FEATURES OF ELECTROSLAG WELDING CURVILINEAR JOINTS FROM TWO-LAYER STEELS

Semenov V. M., Markov O. E.

The article is dedicated to increase of production efficiency and quality of large welded products from two-layer steel with curvilinear welded joints. The regime of electroslag welding of thick-walled constructions is proposed. To form the seam at electroslag welding of two-layer steel developed the water-cooled slider-block. To investigate mechanical properties the samples of welded joints treated with different kinds of heat treatment. Microstructural investigations have shown perlite-ferrite structure of the samples independently of the heat treatment kind.

Статья посвящена исследованию проблемы увеличения производительности изготовления и повышения качества крупногабаритных изделий из двухслойной стали с криволинейными сварными соединениями. Предложен режим электрошлаковой сварки толстостенных конструкций. Для формирования шва при электрошлаковой сварке двухслойной стали разработан ползун с водяным охлаждением. Для исследования механических свойств образцы сварных соединений подвергали различной термической обработке: нормализации с отжигом и отпуску в печи. Микроструктурные исследования показали, что структура образцов независимо от типа термообработки является перлито-ферритной.

Стаття присвячена дослідженню проблеми збільшення продуктивності виготовлення та підвищення якості крупногабаритних виробів з двошарової сталі з криволінійними зварними з‘єднаннями. Запропоновано режим електрошлакового зварювання товстостінних конструкцій. Для формування шву при електрошлаковому зварюванні двошарової сталі розроблено повзун з водяним охолодженням. Для дослідження механічних властивостей зразки зварних з‘єднань піддавали різній термічній обробці: нормалізації з отжигом та відпуску у печі. Мікроструктурні дослідження показали, що структура зразків незалежно від типу термічної обробки є перліто-феррітною.

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UDC 621.791.75.042

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In modern conditions of a universal world energy crisis competitiveness of techniques and technology is defined by their return [1]. Therefore in domestic and world practice of mechanical engineering the established tendency of perfection of designs and search of essentially new decisions at creation of all levels methods, having the big economic value of the country. Especially sharply it concerns manufacturing of large details from forgings, castings and connected with big material and especially power expenses. Therefore maintenance of their competitiveness first of all is expressed in growth of requirements to quality and efficiency [2, 3].

At a market gain urgently the decision of such actual and important problems, as decrease in weight and increase of a resource of a product in whole and its separate elements in particular. One of the major directions of increase of a technological level in mechanical engineering is introduction of processes low consumption technologies in heavy and transport machine building and introduction acceleration in manufacture of results of fundamental scientific researches. Studying of a condition and prospects of the further development of manufacture of large welded designs in domestic and foreign practice should precede it [4].

The aim of the article is to increase of production efficiency and quality of large welded products with radius of curvature 1800 mm and length of a curvilinear joint 2200 mm.

Working conditions of chemical equipment, such as for example reactors catlic reforming – temperature to 600 °C, pressure – 600 MPa and above, an excited environment demand applications for their manufacturing of two-layer steels. In the reactors intended for reception of high octan of gasoline, are used for the basic external layer a steel 12CrMo, and for plating internal –austenitic acid-proof steel Ocr18Ni10Ti. Such composite materials industrially are welded manually, sometimes automatic welding under a flux in the bottom position. However with increase in a thickness of metal productivity of these ways sharply decreases, and them replace with an electroslag methods. Electroslag welding of bimetallic designs by thickness 20 … 30 mm and thick-walled equipment from a steel 12CrMo was already investigated. Welding without removal of a plating layer that leads to occurrence of defects of type of the so-called "moustaches" weakening connection is tested. Welding with removal of a plating layer is inexpedient because of necessity of mechanical removal of wide strips with the next great volume depositing [5].

It was necessary to develop technological process of electroslag welding of products with curvilinear joints from a two-layer steel. For this purpose research of two basic questions was required: reception of a seam in the absence of hashing of a plating, corrosion-proof layer with the basic metal and elimination of danger of formation non penetration at ESW a curvilinear not rotary joint. From a two-layer steel 12CrMo (thickness of 80 mm) and plating steel layer OCr18Ni10Ti (thickness of 8 mm) according to technical requirements mechanical properties of welded joints should be: $\sigma_\beta \geq 450$ MPa, KCU ≥ 50 J/sm^2 angel bend $\alpha \geq 40°$.

Studies were performed with the sample ESW consumable mouthpiece of the two-layer steel with a length of 600 mm. There was used filler materials: welding wire Sv-04Cr2Mo, flux AN-8, a plate melting mouthpiece – 12CrMo steel, 12 mm thick. Welding was performed on the regime: the voltage - 40 ... 42 V, wire feed speed Vp = 120 m / h (a wire diameter of 3 mm), the depth of the slag pool - 45 ... 50 mm. To form the seam of the clad layer were developed water-cooled copper slider and lining with a projection, which was part of the welding joint gap. Experiments have established that the height of the protrusion must be 5 ... 6 mm larger than the thickness cladding layer to compensate for the looseness fit lining to the surface of workpieces (Fig. 1, 2).

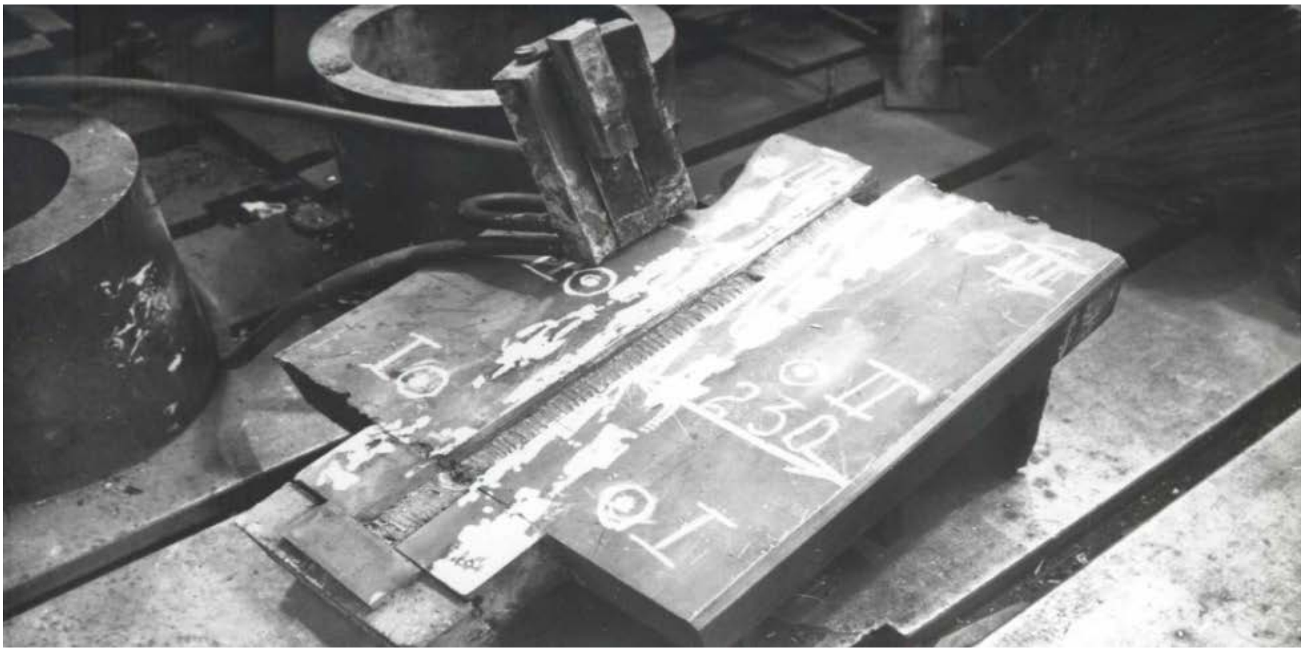

Fig. 1. The sample welded from a two-layer steel and forming slide-block with a ledge, preventing hashing of a plating layer with the basic metal

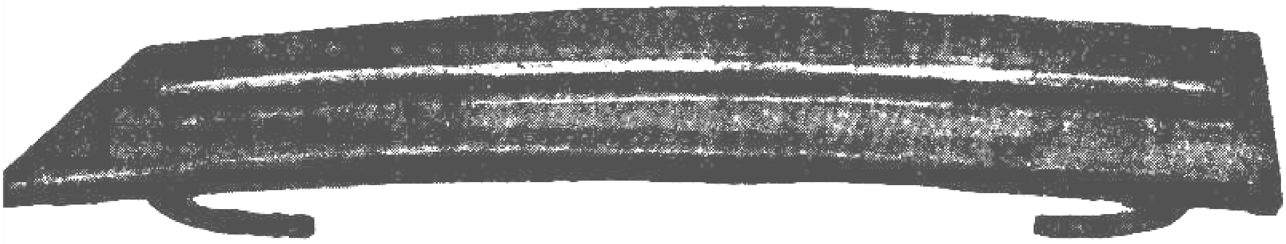

Fig. 2. A forming lining with a ledge

After welding the sample cut on some parts, subjected to various heat treatment, and investigated. The actual chemical compound of initial materials and seam metal is presented to tab. 1, and macrosection of welded connection (Fig. 3).

Table 1

The actual chemical compound of initial materials and seam metal, %

Materials	C	Mn	Si	S	P	Cr	Ni	Mo
Wire								
Sv-04Cr2Mo	0.06	0.52	0.24	0.02	0.025	2.1	0.25	0.50
Steel 12CrMo	0.16	0.50	0.29	0.012	0.016	1.15	0.05	0.44
Seam (0.4 Cr2Mo)	0.11	0.66	0.15	0.014	0.018	1.44	0.14	0.29
Inter.layer	0.08	1.6	0.70	0.021	0.011	18.6	10.2	2.3
Anti corross. layer	0.08	1.6	0.3	0.018	0.025	18.5	9.3	0.7(Nb)

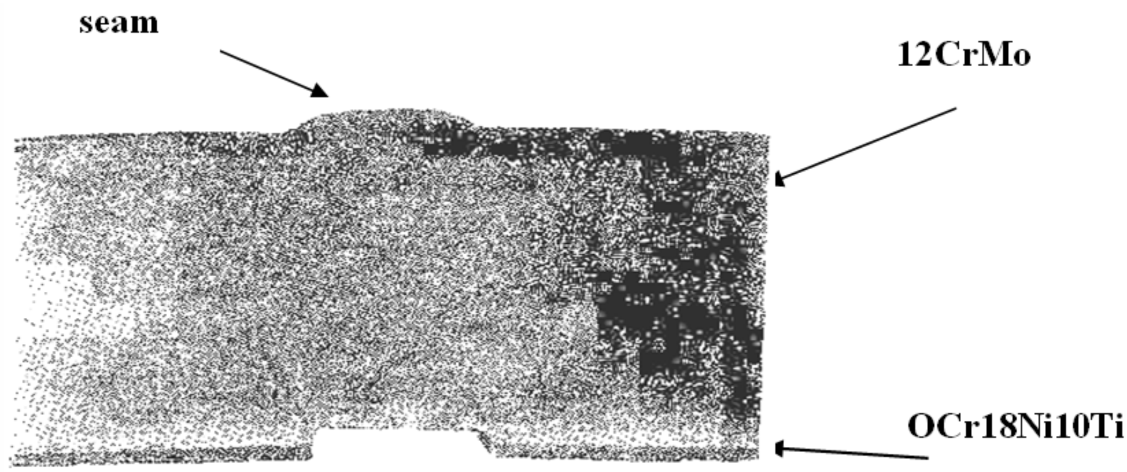

Fig. 3. Macrosection of welded joint

After electroslag welding in the received groove was deposited intermediate and anticorrosive layers. The intermediate layer was carried out electrodes ENTU -3 from a wire of Sv-04Cr19Ni11Mo3 in diameter by of 4 mm with ftor-calcium covering. In order to avoid formation martensit structure deposite carried out with heating to 100... 150 °C. There was used of the specified electrodes and heating have provided basis preparation (on a chemical compound and structure) for deposited an anticorrosive layer on metal of the seam executed by electroslag welding by a wire of Sv-04Cr2Mo. An anticorrosive layer was deposited by a wire of Sv-08Cr19Ni10V in diameter of 5 mm. Regime depositing both layers: a current – constant, polarity – return; a current for electrodes: ENTU-3 I_{ew} = 120 … 140 A; for electrodes CT-15: I_{ew} = 150 … 180 A. A welded joint was researched metalographic and mechanical tests. Results researches have shown that the structure deposited metal consists from austenite with ferrite component (3...5 %) and carbides (Fig. 4).

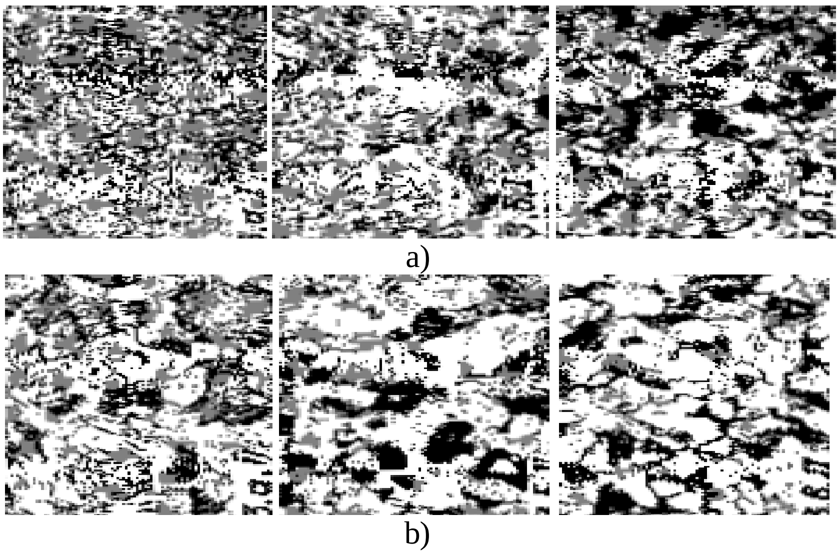

Fig.4. Microstructure of welded joint steel 12CrMo after anneaing (a) and after normalisation with anneaing (b) (x 100)

For definition of mechanical properties of welded joints the part of samples was subjected by normalisation with anneaing on a regime: landing in the furnace at 200 °C, heating to 900 °C, alignment at this temperature – 2.5 h endurance – 3 h, cooling on air – to 300 °C, then heating to 590 °C, endurance – 10 h and cooling on quiet air. Other samples released on a regime landing in the furnace at 200 °C, heating – to 640 °C, endurance – 6 h, cooling on air. Quality of joints are supervised by ultrasonic defectoscopy which has not found out defects. The cutting of samples for mechanical tests was carried out according to «by Instructions IS 9-75 on test of welded joints of vessels of a high pressure». At definition of impact strength of joints a cut in the sample had on distance 1.5 ….2.0 mm from a line melting. Results of mechanical tests (tab. 2) have shown that strength of metal of a seam after annealing is slightly more, and plasticity more low, than after normalisation. Impact strength of metal seam after normalisation exceeds its corresponding values after annealing. Strength of the metal which has passed annealing and normalisation, is approximately identical. The bend corner in both cases has made 180°.

Table 2

Mechanical properties of welded joints

Place of test	Heat treatment	$\sigma_{0.2}$, MPa	$\sigma_в$, MPa	δ, %	φ, %	a, J/sm^2
Joint	Annealing	–	499	Tear at base metal		135
	600^0 C			22.7	72.7	
Seam		462	563	20.5	69.5	131
Base metal		310	516	Tear at base metal		79
Joint	Normalisation			32.3	73.9	178
	980 °C and	–		32.9	65.9	
Seam	Annealing	303	482			148
Base metal	590^0C	332	503			96

Microstructure of samples after both kinds of heat treatment is perlit-ferrit. The size of grain of the basic metal after annealing and normalisation with annealing corresponds to a point 7…8; zones of thermal influence – to a point 4 … 6 after annealing and after normalisation with annealing accordingly; for metal of a seam to a point 4 … 5 too. The received results have been used by working out of technology ESW of the bottoms of reactors.

CONCLUSION

The technological process of electroslag welding of products with curvilinear joints from a two-layer steel working in tough conditions and excited enviorment is developed. The regimes of electroslag welding and deposition of intermediate and anticorrosive layers are proposed. The reaserches of influence of the heat treatment on the welded samples have shown the perlit-ferrite structure after both kinds of heat treatment.

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Статья поступила в редакцию 17.05.2016 г.