Study of Gasdynamic Effect Upon the Weld Geometry When Concumable Electrode Welding

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Abstract. The paper considers the ways of weld geometry controlling when consumable electrode welding under single-jet and double-jet gas shielding. The authors provide comparative results of experimental studies on the effects of shielding gas supply upon the weld geometry in weld joints produced from construction carbon steel 45. It has been established that gas-dynamic effect of the shielding gas has a significant impact upon shaping and weld geometry when consumable electrode welding under double-jet gas shielding.

1. Introduction

During the recent decades much work has been done to ensure high service reliability, safety and efficiency of engineering products. Technological advance imposes new requirements on production methods and welding practices. One of the most wide-spread welding techniques is shielded arc welding. This welding technique has a number of advantages [1]: the opportunity of human observation, opportunity of welding items with varying thickness, application of robotic technologies, etc. The basic technological parameters of consumable electrode gas shielded welding are intensity of arc current, arc voltage, density and type of arc current, cross-section area (diameter) of the electrode, welding rate. During gas-shielded welding gas is applied to protect the welding area . The gas is supplied into the welding area in the firm of a jet. The type of gas applied in the process determines the physic, metallurgic and operational characteristics of the welding method [2].

Controlling weld geometry is one of the most important tasks when consumable electrode welding as the geometrical dimension of the weld determines the efficiency of the metallic construction. Complementary parameters: length of the welding wire, gas composition and flow rate, method of gas shielding, electrode and article position when welding, etc. [2].

There are various ways of controlling weld geometry and improving the operational properties of welded metallic structures but, at the same time, none of them can be considered as a universal approach to problem solution. Many scientists study the opportunities of controlling weld and HAZ shaping when consumable electrode welding. Many techniques and devices contributing to controlling weld joints shaping [2]: changing welding conditions, current pulse pile-up, programming welding conditions, application of magnetic fields over the weld pool, formation of mechanical impulses and electrode vibration, changing electrode geometry, adding various chemical elements into the wire composition, changing shielding gas composition, etc.

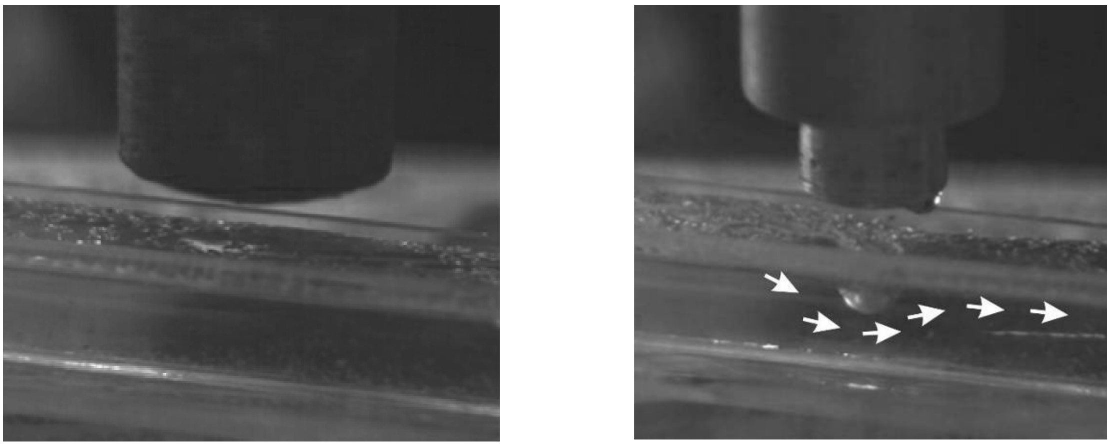
Authors [3-12 and other] studied how the changes of shielding gas flow effect the process of consumable electrode welding and note that with increase of gas flow rate the quality of the weld shape and protection of the weld area improve. Increasing the stiffness of the gas jet is especially important when the welding works are completed in open areas [6, 8]. In works [2, 4] the authors show that the electrode metal drop, beside the basic forces, is significantly effected by the pressing force of the shielding gas jet.

Application of double-jet gas shielding [12] as contrasted to traditional (single-jet) one ensures reliable protection of the weld pool, refinement of the weld metal structure, graded transition from the weld to the basic metal, improvement of mechanical properties of the weld joints, decrease of chemical inhomogeneity of the weld due to more rapid gas-dynamic mixing of the molten metal in the weld pool. In other words, it allows controlling the operational properties of the weld joints.

Aim of the work: determine the influence of gas-dynamics of single-jet and double-jet gas shielding upon the weld geometry when consumable electrode welding in the gas mixture of 82% Ar + 18% CO_2.

2. Methodology

To estimate the effect of shielding gas jet upon the weld pool surface we completed research with the physical model of the weld pool presented as a pan with liquid. Molten liquid metal of the weld pool was simulated with glycerin (identical viscosity). For the ease of liquid motion observation convenience the researchers added aluminum powder to the glycerin. The process of simulation of shielding gas flow from the weld nozzle and its effect upon the glycerin surface was recorded with high-speed camera "VideoSprint". The experiment was carried out under the following conditions: gas flow rate Q = 40 l/min, welding rate V = 25 cm/min, length of the welding wire L = 12 mm (Fig. 1).



a) b)

Figure 1. Effect of shielding gas jet upon the surface of glycerin:
a) traditional single-jet gas shielding; b) double-jet gas shielding

The experiment showed that under the traditional single-jet gas shielding the surface of the glycerin slightly trembled and the powder particles in the surface layer of glycerin did not practically move (Fig. 1, a). Under the double-jet gas shielding glycerin surface buckled forming a hollow 4-5 mm in diameter and powder particles in the upper glycerin layer were moving from the front area, over the bottom of the hollow, rounding the gas jet, to the back area of the simulated weld pool (Fig. 1, b). This way, significant effect of the shielding gas jet upon the weld pool surface and possibility of weld geometry controlling when consumable electrode welding under controlled gas-dynamics of the shielding gas has been established.

To determine the effect of the gas-dynamics of single-jet and double-jet gas shielding upon the weld geometry when consumable electrode welding in the gas mixture of 82% Ar + 18% CO_2 an experiment was completed on the real object of research. In the course of the experiment we completed bead welding over a plate of steel 45 10 mm thick with welding wire Sv-08G2S, 12 mm in diameter in the gas mixture of 82% Ar + 18% CO_2. Bead welding was completed with traditional (single-jet) and double-jet gas shielding. Welding conditions: I=195…200 A, length of the welding wire L= 10 mm, gas flow rate was changed from 5 to 25 l/min at the interval of 5 l/min (Table 1), arc voltage U = 25…26 V, welding rate V = 5 mm/s. Power supplies Shtorm-Lorch V 50 AC/DC, welding unit VD – 1500.

Table 1

Planning matrix of the experiment

The controlled parameter	Experiment №									
	Single-jet gas shielding					Double-jet gas shielding				
	1	2	3	4	5	6	7	8	9	10
Shielding gas flow rate Q, l/min	5	10	15	20	25	5	10	15	20	25

3. Results and Discussion

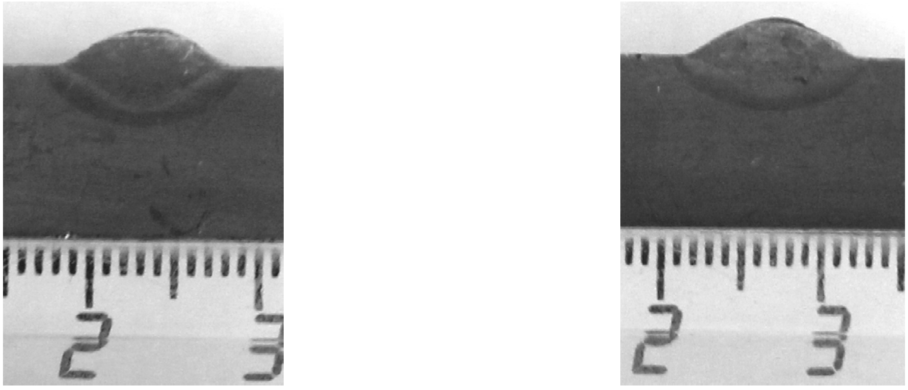
The geometrical parameters of the welds of obtained welded samples were studied (e – weld width, g – weld reinforcement, h – penetration) (Table 2).

Table 2

Geometry of welds in relation to gas flow rate

Shielding gas flow rate Q, l/min	Single-jet gas shielding			Double-jet gas shielding		
	Weld width e, mm	Penetration h, mm	Weld reinforcement g, mm	Weld width e, mm	Penetration h, mm	Weld reinforcement g, mm
5	10	3	2.8	10	3	2.7
10	10	3	2.9	11	3	2.7
15	10	2.5	2.6	11	2	2.6
20	10	2.5	2.8	12	2	2.6
25	10	2.5	2.7	12	1.8	2.5

According to the results of experimental study the geometrical parameters vary significantly under similar welding conditions and gas flow rate but different gas shielding methods. Figure 2 shows that geometry of the bead produced with application of double-jet welding nozzle is flatter. It contributes to significant increase of weld joints strength especially under variable load.



a) b)

Figure 2. Experimental samples welded under gas shielding Q = 15 l/min
a) single-jet gas shielding b) double-jet gas shielding

The composition of the shielding gas has a significant effect on the manufacturing characteristics of the welding process. When welding in the gas mixture of 82% Ar + 18% CO_2 stable transfer of electrode metal, minute spattering and fine weld formation are observed (Fig. 2).

All geometrical dimensions of steel 45 weld joints (E, h, g) under the conditions of the given experiment are effected by gas shielding method and shielding gas flow rate. Other significant controlled parameters (welding current, voltage, welding rate, stick-out distance of electrode wire) were not changed under the conditions of the given experiment.

As gas flow rate and correspondingly, gas consumption increase we observe decrease of penetration both for single-jet and for double-jet gas shielding. Weld reinforcement changes insignificantly within the whole range of shielding gas flow rate changes. Weld width for traditional gas shielding does not change with alteration of shielding gas flow rate. In the case of double-jet gas shielding weld width increases with the growth of shielding gas flow rate which is explained by high density of the shielding gas jet and its pressure over the weld pool metal surface.

When welding with double-jet gas shielding we observe smooth transition from the weld joint to the base metal improving efficiency of weld joints. Under traditional welding noticeable bulge of the weld joint is observed which is a negative factor.

Analysis of penetration, width and weld reinforcement changes showed that controlled parameter of the welding conditions Q significantly effects formation of the weld joint.

The diagrams showing the dependences of penetration, width and weld reinforcement changes upon shielding gas flow rate are presented in Fig. 3, 4 and 5.

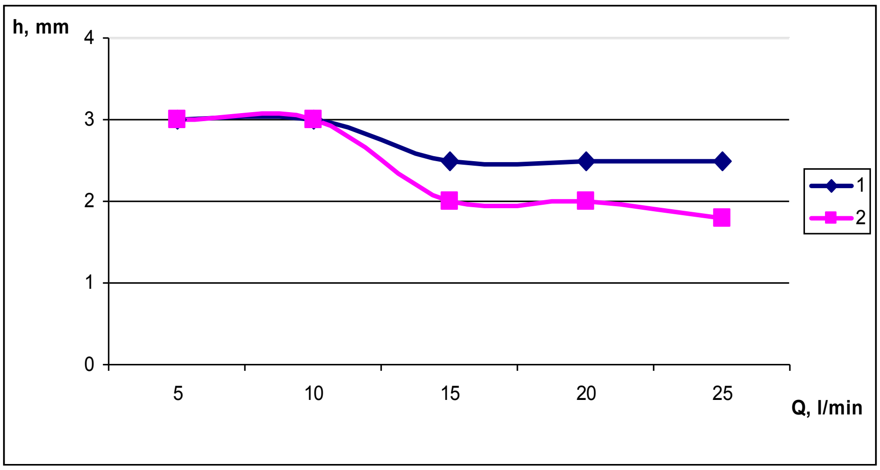


Figure 3. The diagram of penetration changes dependence upon shielding gas flow rate:
1 – single-jet gas shielding 2- double-jet gas shielding

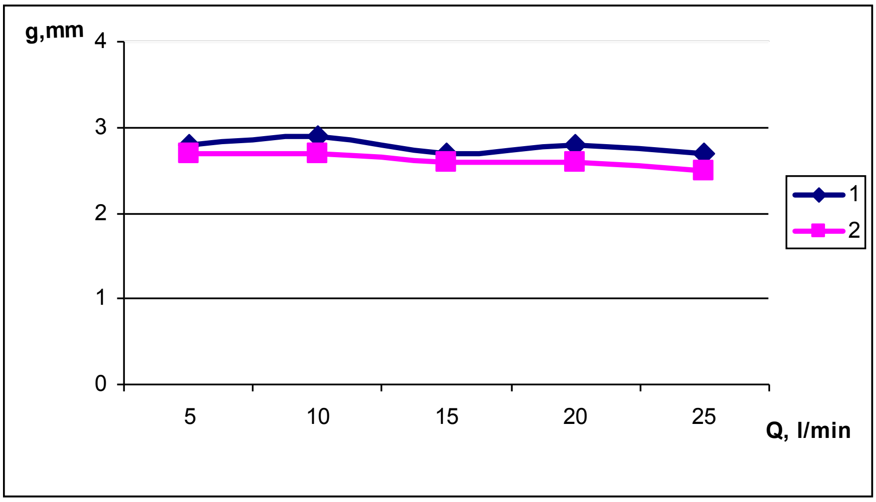


Figure 4. The diagram of weld reinforcement changes dependence upon shielding gas flow rate:
1 – single-jet gas shielding 2- double-jet gas shielding

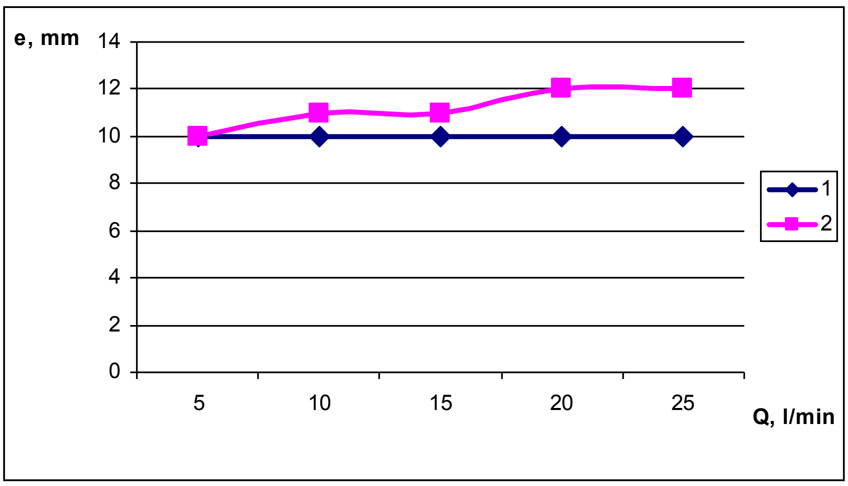


Figure 5. The diagram of weld width changes dependence upon shielding gas flow rate:
1 – single-jet gas shielding 2- double-jet gas shielding

Conclusion

It has been established that gas-dynamic effect of the shielding gas has a significant impact upon formation and geometry of the weld when consumable electrode welding under double-jet gas shielding. As the gas-dynamic effect (gas consumption and gas flow rate) on the weld pool surface and processes in the weld area increase we also observe increase of the weld width, decrease of penetration and insignificant alteration of the weld reinforcement. Gas-dynamic control of formation and geometry of the weld joint is of great practical importance and allows improving maintenance reliability of the welded construction without extra charges.

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