METHOD FOR MANUFACTURE OF LARGE-SIZED FORGED-CAST BILLETS USING ELECTROSLAG WELDING

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Given are the results of application of a new technology for production of combined bimetal parts by using consumable-nozzle electroslag welding with the complicated-configuration welds.

Keywords: *electroslag welding, combined bimetal billet, consumable nozzle, joints and Π-shaped welds*

Development of current machines and assemblies of press-forging, rolling-mill and power equipment tightly connected with manufacture of large-sized monolithic billets of up to 300 t and more weight. Two ways are mainly used to solve this at present stage. The first is application of corresponding capacities of steelmaking, press-forging and cast productions allowing obtaining of large-sized billets, and the second is enlargement of billets using welding.

Decisions about a method for obtaining of billets at Novo-Kramatorsk Machine-Building Works (NKMZ) are made by engineering services based on analysis of structural, technological and economic aspects of a problem. The aim at that is minimization of expenses and providing of necessary quality of the part. Considering this the Plant created technological capabilities for application of electroslag welding of rectangular sections of 5000 × 6000 mm size and automatic submerged arc welding of cylinder parts of up to 4000 mm in diameter at 500 mm wall thickness [1].

Calculations of strength and verification of structure serviceability (these procedures are carried out with the help of ABAQUS, SIMULATION and COSMOS-MOTION programs at NKMZ) show that the whole structure has a non-uniform loading. Specifying of material for the whole part orienting at stressed state in places of maximum loading is economically unpractical. It is desirable to provide necessary mechanical properties in the separate segments of the part minimizing at that excessive strength margins and surplus expenses, respectively.

Development of large-sized combined bimetal parts is used at the present time at NKMZ for solving this task. Significant reduction of expenses for production of quality billets, reduction of prime cost and increase of product competitiveness is promoted by means of application of forged inserts from alloyed steels in the places of maximum loading of the part manufactured from unalloyed steel cast.

Forged-cast structure of anvil block of stamping hammer, in which maximum level of stresses appears under the effect of work loading in the middle zone of the anvil block, can serve an example.

Decision about bimetal structure of the anvil block combining forged middle part from steel ITs-1A (analog of 16GNMA steel) with cast side pieces from steel 30L was made in development. Tables 1 and 2 show chemical composition and mechanical properties of applied materials, respectively. Parts of the anvil block were joined by traditional welds made using electroslag welding (ESW) and located in one plane (Figure 1). Such a welding technology is mastered and widely used at NKMZ.

New methods of strengthening of stressed places of the part (Figure 2) through obtaining of combined billets of more complex shape were developed by engineers of Chief Welder Department of NKMZ in the process of improvement of technique and technology

Table 1. Chemical composition of the materials used for anvil block manufacture, wt.%

Material of the anvil block	C	Si	Mn	Ni	P	S	Mo	Cr
Steel 30L (GOST 977–75)	0.27–0.35	0.20–0.52	0.4–0.9	–	≤ 0.04	≤ 0.04	–	≤ 0.3
Steel ITs-1A (steel 16GNMA GOST 2246–80)	0.12–0.18	0.17–0.37	0.8–1.1	1.0–1.3	≤ 0.04	≤ 0.04	0.40–0.55	≤ 0.3

Table 2. Mechanical properties of the materials used for anvil block manufacture (T = 20 °C)

Material of the anvil block	σ_t, MPa	σ_y, MPa	δ, %	ψ, %	KCU, kJ/m^2
Steel 30L	480	260	17	30	350
Steel ITs-1A	560	400	21	60	1200

of consumable-nozzle ESW for further reduction of prime cost of large-sized billets. The task at that is to master a technology of ESW of welds of П-shape.

Welds of such shape and sizes were not performed earlier in welding engineering practice on technical as well as technological reasons. First of all, corresponding specialized welding equipment is necessary for obtaining of П-shaped welds. Secondly, welding-in of such a called implantate simultaneously to three planes of rigid edges of massive billet (Figure 3) can be accompanied by formation of cracks in HAZ and weld. In this connection there can be hot as well as cold cracks.

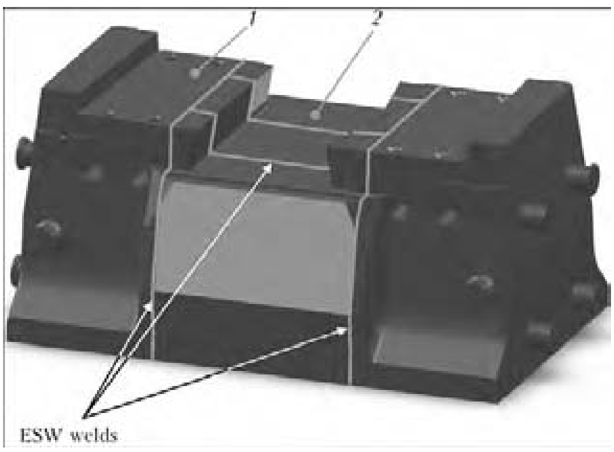

Figure 1. Location of ESW welds in manufacture of the anvil block: *1* — cast parts (steel 30L); *2* — forged-welded middle part of the anvil block consisting of three forged pieces from steel ITs-1A

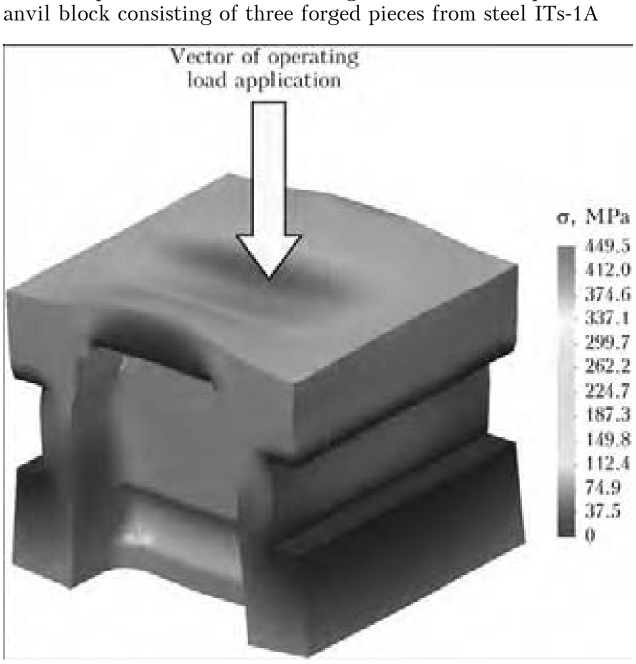

Figure 2. Stress-strain state of basis of the anvil block at the moment of application of operating load

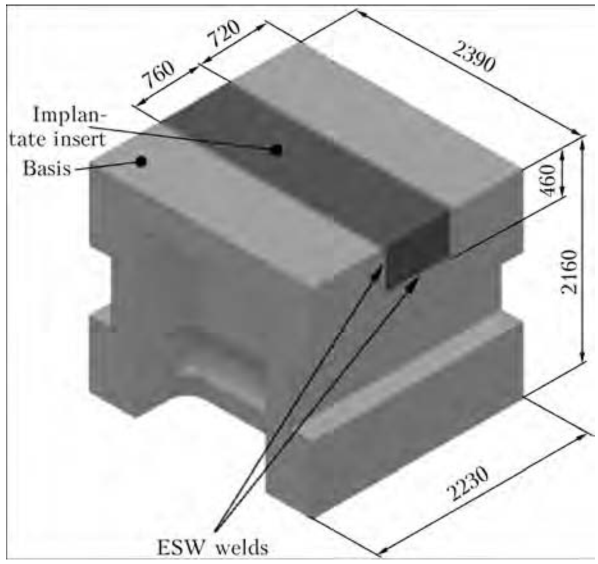

Figure 3. Variant of combined bimetal basis with insert from 20KhN2M steel

Agreement was made between the NKMZ and the E.O. Paton Electric Welding Institute about a joint work in this important direction due to old industrial relations as well as their common interest to indicated complex task. Necessary temperature-time conditions of formation of welded joint in closed rigid space were determined considering technical capabilities of welding production of NKMZ [1] and obtained experience in ESW of the parts of large thickness [2]. At that the welded-in implantate suffers from influence of complex heat-deformation simultaneously along the whole weld perimeter. Technique and technology of consumable-nozzle ESW of complicated-configuration welds were developed as well as modes of further volume high-temperature treatment of welded part were selected. A decision was made about industrial-experimental testing of developed technique and technology using standard part, i.e. basis from parent metal of GS-45 steel (analog of steel 25L) with forged implantate of 420 × 680 × 2590 mm size from steel 20KhN2M and П-shaped weld (Figure 4).

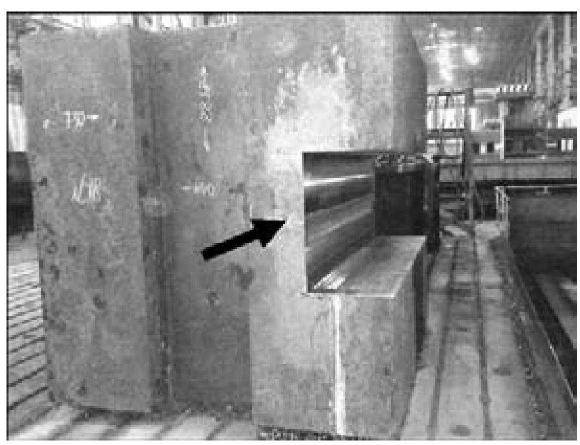

Figure 4. Appearance of the billet prepared for welding-in of forged implantate in the cast billet of anvil block basis using ESW method

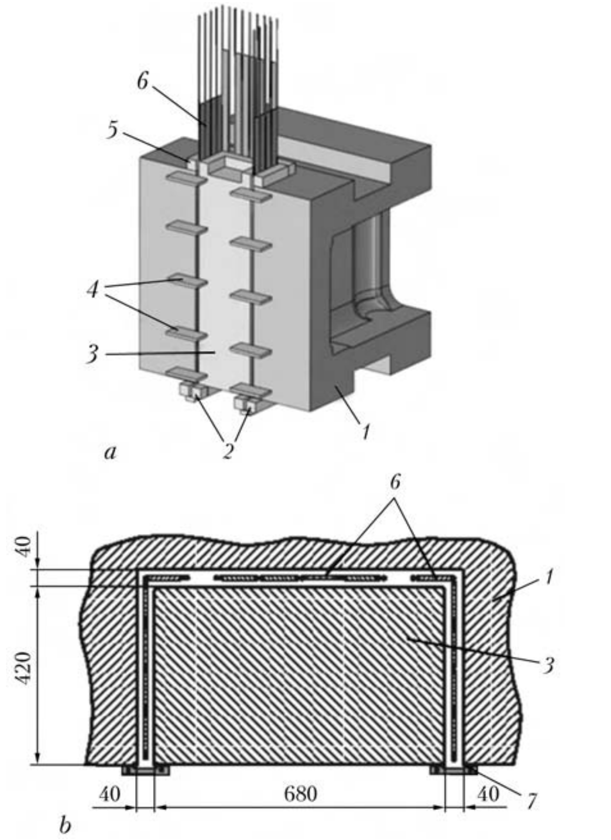

Figure 5. General view (*a*) and scheme of assembly for consumable-nozzle ESW (*b*): *1* — welded part; *2* — inlet implantate; *3* — forged insert (implantate); *4* — technological bars; *5* — outlet pockets; *6* — consumable nozzle; *7* — forming devices

Three sections of consumable nozzles, made from separate plates (Figure 5) and 1100 kg of welding wire was necessary for ESW of joint of complicated П-shaped form and dimensions, indicated in Figure 5, *a*. At that system for duplicating of feeding of welding wire provided safe performance of complicated П-shaped weld as in welding of welds in one plane.

Figure 6. Moment of welding-in of the implantate at plant complex

The welded part after mechanical and heat treatment (Figure 6) was subjected to ultrasonic testing. The latter confirmed high quality of welded joint obtained using new technology. Two similar parts have already been welded at present time.

Therefore, manufacture of welded parts as well as parts from metals with different properties was proposed for the purpose of reduction of prime cost of the manufacture of large-sized billets for components of rolling-mill, power and press-forging equipment. At that, selection of material for separate parts of the billet should be made based on analysis of stresses appearing in them under effect of operating loads. The new technology of ESW with the large-sized complicated-configuration welds was developed and successfully tested by the specialists of NKMZ and E.O. Paton Electric Welding Institute for the most efficient realization of the proposed concept.

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