supplying shielding gas consisting of 0-40% carbon dioxide with the balance being argon, energizing an arc between the electrode and the bottom of the groove, alternately changing the voltage supplied to the arc between a low value and a high value at a frequency of alternation cycle in the range of 0.5 to 2.0 Hz, adjusting the low voltage to produce a dip transfer of the metal from the electrode into the groove during short circuit periods, adjusting the high voltage to produce a spray transfer of the metal, adjusting the welding speed and the electrode feeding speed to deposit metal in the groove in the range of 0.15 - 0.35 grams per mm length of the pass, and successively depositing overlapping passes for filling the groove.

30 10. A method according to Claim 9, wherein the passes adjacent the root pass are deposited by feeding an electrode having a diameter not larger than 1.0 mm into the groove, supplying shielding gas consisting of 0-95% argon with the balance being carbon dioxide, energizing an arc between the electrode and the root pass, alternately changing the voltage supplied to the arc between a low value and a high value at a frequency of alternation cycle between 0.5 and 2.0 Hz, adjusting the low voltage to produce dip transfer of the metal from the electrode into the groove during short circuit periods and adjusting the high voltage to produce a spray transfer of the metal.

35 11. A method according to Claim 10, wherein the shielding gas consists essentially of carbon dioxide.

40 12. A method of butt welding together tubular members substantially as hereinbefore described with reference to the accompanying drawings.

45 13. Tubular members when butt welded together in accordance with a method as claimed in any one of the preceding claims.

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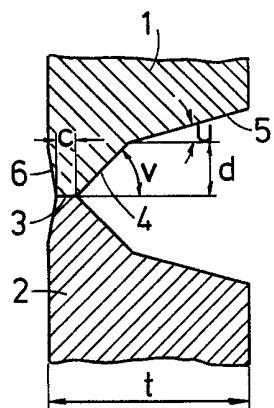


Fig.1

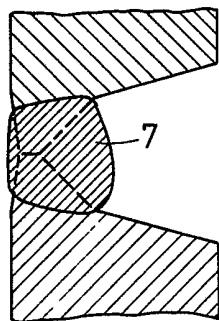


Fig. 2

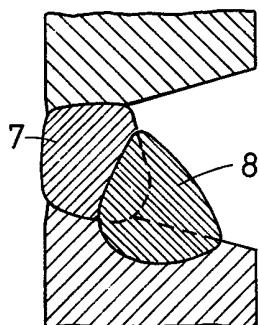


Fig. 3

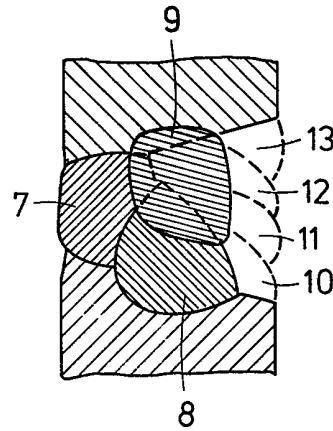


Fig. 4

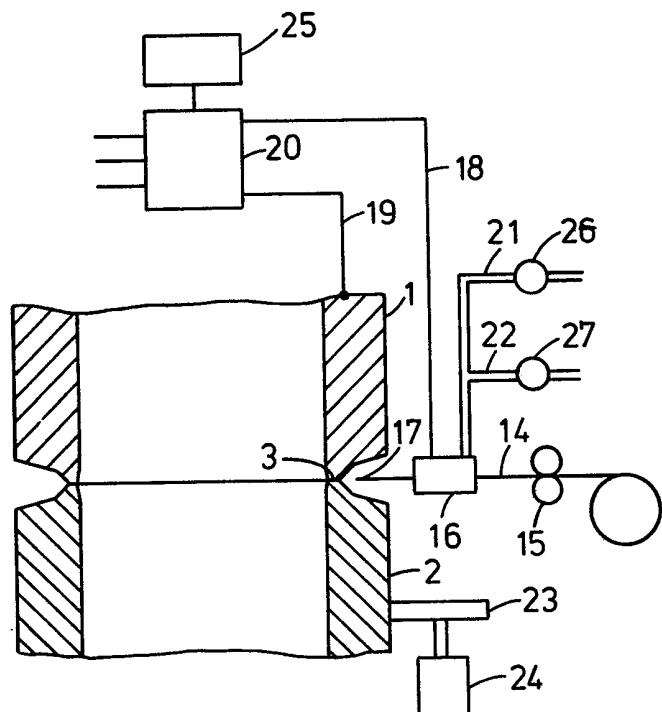


Fig. 5