MIG/MAG AUTOMATIC WELDING PROCEDURE

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MIG/MAG welding, circular welding, drill-pipe welding aplication

The circular welding is aplied in drill pipe welding. They are produced by welding two drill pipe pin connections and a coupling to the body of the pipe. Due to the stresses the drill pipes are subject to during the drilling operation, as well as due to the big distances, the drill pipes are connected between them by screwing up the drill pipe pin into the coupling. These connections are made of high resistant steels, which differ from the material of the drill pipes, and, thus, heterogeneous butt joints are obtained after welding. The industrial procedure used at the fabrication of these products is “resistance butt welding with intermediate melting”.

1. CHOICE OF THE WELDING PROCEDURE AND SETTING UP ITS PARAMETERS

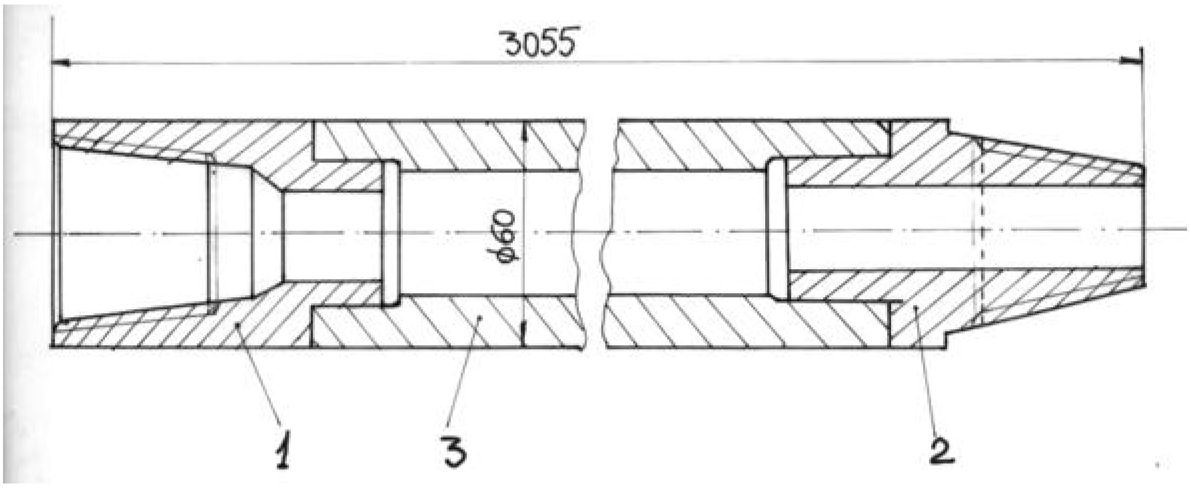

Fig. 1. Drill pipe assembly before welding

Therefore, it is imposed that the participation of the base materials (dilution at the seam formation) should be as low as possible, and, in this case, the chemical composition of the welded butt will be as close as possible to that of the filler material.

Dilution depending on the welding procedure is presented in Table 1.

Table 1. Dilution (%) depending on the welding procedure

No	*Welding procedure*	*Dilution (%)*
1.	Electric arc welding with basic electrodes	20-30
2.	MIG/MAG gas shielded metal arc welding	20-30
3.	TIG welding	10-100
4.	Submerged arc welding	30-60

The choice of the welding procedure is important not only for getting a high productivity but, especially, for getting welded joints with higher mechanical characteristics that those of the base materials. The same welding procedures, different parameters, or even different welding problem can be solved, in the most cases, by more ways: using different welding procedures, different parameters or even different filler materials.

The choice of the welding procedure was performed in two stages. At first, the procedure that allowed to solve the technological problems from technical points of view was set up, then, in the second stage, the procedure was improved so as to provide maximum efficiency. Therefore, the MIG/MAG gas shielded meta l arc welding procedure was used for drill pipes.

1.1. BASE AND FILLER MATERIALS

The drill pipe is made of OLT-45 steel, usually used in oil industry, and is delivered as tubular product of 60mm diameter and 12mm thickness. The prescribed and found chemical composition of the OLT-45 steel, determined on homologation samples, is presented in
Table 2.

Table 2. Chemical composition of the OLT-45 steel

Steel grade	Chemical composition (%)					Observations
	C	Mn	S	P	Si	
OLT 45	0,17-0,24	0,4-0,8	Max 0,045	Max 0,045	0,17-0,3	Prescribed
OLT 45	0,19	0,8	0,001	0,001	0,17	Determined

The “drill pipe pin” and the “coupling” connections have high mechanical characteristics as required for the material from which the special “FLOWTER” threads are made of. To this category belong the improving low alloy steels, as well. Actually, 30MoCrNi20 steel is recommended. Its prescribed and found chemical composition, determined on homologation samples is presented in Table 3.

Table 3. Chemical composition of the 30MoCrNi20 steel

Steel grade	Chemical composition (%)								Observations
	C	Mn	S	P	Cr	Ni	Mo	Si	
30MoCrNi20	0,26-0,34	0,3-0,6	Max 0,035	Max 0,035	1,8-2,1	1,8-2,1	0,25-0,35	-	Prescribed
30MoCrNi20	0,3	0,60	0,03	0,02	1,83	2	0,25	0,37	Determined

The mechanical and physical characteristics of the base materials were also taken into account. The filler materials, the electrode wire and the shielding gas were chosen on the basic of a study concerning the welding behaviour of the drill pipe assemblies, and, eventually, of a pre-heating thermal treatment, or of a tempering one. Depending on these observations, a filler material is chosen with a chemical composition close to that of the base metal. In same cases, austenitic materials of 25Cr20Ni type are used, with a high reserve of austenite, but a high risk of cracking at the same time, or materials of 18CrNi6Mn type with a reserve of austenite sufficient to compensate its dilution with the base metal, what reduces the risk of cracking.

A high alloy austenitic filler material of 18/8/6 type was chosen, what simplified the welding technology by eliminating both the pre-heating and the post-welding tempering thermal treatment. The chemical composition of the welding wire SGX15CrNiMn18.8 DIN 8556 is presented in Table 4.

Table 4. Chemical composition of the filler material

Steel grade	Chemical composition (%)				
	C	Mn	Si	Cr	Ni
SGX15CrNiMn 18.8	0,07	6,5	0,8	18	8

The diameter of the wire was of 1,0mm, and the recommended and used shielding gas for this wire was Ar + 1-3% O_2.

1.2. PREPARATION OF THE COMPONENTS FOR WELDING

The preparation of the drill pipe body, of the coupling and of the drill pipe pin was carried out by turning a "V' groove on a "lock" type backing, whose sizes are given in Fig.2.

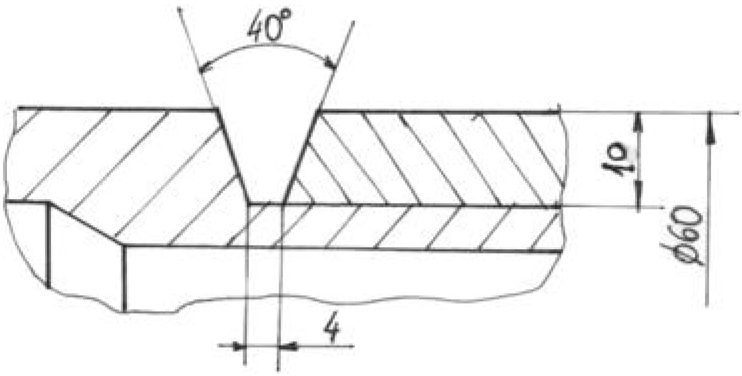

Fig.2. Shape and sizes of the groove

The number of passes for this type of groove was calculated taking into account its own area and the seam area. After some experimental tests the number of passes was fixed at 4.

2. CALCULATION OF THE WELDING PARAMETERS

A high number of ways of the drop transfer through the electric arc are possible with MAGMA welding procedure: short, intermediate or long arc, spray, pulsate or rotating arc.

Based on the study performed on the groove geometry and on the level of the welding mechanization, the pulsate arc was chosen. It provides a high deposition rate, controlled and consequent penetration, control of dilution, and it is suited for automatic welding with wires below 100mm diameter.

The welding operation condition is defined by the welding current, arc voltage, welding speed, wire stick out, gas flow, heat input, and the position of the torch head

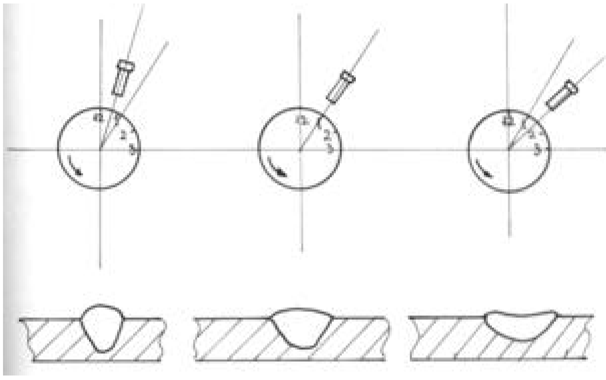

Fig.3. Orientation of the torch heat against 12 o'clock

against the vertical axis of the groove. The influence of this position on the groove geometry in case of a circular butt joint is presented in Fig.3.

In case of circular welding is important to keep the axis of nozzle of the torch heat at an angle of 30° against the vertical position, 13o'clock (position b, Fig.3). The difference showed by 12.30 o'clock and by 13.30 o'clock may result either in an excessive over raise (position a, Fig.3) or in an exaggerated width (position c, Fig.3).

3. TESTINGS AND EXPERIMENTAL RESULTS

After the groove geometry and the welding parameters were set up they were tested on a work piece made of OL 37. to find out the optimum size at welding (safe penetration at the root), five welding grooves, identical in shape but different in opening, were simulated. The appearance of the depositions can be seen in the macrostructure presented in Fig.4, and the technological parameters are presented in Table 5. The results evince that the optimum opening for the MIG/MAG welding of drill pipes is of 4.0 mm, and

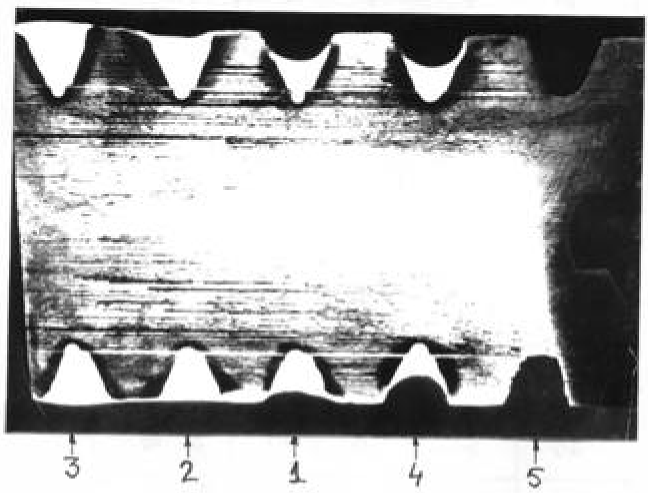

Fig.4. Macrostructure of the welding layers

1- a layer at the opening of 4 mm; 2- two layers at the opening of 4 mm; 3- three layers at the opening of 4 mm; 4- a layer at the opening of 5 mm; 5- groove geometry the angle is of 40°.

Table 5. Welding parameters of layers

No. of groove	Wire diameter	v_{as}	Travel speed	Electrical stick out	Amps	Voltage	Wall thickness	Number of passes	Root
	mm	m/min	cm/min	mm	A	V	mm	-	mm
1	1,0	8,0	22	12	190-196	23,6	9	1	4
2	1,0	8,0	22	12	188-192	23,6	9	1	4
					194-200	25		2	
3	1,0	8,0	22	12	190-196	23,6	9	1	4
					194-200	25		2;3	
4	1,0	8,0	22	12	186-194	23,6	9	1	5
Obs.: type of current: pulsed MIG/MAG; gas flow: 16 l/min; electrode wire: 18.8Mn; d_S = 1,0 mm position of nozzle: 3mm outward work piece.									

The parameters used at the welding of drill pipes of 60mm diameter, chosen on the basis of results that can be seen on the sample in Fig. 4 are presented in Table 6.

Macroscopic analysis of a heterogeneous pipe- coupling joint sampled from the butt weld, Fig.5, evinces a penetrated seam, with a uniform HAZ and corresponding sizes.

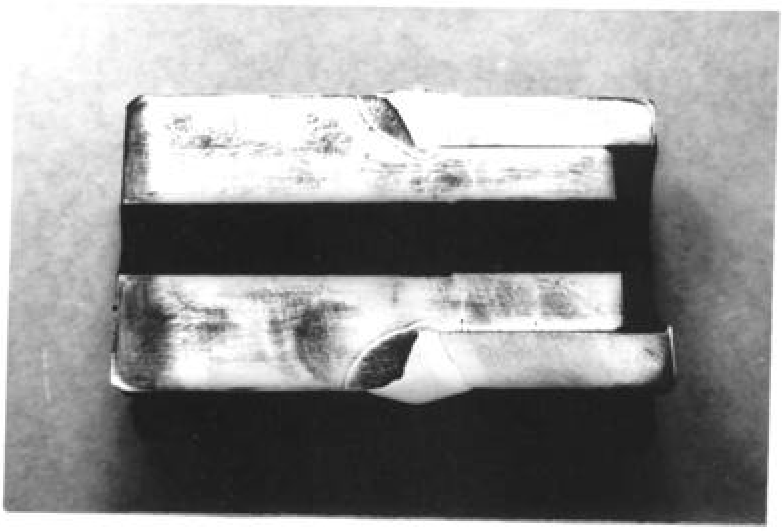

Fig. 5 Macroscopic appearance of the welding

Table 6 Welding parameters of drill pipes

Type of welding	Welding parameter						
	Travel speed	Amps	Voltage	Number of passes	Electrical sickouts	Root	Position of the contact tube against the gas nozzle
	cm/min	A	V	-	mm	mm	-
Pipe 1 - bit pin	23-25	178-180	24.2	1	10-11	4	3mm outward, stable welding
	33-36	174-180	25.0	2;3			
Pipe 1 - coupling	23-25	194-200	24.0	1	10-11	4	
	33-36	189-196	24.8	2;3			
Pipe 2 - bit pin	21	190-194	24.2	1	10-11	4	3mm outward, unstable welding
	30	186-188	25	2;3			
Pipe 2 - coupling	21	184-190	24	1	10-11	4	
	30	168-172	25.2	2;3			
Pipe 3 - bit pin	25	198-200	24	1	10-11	4	3mm outward, very stable welding
	36	170-180	25	2;3			
Pipe 3 - coupling	22	190-196	24	1	10-11	4	
	31.5	170-180	25	2;3			
Obs. diameter wire: 1,0mm; gas flow:16 l/min							

4. CONCLUSIONS

- a good geometry of the butt weld;
- uniform HAZ and corresponding sizes;
- maximum hardness of 233 HV5 in the connection (coupling and drill pipe pin);
- ferrite- perlite structure in the base material and in HAZ, as well as austenite + ferrite in the butt weld.
- The values of the hardness in the HAZ are lower that the maximum limits of hardness for the corresponding materials, what proved to be a favorable factor in the exploitation of these drill pipes. The results obtained after the experimental testing as well as the behavior of the drill pipes during operation confirms the fact that MAG welding with pulsed arc, using austenitic filler material, is suited and efficient for repairing by welding the drill pipes and even for realizing new products.

5.BIBLIOGRAPHY

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