APPLICATION OF PULSE ELECTROMAGNETIC EFFECTS TO CONTROL THE PROCESS OF ELECTRODE METAL TRANSFER IN ARC WELDING

P.Yu. SIDORENKO and **R.N. RYZHOV**
NTUU «Kiev Polytechnic Institute», Kiev, Ukraine

The impact of electromagnetic effects induced by axial pulse magnetic fields on parameters of electrode metal transfer in metal-arc welding was evaluated.

Keywords: *arc welding, pulse electromagnetic effects, control of transfer, axial controlling magnetic fields*

Control of electrode metal transfer in arc welding is an important problem, the solution of which allows reducing metal losses for spattering and improving the weld formation.

The use of electromagnetic effects (EME) is one of the most efficient methods for controlling the transfer process. These effects based on axial low-frequency magnetic fields were successfully applied in submerged metal-arc welding [1, 2]. However, application of these effects in gas-shielded welding received no acceptance because of increased spattering caused by the impact on metal drops by the centrifugal forces formed in rotation of the drops at the electrode tip.

The EME based on the pulse axial controlling magnetic fields (CMF) were used to advantage to provide proportioned transfer of filler metal in arc brazing [3] and increase hot crack resistance of TIG welds [4]. As shown by analysis, no experience of using EME in metal-arc welding is available now. Unlike the widely applied EME based on the low-frequency magnetic fields, the EME under consideration are based on the force impact on the molten metal drops, which is generated as a result of interaction of the magnetic field with eddy currents induced in their volumes.

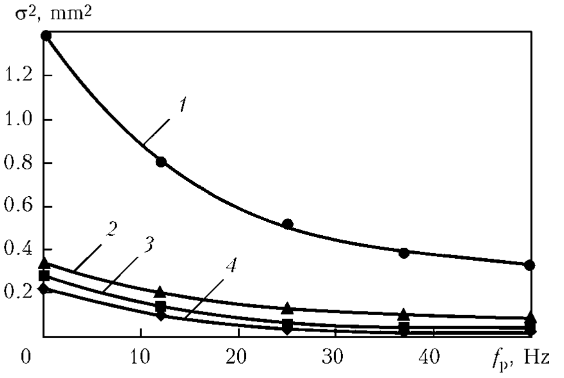

Figure 1. Dependence of variance of distribution of electrode metal drop sizes on frequency of axial pulse CMF in welding using flux-cored wire PPT-9 (*1*), CO_2 welding (*2*), welding in a mixture of Ar + 18 % CO_2 (*3*), and welding in argon atmosphere (*4*)

© P.Yu. SIDORENKO and R.N. RYZHOV, 2010

Investigations were carried out in gas-shielded (Ar, 82 % Ar + 18 % CO_2, and CO_2) metal-arc welding of low-carbon steel, and in welding using self-shielding flux-cored wire of the PPT-9 grade. VDU-504 unit was used as a welding power supply. Sizes of the electrode metal drops detached from the electrode tip were fixed by using a digital camera. The welding parameters are given in the Table. Sizes of the drops were determined, and variance (deviation of sizes of the drop from their mean value characteristic of a given transfer frequency) was calculated after computer processing of images of the arc region.

It was found that the size of the drops detached from the electrode tip in welding under conventional conditions may vary 2 times. The use of the given EMF leads to decreased variance of distribution of sizes of the drops in welding in argon atmosphere by 92 %, in a mixture of Ar + 18 % CO_2 — by 85 %, and in CO_2 — by 74 % (Figure 1).

The highest value of variance was observed in flux-cored wire welding, which is attributable to non-uniform melting of the charge and sheath, having different physical-chemical properties and specific characters of the energy balance at the electrode extension [5]. The above factors make the electrode metal transfer process unstable.

The impact of pulse EME on losses of electrode metal for spattering was evaluated. The level of spattering was determined by the standard procedure. It is a known fact [6] that CO_2 welding is characterised by increased losses of electrode metal for spattering, this being associated with systematic short-circuiting of the arc gap accompanied by blowups of the bridges. In this case, metal may spatter both from electrode and from pool [7]. Similar results were obtained in the course of the experimental investigations (Figure 2).

The use of pulse EME allows reducing the electrode metal losses in welding in argon atmosphere by 38 %, in welding in a mixture of Ar + 18 % CO_2 — by 43 %, and in CO_2 welding — by 32 %. This effect is explained by a decreased number of short-circuits due to a decreased size of the drops. In addition, the use

Parameters of gas-shielded metal-arc and self-shielding flux-cored wire welding of low-carbon steel

Wire grade	Shielding gas	I_w, A	U_a, V
Sv-08G2S, 1.2 mm diameter	Ar	100	24
	82 % Ar + 18 % CO_2		
	CO_2	110	22
PPT-9, 2.5 mm diameter	–	200 175	34 26

of these pulse effects makes it possible to control movement of the drops into the weld pool.

Investigations with flux-cored wire welding were performed in two modes differing in arc voltage (see the Table). The experiments showed that increase in the arc voltage leads to a substantial decrease in the spattering level. This, like in the previous case, is associated with a decreased probability of short-circuits.

Increase of the frequency of the EME under consideration was accompanied by a 30 % decrease in size of the transferred drops, and by an exponential decrease in the coefficient of losses of electrode wire metal for spattering (Figure 2). Welding at a lower voltage is characterised by instability of the processes of electrode metal transfer, and by a higher variance of distribution of the drop sizes. Most probably, it is this fact that determines the increased losses for spattering (up to 12.5 %, see Figure 2).

Therefore, application of EME based on the axial pulse magnetic fields allows increasing the frequency of transfer of the drops and, accordingly, decreasing their sizes. The efficiency of the given EME grows with increase of the frequency of the CMF pulses. As a result, this makes it possible to reduce the electrode wire metal losses for spattering.

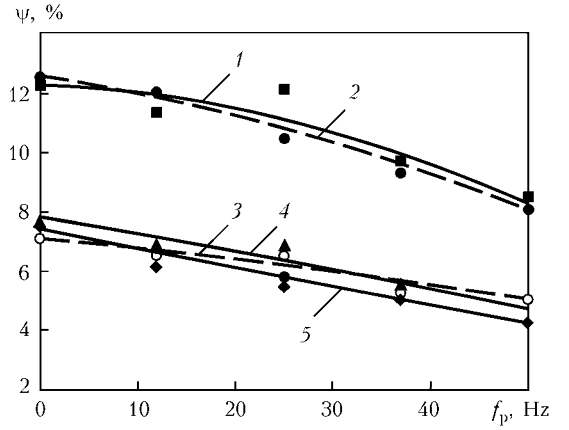

Figure 2. Variations in coefficient of electrode metal losses for spattering in welding with pulse EME: *1, 4, 5* — CO_2 welding, welding in a mixture of Ar + 18 % CO_2, and welding in argon atmosphere, respectively; *2, 3* — welding with flux-cored wire PPT-9 at U_a = 26 and 34 V, respectively

1. Zavialov, V.E., Zvorono, Ya.P., Petrakov, A.B. (1990) Application of longitudinal magnetic field in submerged-arc surfacing. *Svarochn. Proizvodstvo*, **2**, 3–6.
2. Zernov, A.V. (1972) Application of longitudinal magnetic fields in automatic submerged-arc welding of root welds of pipeline roll butt joints. *Ibid*., **3**, 26–27.
3. Tarasov, M.M., Kapustin, S.S. (1982) Application of high-frequency electromagnetic field for proportioned electrode metal drop transfer. *Avtomatich. Svarka*, **8**, 10–12.
4. Ryzhov, R.N. (2007) Influence of pulse electromagnetic actions on formation and solidification of welds. *The Paton Welding J*., **2**, 49–50.
5. Pokhodnya, I.K., Suptel, A.M. (1972) *Flux-cored wire welding*. Kiev: Naukova Dumka.
6. Khejfits, A.L. (1986) Comparative evaluation of some methods for reduction of spattering in CO_2 welding. *Avtomatich. Svarka*, **3**, 58–60.
7. Potapievsky, A.G. (1974) Types of metal spattering in CO_2 welding. *Ibid*., **5**, 10–12.