RESISTANCE WELDING OF STEEL REINFORCEMENT USING COMPOSITE INSERT

V.S. KUCHUK-YATSENKO, A.A. NAKONECHNY and **A.G. SAKHATSKY**
E.O. Paton Electric Welding Institute, NASU, Kiev, Ukraine

The process of resistance welding of reinforcing steels with application of fluxed intermediate inserts has been investigated. It was determined that inserts allow producing joints equal in strength to the parent metal at sufficiently lower degrees of plastic deformation and specific power of the equipment. Technology of welding the reinforcement of classes AI–AV of diameter from 8 up to 32 mm is offered.

Keywords: *resistance butt welding, steel reinforcement, composite insert, fluxing components*

Increase in efficiency and quality of welded joints in welding structures of reinforcing steels is an urgent problem, as the technologies, used in construction, envisage the presence of a large volume of welding jobs, including those under the site conditions. The development of the new technology of resistance butt welding with use of composite inserts at the E.O. Paton Electric Welding Institute [1] gave large opportunities for improvement both of the welding process itself and also machines for resistance welding, in particular the improvement of mass and dimension characteristics, simplification of control circuit and drive of welding machines.

The resistance butt welding is widely used for joining of wires, rods, pipes of steels, non-ferrous metals and alloys. This method has found a wide spreading owing to its simplicity, high efficiency, hygienic characteristics, low cost of the applied equipment. However, the traditional resistance butt welding has significant drawbacks, main of which is the deterioration of mechanical properties of welded joints, in particular ductility. The decrease in mechanical properties is due to metal overheating and formation of coarse grains, caused by this in the joining zone, and also defects in the form of oxide films and microcracks [2]. This is greatly manifested in resistance welding of reinforcement of diameter of more than 8 mm, and, therefore, this method of welding is not used for joining the large-diameter reinforcement.

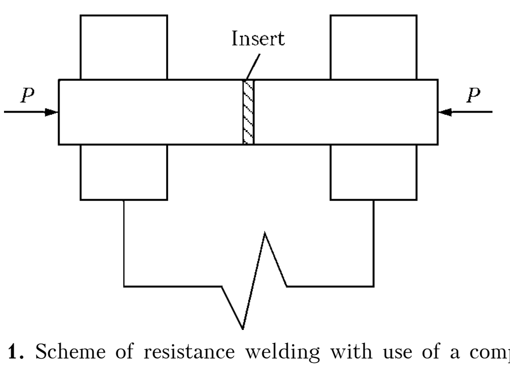

Figure 1. Scheme of resistance welding with use of a composite insert

The improvement of process of the resistance welding requires the reduction of volumes of overheated metal in welded joint, increase in concentration of heat generated in the zone of contact, protection of joint zone from oxide films. In the given work the feasibility of intensification of heating of contact zone was investigated by using the inserts (Figure 1) during resistance heating, which represent interlayers of a composite structure consisting of a metallic base and fluxing components. When current is passed through the butt with an insert, its intensive heating and melting take place due to its high internal resistance. Here, a high localization of resistance heating is occurred as compared with the traditional method.

For comparison, Figure 2 shows the temperature distribution in the butt in resistance flash-butt welding of reinforcement. It is seen from the Figure that during resistance heating using a composite insert the heating is more concentrated, and the temperature field is approximately same as in flash-butt welding.

The composition of a composite insert includes fluxing elements, whose melting temperature is lower

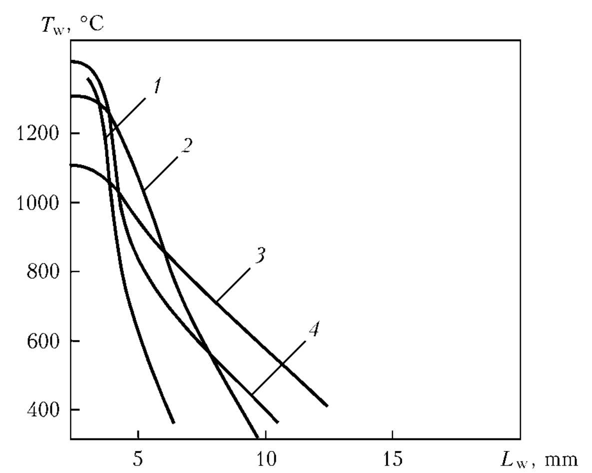

Figure 2. Distribution of welding temperature T_w before upsetting in resistance welding of reinforcement of 32 mm diameter using continuous flashing (*1*), composite insert (*2*), resistance (*3*), flashing with preheating (*4*): L_w — distance from welding zone

Figure 3. Appearance of welded joint of reinforcement of 32 mm diameter of steel 25G2S

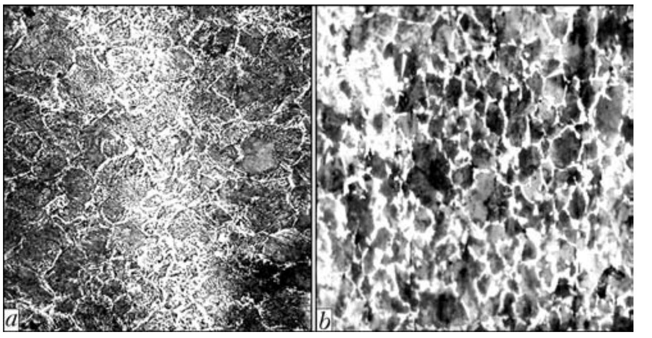

Figure 4. Microstructures (×150) of joint zone metal (*a*) of steel 25G2S and HAZ metal (*b*)

than the melting temperature of parent metal of parts being welded. The presence of fluxing components makes it possible to protect the heated metal in the contact zone from oxidizing, thus providing the formation of quality joints in the process of parts pressing during upsetting. Here, the feasibility is provided for producing joints at the temperature of heating of near-contact metal layers, which is lower than solidus temperature of parent metal. In this case the smaller deformation of edges is required for the joint formation than in traditional resistance welding.

The base of a composite insert is a profiled sheet of low-carbon steel of 0.8–2.0 mm thickness, the height and profile pitch are selected with account for allowable current density, then the intensity of heat generation in the contact zone is determined.

The flux composition includes oxides, chlorides and fluorides of alkali and alkali-earth metals, the flux melting temperature is 900–1000 °C. To deoxidize and improve the weld metal structure, the powders of carbon, manganese, silicon, nickel and molybdenum are added into the flux.

To conduct experiments, the machine AMG 20/170 Schlatter of 170 kV·A capacity for the resistance flash-butt welding was modified. The drive of this machine was modified for the resistance welding. The system of welding process control on the basis of KSU KS 02 in the variant for butt welding provides its automatic control and recording.

As test specimens, the rods of reinforcement of diameter from 8 to 32 mm of classes AI–AV were selected [3]. Results of evaluation of specifics of heating (Table) allowed optimizing the welding conditions and welding flux composition. Specimens of 8, 12, 20 and 32 mm diameter were welded (steels 20, 25G2S, 70), whose edges were subjected to rough lathe machining. Figure 3 shows almost complete absence of weld reinforcement, that is due to a significant decrease in tolerance for upsetting.

Metallographic examinations were conducted on specially manufactured sections of welded joints. The samples were etched in 4% HNO_3 solution in alcohol. Hardness was measured using the LECO hardness meter M-40 at 0.5 N load. The grain size was determined in accordance with GOST 5639–82.

Microstructure of metal of 25G2S steel welded joint and HAZ is presented in Figure 4.

Metallographic examinations showed that the structure of welded joint metal is ferrite-pearlite with a dominating ferrite component. At the area of indented metal and adjacent zone to it, the size of ferrite grain corresponds to No.6, hardness is *HV*0.05 180–200. In the fusion zone there are no traces of melt and non-fused remnants of a composite insert.

In HAZ the recrystallization of a grained pearlite into a lamellar one is occurred. Microhardness in HAZ corresponds to a classical region of overheating and is varied from *HB* 160 up to 170, the presence of

Technological parameters and mechanical properties of welded joints of rods and reinforcement

Grade of steel	Diameter of reinforcement, mm	Time of welding, s	Density of welding current, A/mm^2	Tensile strength σ_t, MPa		Impact strength *KCV*, J/cm^2, at 20 °C	
				Parent metal	Welded joint	Parent metal	Welded joint
20	8 12 20	2.3 3.3 4.3	17 12 10	490–510 (500)	485–505 (495)	90	55–70 (63)
25G2S	20 32	4.3 6.1	10 8	600–620 (610)	597–625 (611)	130	75–90 (83)
70	12 20	2.3 3.3	15 12	840–890 (865)	843–870 (857)	55	22–30

Note. In brackets the mean values of σ_t and *KCV* are given.

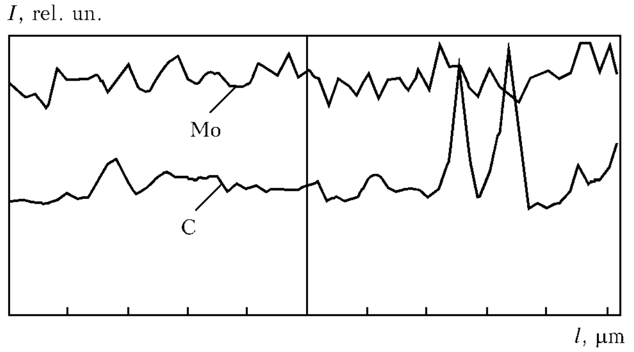

Figure 5. Distribution of carbon and molybdenum across the weld made of steel 25G2S (base of measurement is 120 μm with 2 μm pitch)

brittle phases and hardening structures was not observed. X-ray diffraction miroanalysis showed that elements-activators from welding flux composition in the form of separate structural components were not observed in metal of weld and HAZ. There are small peaks of concentrations of carbon and molybdenum, located at a certain distance from the fusion zone. This proves that a negligible alloying of metal of weld and HAZ is occurred during welding due to the diffusion process (Figure 5).

The carried out investigations made it possible to develop the technology of resistance butt welding of reinforcement of diameter of up to 32 mm with use of a composite insert.

The application of a special composite fluxed insert in resistance welding provides a highly-concentrated heating in the zone of contact, flux protection of the joint zone, decrease in process duration and in tolerances for heating and upsetting, as well as significant (6–8 times) reduction of forces in upsetting.

Welding requires the lower specific power of welding equipment, thus widening the technological capabilities of improvement both of the welding process itself, and also machines for the resistance welding.

1. *Method of resistance butt welding*. Pat. 78378 Ukraine. Int. Cl. B 23 K 11/02. Publ. 15.03.2007.
2. Gelman, A.S. (1970) *Principles of pressure welding*. Moscow: Mashinostroenie.
3. *GOST 14098–91*: Welded joints of reinforcement and embedded elements of reinforced concrete structures. Introd. 01.07.92.