Influence of Welding With Two-Jet Gas Shielding On the Shaping of a Welding Joint

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Influence of Welding With Two-Jet Gas Shielding On the Shaping of a Welding Joint

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Abstract. The author considers gas-dynamic influence upon microhardness and weld configuration of single-pass welds from steel 30HGSA when welding with consumable electrode under double-jet shielding. The relations to the chosen controlled welding parameters (Q, L, I) are developed and the controlling influence of the gas-dynamic affect of dynamic shield gas jet over formation of welds from alloy-treated steel 30HGSA is determined.

1. Introduction

Alloyed steels possessing a wide range of operational properties are used in manufacturing essential welded constructions [1, 2]. They provide a high strength of a construction and simultaneously reduce its specific quantity of metal. However, under the thermal cycle of welding in the heat-affected area of joint welds quenched structures are formed. The latter show high values of hardness at low values of toughness. As the consequence, the maximum quantity of low-temperature cracks when welding is formed in the heat-affected area [3].

There are various methods for improving operational properties of alloyed steel joint welds and their resistance to forming low-temperature cracks when welding. For instance, the level of high-temperature chemical micro-inhomogeneity, structural and mechanical inhomogeneity in the fusion area and in the weld metal can be decreased by means of intense mixing of electrode and base metals [4]. Electrode and base metals are mixed better as the time of weld pool metal being liquid increases, but at the same time, it causes the saturation of the weld metal with hydrogen and results in its embrittlement [1]. We can reduce the time of the weld pool metal being liquid and simultaneously increase the rate of its mixing by the impulse-dynamic impact, for example, by controlling the electrode metal transfer into the weld pool [5–7] or by controlling the impact of gas shielding medium [8–10].

The paper is aimed to determine the influence of the parameters of consumable electrode welding under double-jet gas shielding upon microhardness and weld configuration in single-pass joint welds from steel 30HGSA.

2. Methodology

The mechanized single-pass welding of plates from steel 30HGSA 150x300 mm in size and 8 mm thick was completed in CO_2 with Sv-08G2S welding wire 1.2mm in diameter and the stationary arc under double-jet gas shielding without preheating and following-up heat treatment. The controlled parameters were varied according to the matrix of planning (Tabl. 1), arc voltage U = 26…27 V, welding rate V = 25…26 cm/min.

Table 1

The matrix for planning of a full factorial experiment

Controlled welding parameter	№ experiment							
	1	2	3	4	5	6	7	8
1. Shielding gas consumption Q, l/min	15	20	15	20	15	20	15	20
2. Electrode wire extension L, mm	8	8	14	14	8	8	14	14
3. Welding current I, A	170	170	170	170	200	200	200	200

3. Results and Discussion

The dispersion of microhardness in the cross-section of the welded samples was measured by microhardness tester Duramin-5 (Fig. 1, 2) in accordance to lines located 2, 4, 6 mm from the upper surface of welded samples.

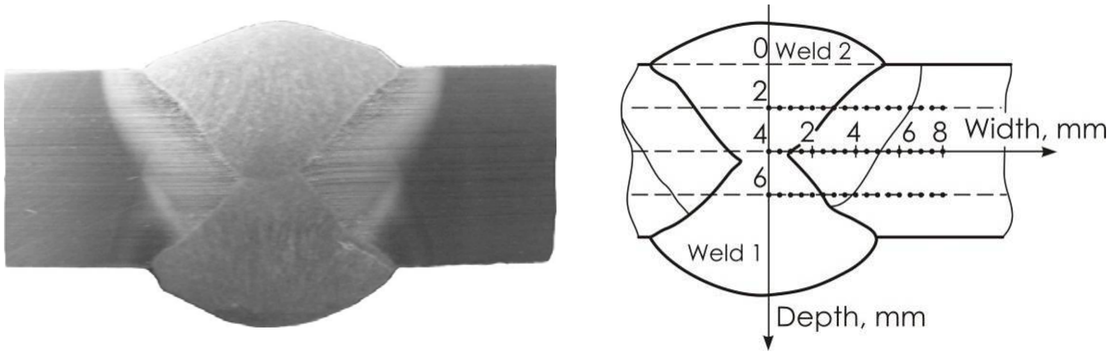


Figure 1. Macrosection and diagram for measuring microhardness of welded samples

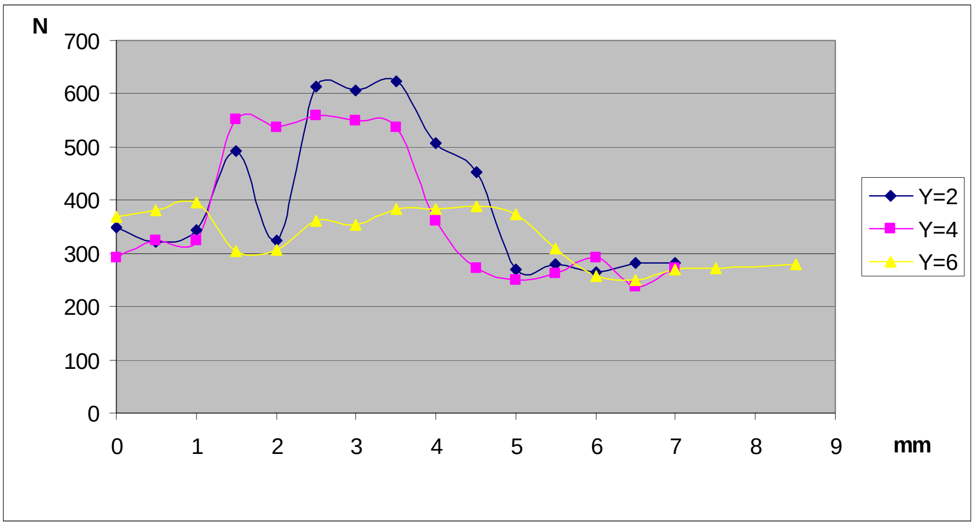
The analysis of the dispersion of microhardness in the cross-sections of joint welds showed the increase in microhardness of the heat-affected area, particularly beyond Y=2 mm from the upper surface of the welded samples. The value of microhardness in the centre of the weld metal of all welded samples is nearly equal and amounts to 300-330 N, which is approximately congruent to the microhardness of the base metal 270-300 N.

To determine the relation of microhardness in the heat-affected area of single-pass joint welds from steel 30HGSA to the controlled parameters (Q, L, I) maximum values of microhardness on each side of the weld axis in line Y=2 mm were implemented (the percentage error doesn't exceed 8%):

$$H\max\_2 = 1428 + 25.94\cdot Q - 78.28\cdot L - 6.49\cdot I - 2.358\cdot Q\cdot L + 0.59\cdot L\cdot I \quad (1)$$

The results of research of microhardness dispersion in the cross-sections of joint welds from steel 30HGSA demonstrated the dependence of the maximum value of microhardness upon the electrode extension. When decreasing the electrode extension there is an increase in microhardness peak, which is possible due to the increase in the density and outflow rate of the shielding gas (when its consumption held equal). It causes the growth of the rate of metal cooling-down under the welding nozzle and, consequently, leads to the increase in microhardness in the heat-affected area [11]. The maximum value of microhardness also rises as the consumption of the shielding gas is increased and falls down as the welding current rises.

The microstructure of joint weld areas formed according to welding modes 1 and 8 of experiments from the matrix for panning a full factorial experiment (Tabl. 1) is shown in Figure 3. The analysis of the microstructure combined with the analysis of microhardness dispersion revealed the significant influence of controlled welding parameters (Q, L, I) upon the microstructure of a weld and both of a heat-affected area and its length.

<table>
<tr><th>No. EXPERIMENT</th><th>MICROHARDNESS, N</th></tr>
<tr><td>1</td><td>
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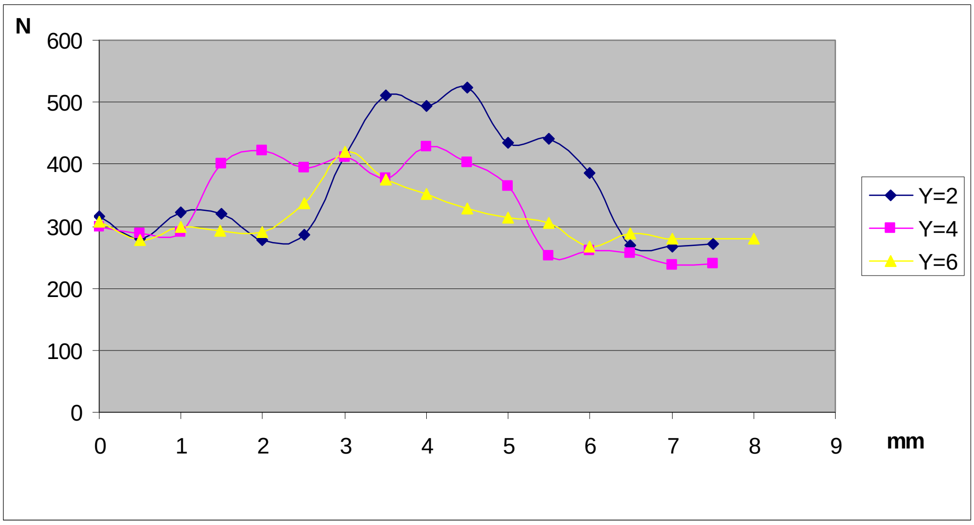
<tr><td>8</td><td>
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Figure 2. The dispersion of microhardness in the cross-sections of joint welds formed according to 1 and 8 welding modes from the matrix of a full factorial experiment

The formed welded samples were used for carrying out measurements of weld dimensions (E – weld width, g – weld reinforcement, h – weld penetration). According to the results of research the multi-factorial relations of single-pass weld dimensions (E, g, h) to the controlled parameters of welding under double-jet gas shielding were developed, the percentage error doesn't exceed 10%:

1. The relation of weld width (mm) to the controlled parameters.

$$E = 64.4 - 3.8 \cdot Q - 4.18 \cdot L - 0.317 \cdot I + 0.3 \cdot Q \cdot L + 0.02 \cdot Q \cdot I + \\ + 0.02 \cdot L \cdot I - 0.00156 Q \cdot L \cdot I \quad (2)$$

2. The relation of weld reinforcement (mm) to the controlled parameters.

$$g = 0.925 \cdot Q + 0.099 \cdot I - 0.005 \cdot Q \cdot I - 15.8 \quad (3)$$

3. The relation of weld penetration (mm) to the controlled parameters.

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$$h = 54.3 - 3.01 \cdot Q - 4.605 \cdot L - 0.245 \cdot I + 0.266 \cdot Q \cdot L + 0.01463 Q \cdot I + \\ + 0.023 \cdot L \cdot I - 0.00133 Q \cdot L \cdot I \quad (4)$$

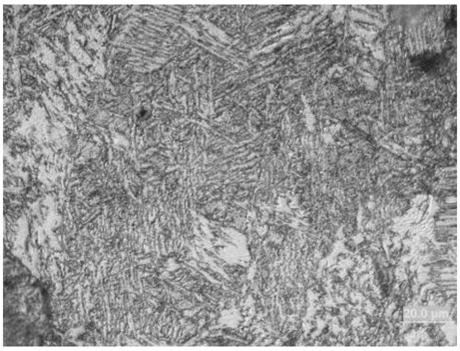
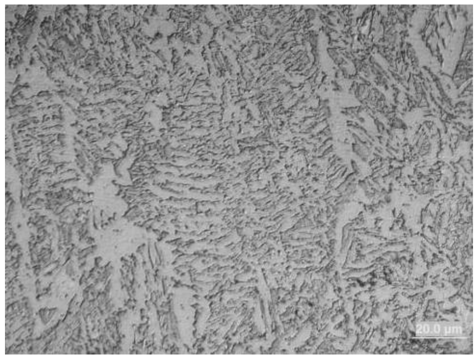
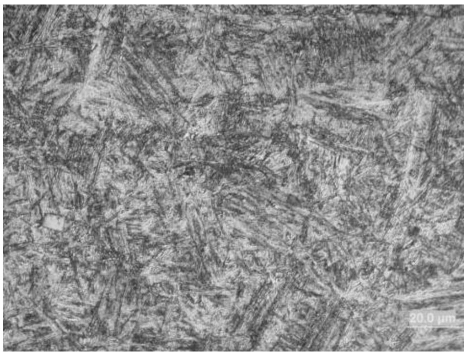
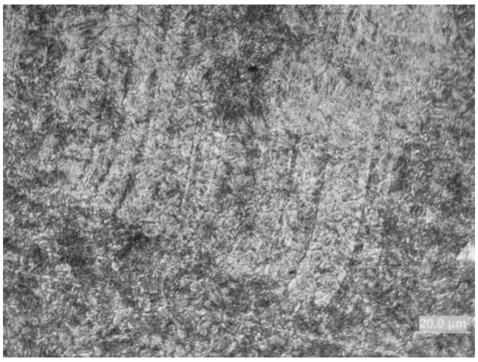
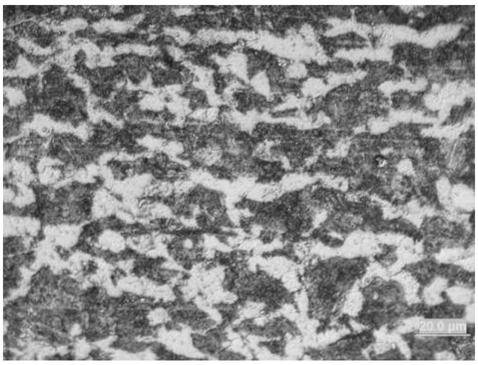
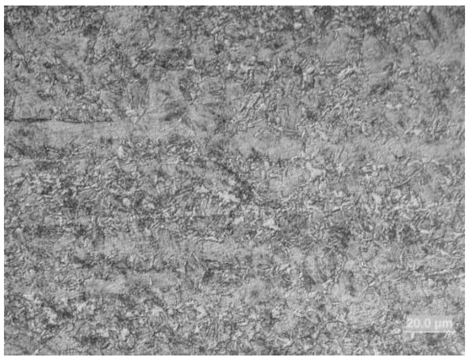
Area	1	8
Weld		
Heat-affected area, 3 mm from weld axis		
Heat-affected area, 4 mm from weld axis		
Heat-affected area, 6 mm from weld axis		

Figure 3. Microstructure in the joint weld areas, formed according to welding modes 1 and 8 of experiments from the matrix for planning a full factorial experiment, in line Y=2mm

All the dimensions of single-pass welds (E, g, h) of joint welds from steel 30HGSA (in conditions of the experiment) are affected both by the welding current, the shielding gas consumption, separately and combined, and by the three factors (Q, L, I), acting simultaneously. There is also a considerable influence of the electrode extension combined with the shielding gas consumption and welding current upon the weld width and penetration.

Conclusion

It's determined that when double-jet gas shielded welding the gas-dynamic impact influences the structural and phase condition, the dispersion of microhardness in the cross-section of joint welds and weld configuration, in other words, it allows controlling operational properties of joint welds from alloyed hardenable steels.

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