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TRANSLATION

ARGON-ARC WELDING WITH ADDITIONAL
ARGON STREAM

By

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FOREIGN TECHNOLOGY DIVISION

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Argon-Arc Welding with Additional Argon Stream

by

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A description is given of argon-arc welding with the employment of an additional stream of argon to increase the depth of melting of the basic metal.

The dependence of seam dimensions upon the consumption of argon in the additional stream was determined. It was shown that at optimum consumption of additional argon stream the depth of melting increased by two times in comparison with welding without additional stream.

The best method of welding thickwalled objects made of AMg6 alloy appears to be argon-arc welding with a consumable electrode with a diemeter of 3-4 mm at a higher welding current of 550-600 amp. A further increase in current deteriorates the protection and intensifies the oxidation of the molten metal.

An increase in the angle of edge separation leads to an increase in the number of layers of the welded on metal and to its repeated overheating, which reduces the quality of seam metal and reduces the productivity of the process.

Investigations enabled to make a conclusion, that for argon-arc welding of details of greater thicknesses, details made of aluminum and its alloys, of greater importance is the increase in depth of melting of the basic metal. Here we have an increase in the share of the basic metal in the welded seam, which cuts losses of individual components of the alloy and reduces the tendency toward the formation of pores (porosity). With an increase in the volume of the welding bath crystallization of seam metal takes place under more equilibrium conditions, the interdendritic and intradendritic deposition decreases and the number of pores decreases [1].

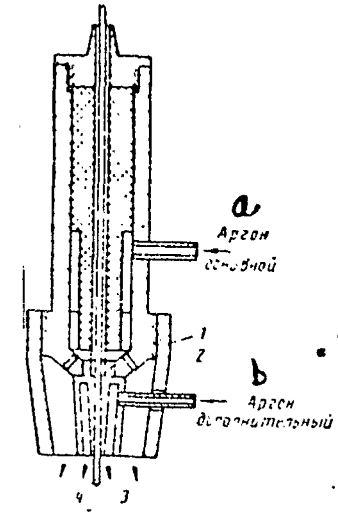


Fig.1.Torch for welding with additional argon stream: 1-nozzle; 2-pipe for delivering additional argon; 3-special current conducting spout; 4-welding wire.a-basic argon; b-additional argon.

To increase the depth of melting of the basic metal when welding in amedium of protective gases was developed a method of welding with an additional gas stream. For welding was designed and constructed a special burner (fig.1).The additional gas stream is fed through a pipe into a special spout and goes into the welding zone.

To investigate the effect of additional consumption of gas stream on the melting depth the welding on with an aluminum wire was done in an argon medium on an aluminum plate 15 mm in thickness. The welding on was carried out at DC current at reverse polarity . The welding on conditions and the dimensions of the roller are described in table 1.

The dependence of the melting depth, width and height of roller upon delivery of additional argon stream is shown in fig.2.

Table 1.

Sample No. 1.	Diameter of electrode in mm 2.	Welding current in amp 3.	Arc voltage in v. 4.	Rate of beading in m/hr 5.	Argon delivery l/min 6. basic	addit	Roller dimensions in mm 7. depth 8	width 9.	height 10.
120	2	200	25	18	22	—	4,7	15	4
121	2	200	25	18	22	9	5,6	15,8	4,2
123	2	200	25	18	22	12	7,5	17,8	3,6
122	2	200	25	18	22	15	8,6	17,2	3,6
124	2	200	25	18	22	22	7,2	15,4	3,3
125	2	200	25	18	22	26	6,8	15,3	4,4
126	2	200	25	18	22	32	8,4	13,3	3,5
146	2	250	25	18	22	—	8,9	17	4,3
134	2	250	25	18	22	9	6,4	15	4,7
136	2	250	25	18	22	12	10,8	18,6	4,6
135	2	250	25	18	22	1	12,7	15,9	3,5
137	2	250	25	18	22	22	14,2	14,8	2,2
138	2	250	25	18	22	26	13,4	14,3	4,5
139	2	250	25	18	22	32	14,0	16,7	4,7
158	3	250	25	18	30	—	4,9	17,4	4,0
148	3	250	25	18	30	9	7,5	17,2	5,0
149	3	250	25	18	30	16	9,8	15,9	4,6
150	3	250	25	18	30	22	10,2	18,6	4,7
151	3	250	25	18	30	26	10,2	16,7	4,0
152	3	250	25	18	30	32	9,8	16,0	5,8

With an increase in delivery of additional argon stream to a certain limit the depth of basic metal melting rises. At an optimum delivery of additional argon stream the depth of basic metal melting increases in double as compared with welding without additional stream.

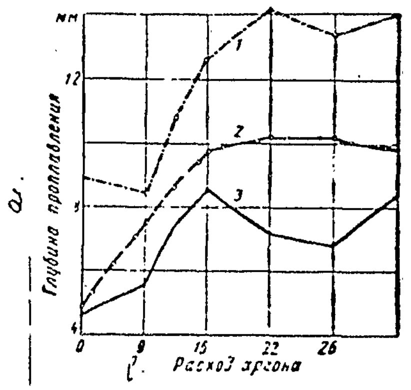


Fig.2.Dependence of melting depth upon delivery of additional argon stream (liters/min): 1-I_{over} = 250 amp,d_3= 2 mm; 2-I_{over} = 250 amp, d_3 = 3 mm; 3- I_{over} = 250 amp, d_3= 2 mm. a-melting depth; b-argon delivery.

Macro slides of weld ups, made with additional argon stream and without it are shown in fig.3 and 4.

The increase in melting depth of basic metal is explained by the fact, that the additional argon stream produces an additional pressure on the liquid metal bath and aids in a more thorough expulsion of same. The heat of the arc is directly transmitted to the basic metal, and not through the layer of molten metal, which is observed when welding without additional argon stream. It can also be assumed that the additional gas stream raises the temperature of the arc column. An increase in melting depth leads to an increase in melting area and in the amount of melted metal (table 2,fig.5)

Upon an increase to a certain maximum delivery of the argon stream the melting area and, consequently, the amount of melted basic metal rise doubly in comparison with welding without additional stream. At the same time the area of welding on remains practically constant. There is a corresponding rise in the share of the section of the basic metal in the formation of welded seam.

The constancy of the beading on area indicates, that the coefficient of beading (building up by welding) does not depend upon the delivery of additional argon stream (Table 3).

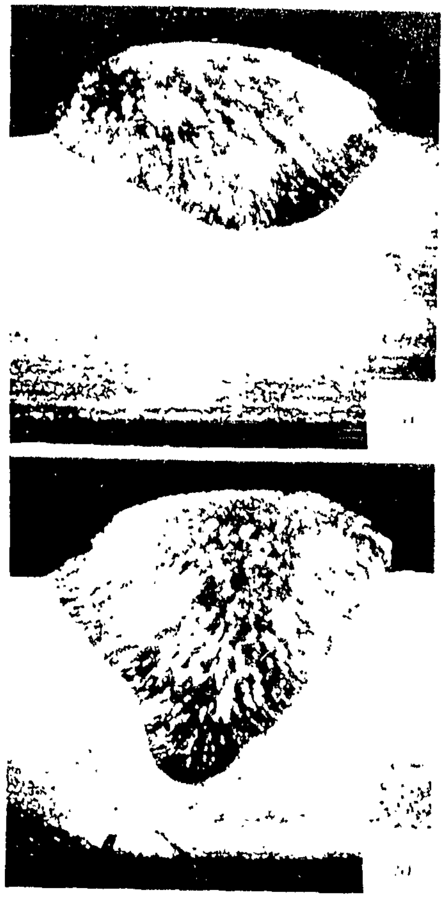


Fig.3.Macroslides of beading: a-without additional argon stream ; b-with additional nal argon stream 16 l/min (I_∂ = 250 amp, U_∂ = 25 v, v_{over} = 18 m/hr, $d_э$ = 3 mm) X 3.

The thermal effectiveness of the process of melting is characterized by the ratio of the amount of heat necessary for melting the basic metal, to the total thermal power of the arc. This ratio is called total thermal coefficient of useful action [2] :

$$\eta_t = \frac{Q_n}{Q_\partial} \cdot 100, \qquad (1)$$

where Q_n - amount of heat consumed for the melting of basic metal, in sec; Q_∂ - amount of heat, emitted by the arc, per sec.

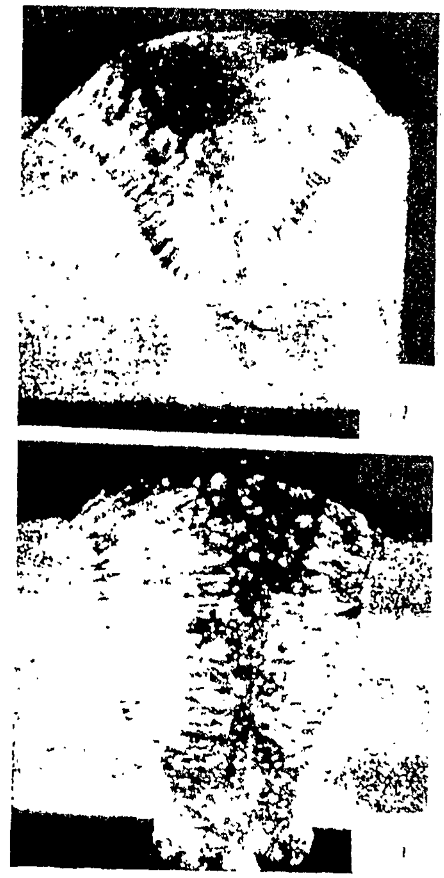


Fig.4.Macroslides of beadings: a-without additional argon stream; b- with additional argon stream 16 l/min (I_∂ = 250 amp, U_∂= 25 v, v_{over} = 18 m/hrs, $d_э$ = 2 mm)X 3

Obtained results are given in table 4 and in fig.6. Total thermal efficiency rises doubly. Consequently, when using an additional argon stream the heat of the arc is utilized more effectively. And so for example, when welding at a current of 200 amp with a welding wire of 2 mm in diameter without additional argon stream the melting of the basic metal consumes 11.5% of the heat, and during the use of an additional argon stream - 22.8%.

Table 2.

Sample No. 1.	Delivery of addit. argon lit/min 2	Area of melting mm² 3.	Area of beading in mm² 4.	Share of section of basic metal in % 5.
№ образца	Расход дополнительного аргона в л/мин	Площадь проплавления в мм²	Площадь наплавки в мм²	Доля участия основного металла в %
120	-	41	46,8	46,6
121	9	51	44,1	54,4
127	12	81,5	41,5	66,4
122	16	80	49	62
124	22	56,7	47,3	60,5
125	26	55,6	40	58
126	32	74	34	68,5
146	—	86,5	50	63
134	9	73,6	52,5	58,3
136	12	94,5	61,8	60,5
135	16	141,3	51,5	74,2
137	22	158	40,5	79,6
138	26	121	44,6	73,5
139	32	157	55,6	74
158	—	50	52,8	48,5
148	9	60	62,5	48,5
149	16	78,5	57,8	57,6
150	22	89,2	63	58,5
151	26	95,5	63,7	60,3
152	32	109	58,5	65

Table 3

Sample No. 1.	Delivery of additional argon lit/min. 2.	Coefficient of beading in g/a-hrs 3.
[illegible]	—	8,8
[illegible]	9	9,15
[illegible]	16	9,55
[illegible]	22	9,7[illegible]
[illegible]	26	[illegible],1
[illegible]	32	9,08

Analogous results have been obtained also in the remainining instances, whereby the effectiveness of utilizing the heat of the arc increases with the rise in current and its density.

The investigations have shown, that during the welding of aluminum with a 2-3 mm in diameter wire at currents of 200-250 amp, most optimum appears to be the delivery of additional argon stream of 16-22 liters/min.

Table 4

Sample No. 1	Delivery of addit.argon in 1/min 2	Welding current in amp 3	Electrode diameter in mm 4	Amount of heat in cal/sec 5: emited by arc 6	consumed for melt basic metal 7	Total thermal effic in % 8
1 № образца	2 Расход дополнительного аргона в л/мин	3 Сварочный ток в а	4 Диаметр электрода в мм	5 Количество тепла в кал/сек: 6 Выделенное дугой	7 Расходуемое на плавление основного металла	8 Полный тепловой к. п. д. в %
120	—	200	2	1200	137,3	11,4
121	9	200	2	1200	170	14,2
122	12	200	2	1200	273	22,8
123	16	200	2	1200	268	22,3
124	22	200	2	1200	190	15,8
125	[illegible]	200	2	1200	186	15,5
[illegible]	32	200	2	1200	246	20,6
[illegible]	—	250	2	1500	270	18,2
134	9	250	2	1500	248	16,5
136	12	250	2	1500	316,3	21
[illegible]	16	250	2	1500	473	31,6
[illegible]	[illegible]	250	2	1500	530	35,2
[illegible]	[illegible]	250	2	1500	405	27
[illegible]	32	250	2	1500	525	35
[illegible]	—	250	3	1500	167,5	11,2
[illegible]	9	250	3	1500	201	13,4
[illegible]	16	250	3	1500	263	17,5
150	22	250	3	1500	298	19,7
151	[illegible]	250	3	1500	324	21,7
152	32	250	3	1500	360	24,2

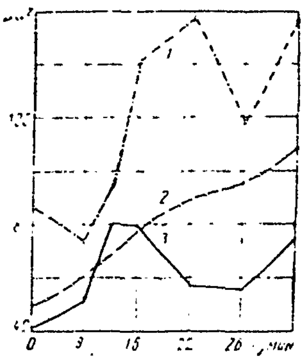
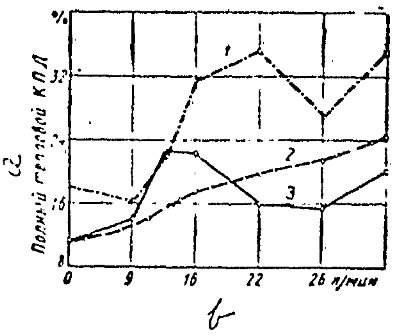


Fig.5.Dependence of melting area upon delivery of additional argon stream a-area; b-delivery of argon. 1-I_{ov} =250 amp, d_3= 2 mm; 2- I_{ov} = 250 amp,d_3= 3 mm; 3-I_{ov} = 200 amp, d_3= 2 mm.

A further increase in delivery leads to a deterioration of seam formation due to deterioration of protection and often to a reduction of melting depth of basic metal. This, most likely, is explained by the intensive cooling of the cathode spot,because the welding is done by reverse polarity, and by the reduction in heat transfer into the basic metal.

At an optimum delivery of additional argon stream the arc burns stably and is easily excited. In fig.7 are given current and

and voltage oscillograms for the beginning of the welding process with additional argon stream (for the purpose of comparison are given oscillograms of the welding process without additional argon stream).



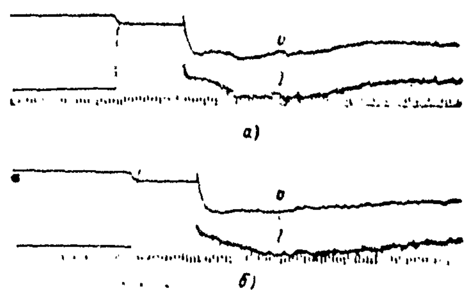


Fig.6.Dependence of total thermal coefficient of useful action upon additional argon stream: I $-I_{ov}$ = 250 amp,d_3= 2 mm; i = 79.5 a/mm^2; 2- I_{ov} = 250 amp, d_3= 3 mm i = 35.4 a/mm^2; 3- I_{ov} = 200 amp, d_3= 2 mm i = 63.6 a/mm^2. a-total thermal efficiency; b-argon delivery.

Fig.7. Current and voltage oscillograms for the beginning of the welding process at a rate of removal of 50 mm/sec: a-without additional argon stream; b- with additional argon stream 16 l/min ($I_д$= 200 amp; $U_д$ = 25 v, v_{ov} = 18 m/hr, $d_э$= 2 mm).

Mechanical properties of welded joints, made with additional argon stream are in no way inferior to the properties of welded joints,made without additional argon stream. In table 5 are given test results of testing gagarinsk samples,made of seam metal

Table 6

Object of analysis	$\sigma_в$ в кг/мм²	δ, в %
Samples welded without additional argon stream	9,2–9,4 / 9,3	24,1–35,0 / 31,1
Samples, welded with additional argon stream.	8,6–9,7 / 9,1	33,7–40,0 / 36,7

The material of the samples – AD1 type aluminum. Welding was done with the application of an additional argon stream and without same in the following manner: $I_д$= 240-250 amp; $U_д$= 22-24 v; $v_{\text{rate of welding}}$ = 12 m/hr.

In table 6 are given results of mechanical tests of flat welded species. Material of the samples D1, thickness 4 mm. Welding condition: I_{wr} = 160-170 amp. $U_д$= 22-24 v; V_{wr} = 24 m/hr.

Table 6

Object of analysis		$\sigma_в$ в кг/мм²
Samples, welded without additional argon stream	Samples with reinforcement	26,0–29,1 / [illegible]
	Samples without reinforcement	25,1–25,[illegible] / 25,6
Samples, welded with additional argon stream	Samples with reinforcement	29,7–[illegible] / [illegible],2
	Samples without reinforcement	23,8–25,2 / 24,5

Conclusions

1. The use of an additional argon stream allows to increase the depth of basic metal melting and the effectiveness of utilizing arc heat.

2. The depth of basic metal melting rises with the increase in delivery of additional argon stream to a certain maximum.

3. During argon-arc welding of aluminum with a 2-3 mm in diameter wire at a current of 200-250 amp the optimum delivery of additional argon is 16-22 lit/min.

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