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# EFFECT OF FLUX-CORED STRIP SURFACING MODES ON GEOMETRIC PARAMETERS OF DEPOSITED BEADS

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The effect of parameters of flux-cored strip surfacing modes on geometric dimensions of deposited beads was investigated. The peculiarities of flux-cored strips melting were considered depending on a sheath type and chemical composition of the core. As the objects of investigations the widely applied flux-cored strips PL-AN 101 and PL-AN 179 were selected, which are manufactured on a base of the steel strip-sheath and also the strip PL-AN 111 based on a nickel sheath. The surfacing was carried out in the machine A-874N, equipped with the power source VDU 1201 and the attachment AD 167 within a wide range of modes. It was found that with increase in current from 600 to 1200 A for all the tested grades of flux-cored strips, the growth of a bead width, its height and penetration depth of base metal are characteristic. With increase in current the value of weld shape factor for all the considered types of flux-cored strips decreases. With increase in the arc voltage in the range of 24–38 V the bead width increases and the height is reduced against the growth in volume of base metal. The change in penetration depth and the weld shape factor are ambiguous and depend on the flux-cored strip type. 10 Ref., 1 Table, 4 Figures.

***Keywords:*** *flux-cored strip, surfacing modes, penetration depth, geometric parameters of bead, volume of base metal*

At the present time the flux-cored strips are widely applied for strengthening the parts of equipment operating under the conditions of abrasive, gas-abrasive and other types of wear. The application of this electrode material allows producing the deposited metal with a high degree of alloying and carrying out the surfacing process with a high efficiency [1–3].

The important factors influencing the obtaining of the preset chemical composition and hardness of the deposited layer are geometric parameters of bead of deposited metal. In a number of works [4–6] the influence of mode parameters on characteristics of beads being deposited using the cold-rolled electrode strips of different width and chemical composition is considered. It is seen from the carried out investigations that except of current, voltage and surfacing speed, the geometric dimensions of beads are also affected by thickness, width of electrode strip, its chemical composition and the grade of flux being used.

In the works [7, 8] the influence of current and voltage on the geometry of deposited bead during surfacing using flux-cored strip of 45×3 mm section on the currents of 1000–1900 A was investigated. In the works [8, 9] the volume of the electrode metal in surfacing using two-locked flux-cored strip on the currents of 700–1100 A was determined. It was experimentally established that with increase in current in the mentioned range the volume of electrode metal decreases from 0.64 to 0.62 at the speed of 16 m/h and with increase in the speed from 16 to 32 m/h it decreases from 0.63 to 0.57.

Recently, for surfacing of different parts the one-locked flux-cored strip with a tight lock, developed at the E.O. Paton Electric Welding Institute, becomes ever more applied. To develop technological processes of surfacing using this electrode material it became necessary to conduct complex investigations on influence of surfacing mode on geometric parameters of deposited beads, as well as characteristics of melting of flux-cored strips.

For investigations three grades of flux-cored strips PL-Np-300Kh25S3N2G2 (PL-AN 101), PL-Np-500Kh40N-40S2RTs (PL-AN 111) and PL-Np-400Kh20B7M6N-5V2F (PL-AN 179) with the section of 16.5×3.8 mm of one-locked design of the type B were selected according to GOST 26467–85. Such a choice was predetermined by the following considerations: the flux-cored strips PL-AN-101 and PL-AN 111 are the serially manufactured electrode materials. The flux-cored strips PL-AN 101 and PL-AN 179 are manufactured on the base of a steel strip-sheath and PL-AN 111 is manufactured on the nickel one. Furthermore, the core of the flux-cored strip PL-AN 101 is composed mainly of a complex master alloy which stipulates its lower melting temperature. The tests were carried out in the surfacing machine A-874N, equipped with the power source VDU-1201 and the attachment AD-167. The surfacing was carried out by separate beads in one layer at direct current of reverse polarity at a constant value of stickout equal to 50 mm and a rigid external characteristic of the power source. As the base metal the plates of St3 of 30 mm thickness and 300×400 mm size were used. On each of the plates the 6 beads of 200–250 mm length were deposited. To eliminate the influence of preheating, each successive bead was applied after complete cooling of the previous one. From the middle areas of beads the specimens were cut out applying an anode-mechanical cutting, on which after the subsequent grinding the geometric parameters of deposited beads, the composition and hardness of the deposited metal were determined. In parallel with the surfacing the measurements were also carried out to determine the melting characteristics of the mentioned flux-cored strips. The surfacing modes using all the mentioned strips are given in Table.

For investigations the following geometric parameters of deposited beads were determined (see Figure 1): *B* —the width of deposited bead; *h* — the penetration depth of base metal; *C* — the height of deposited bead, as well as the area of deposited bead over the base metal and the area of penetration base metal were determined.

By calculations according to the formulas the volume of base metal γ and the shape factor of bead φ were determined:

$$\gamma = \frac{F_p}{F_b + F_p},$$

where $F_p$ is the area of penetration of base metal; $F_b$ is the area of deposited bead over the base metal

$$\varphi = \frac{B}{h},$$

where B is the width of deposited bead; h is the penetration depth of base metal.

The obtained results are presented in a graphic form. Moreover, it should be indicated out that to each point on the diagram the mean value of not less than five measurements and calculations produced on them is corresponded.

Figure 2 shows the change in geometric parameters of deposited bead depending on current. As the current increases from 600 to 1200 A for all the tested grades of flux-cored strips the growth of bead width (Figure 2, *a*), height (Figure 2, *b*) and penetration depth of base metal (Figure 2, *c*) is characteristic. Regarding the flux-cored strip PL-AN 101, the growth in width and height of the bead is observed at the currents of up to 900 A. The further increase in current does not result in the change of these parameters but the area of the deposited bead is increased. In our opinion, this is explained by a great fluidity of molten metal of weld pool, which in its turn is associated with the type of alloy being deposited and the use of the complexly-alloyed master alloy as a powder-filler. The values of weld shape factor for all the considered flux-cored strips are reduced with increase in current (Figure 2, *d*).

In the current range from 600 to 800 A for the strips PL-AN 101 and PL-AN 179 a sharp increase in volume of base metal from 0.45 to 0.5–0.53 is observed, and for the flux-cored strip PL-AN 111 in the same range a sharp decrease from 0.6 to 0.55 is observed. The volume of base metal for all the three flux-cored

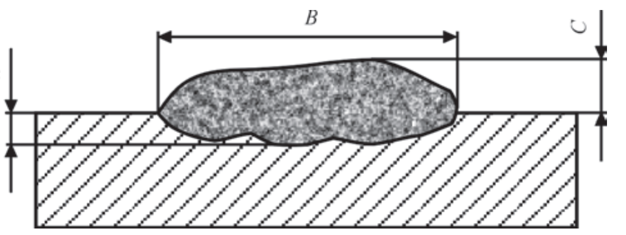


**Figure 1.** Cross-section of bead deposited using flux-cored strip

strips with further increase in current in the range of 800–1200 A remains almost constant, equal to 0.5–55 (Figure 2, *e*). Such ambiguous behavior of this parameter for different flux-cored strips, in our opinion, can be explained by differences in the nature of their melting caused in the first turn, by the strip-sheath material. So, the flux-cored strip PL-AN 111 is manufactured using nickel strip-sheath having a high specific resistance, which contributes to a more significant preheating of flux-cored strip at the stickout. At the lower values of current, consequently at a lower feed speed of the electrode material, in the total heat balance the increasingly important role belongs to heat evolution at the electrode stickout consumed for its preheating [10]. In melting of flux-cored strips PL-AN 101 and PL-AN 179 with a steel strip-sheath, having a lower ohmic resistance, the melting of the electrode metal is carried out mainly due to heat power of the arc. After reaching the certain values of current, which is 800 A in the considered case, the character of change in deposited beads parameters for different flux-cored strips becomes almost the same. At the same time for the tested electrode materials the heat balance of the arc becomes constant, consumed for melting of electrode and the base metal. We believe that a more precise explanation of the nature of change in volume of base metal can be obtained after additional investigations of changes in flux-cored strip resistance depending on temperature and other parameters influencing the nature of melting electrode materials.

Figure 3 presents the geometric parameters of deposited beads depending on arc voltage. With increase in voltage in the range of 24–38 V the bead

Surfacing modes

| Current, A | Voltage, V | Surfacing speed, m/h |
|---|---|---|
| 600 ± 25 | 32 ± 1 | 32 ± 1 |
| 750 ± 25 | 32 ± 1 | 32 ± 1 |
| 900 ± 25 | 32 ± 1 | 32 ± 1 |
| 1150 ± 25 | 32 ± 1 | 32 ± 1 |
| 1200 ± 25 | 32 ± 1 | 32 ± 1 |
| 900 ± 25 | 24 ± 1 | 32 ± 1 |
| 900 ± 25 | 28 ± 1 | 32 ± 1 |
| 900 ± 25 | 36 ± 1 | 32 ± 1 |
| 900 ± 25 | 40 ± 1 | 32 ± 1 |
| 900 ± 25 | 32 ± 1 | 19 ± 1 |
| 900 ± 25 | 32 ± 1 | 40 ± 1 |
| 900 ± 25 | 32 ± 1 | 48 ± 1 |
| 900 ± 25 | 32 ± 1 | 55 ± 1 |

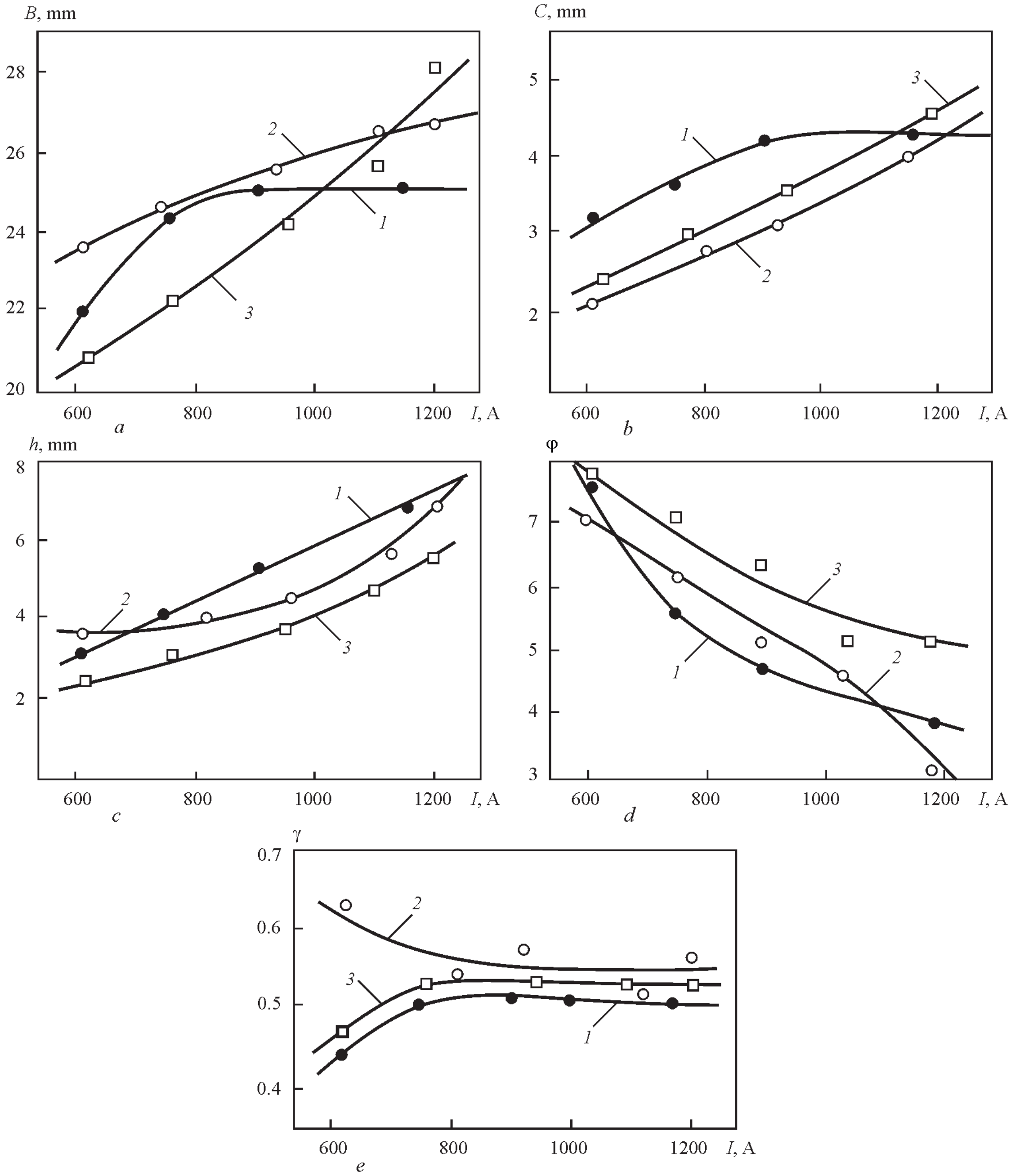


**Figure 2.** Change in geometric parameters of deposited bead: width (*a*), height (*b*), penetration depth of base metal (*c*), weld shape factor (*d*), volume of base metal (*e*) depending on current in surfacing using flux-cored strips: *1* — PL-AN 101; *2* — PL-AN 111; *3* — PL-AN 179

width increases from 21–22 to 29–31 mm depending on grades of flux-cored strips (Figure 3, *a*).

The height of the bead (Figure 3, *b*) for all the strips decreases and the volume of base metal (Figure 3, *c*) is growing from 0.45–0.5 to 0.6. Regarding the penetration depth (Figure 3, *d*) and the weld shape factor (Figure 3, *e*), their change is ambiguous and depends on the tested grade of a flux-cored strip. Thus, the penetration depth in using the strip PL-AN 111 is increased in proportion to the voltage in the whole range. Whereas in surfacing applying the strips PL-AN 101 and PL-AN 179 at voltage increase from 24 to 32 V the growth of penetration depth of base metal and the reduction of this value in the range of 32–38 V occurs. Moreover, it is expressed particularly strongly for the flux-cored strip PL-AN 101.

In our opinion, this is connected both with the nature of melting the electrode material with different strip-sheathes as well as with different properties of liquid molten metal.

The lowest value of weld shape factor corresponds to the voltage of 28 V for all the tested grades of flux-cored strips (Figure 3, *e*).

In the range of minimum and maximum values of arc voltage the weld shape factors are increased. The influence of surfacing speed on geometric parameters of deposited bead is presented in Figure 4. With increase in the surfacing speed from 19 to 55 m/h

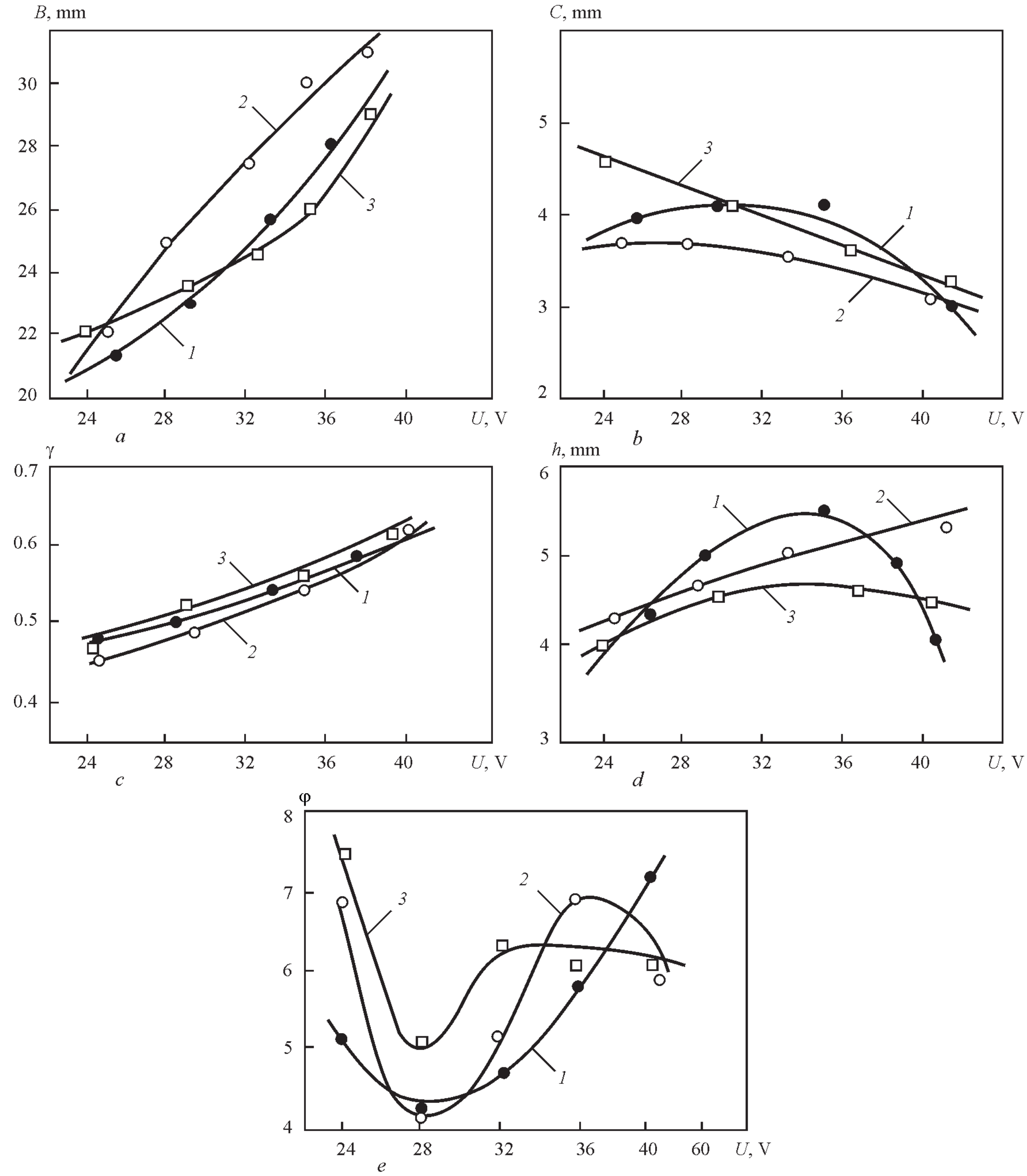


**Figure 3.** Change in geometric parameters of deposited bead: width (*a*), height (*b*), volume of base metal (*c*), penetration depth of base metal (*d*), weld shape factor (*e*) depending on voltage in surfacing using flux-cored strips: *1* — PL-AN 101; *2* — PL-AN 111; *3* — PL-AN 179

the bead width is reduced from 30–32 to 20.5 mm (Figure 4, *a*), the height — from 4–5 to 2–3.5 mm (Figure 4, *b*), the penetration depth — from 5.5–6.5 to 3–4.5 mm (Figure 4, *c*). At the same time the volume of base metal increases with increase in the speed from 19 to 20 m/h (Figure 4, *d*). The further increase in the surfacing speed does not influence the volume of base metal. The weld shape factor has the lowest values at 40 m/h speed for flux-cored strips PL-AN 101 and PL-AN 111. The lowest value of weld shape for flux-cored strip PL-AN 179 is observed at the surfacing speed of 19 m/h (Figure 4, *e*).

Considering the obtained results in general, the following should be noted. The geometric parameters of deposited beads, characteristics of melting the flux-cored strips, and consequently, the composition and hardness of the deposited metal, except surfacing modes, are significantly influenced by the composition of the powder-filler and strip-sheath material. Thus, in surfacing using flux-cored strip PL-AN 111, manufactured on the base of a nickel strip-sheath, all the investigated characteristics are rather different from the data obtained in surfacing using flux-cored strips PL-AN 101 and PL-AN 179, manufactured of a steel strip-sheath. This, obviously, can be explained by a higher ohmic resistance of a nickel strip-sheath. At the same time, due to a larger voltage drop at the electrode stickout the more intensive heating of the

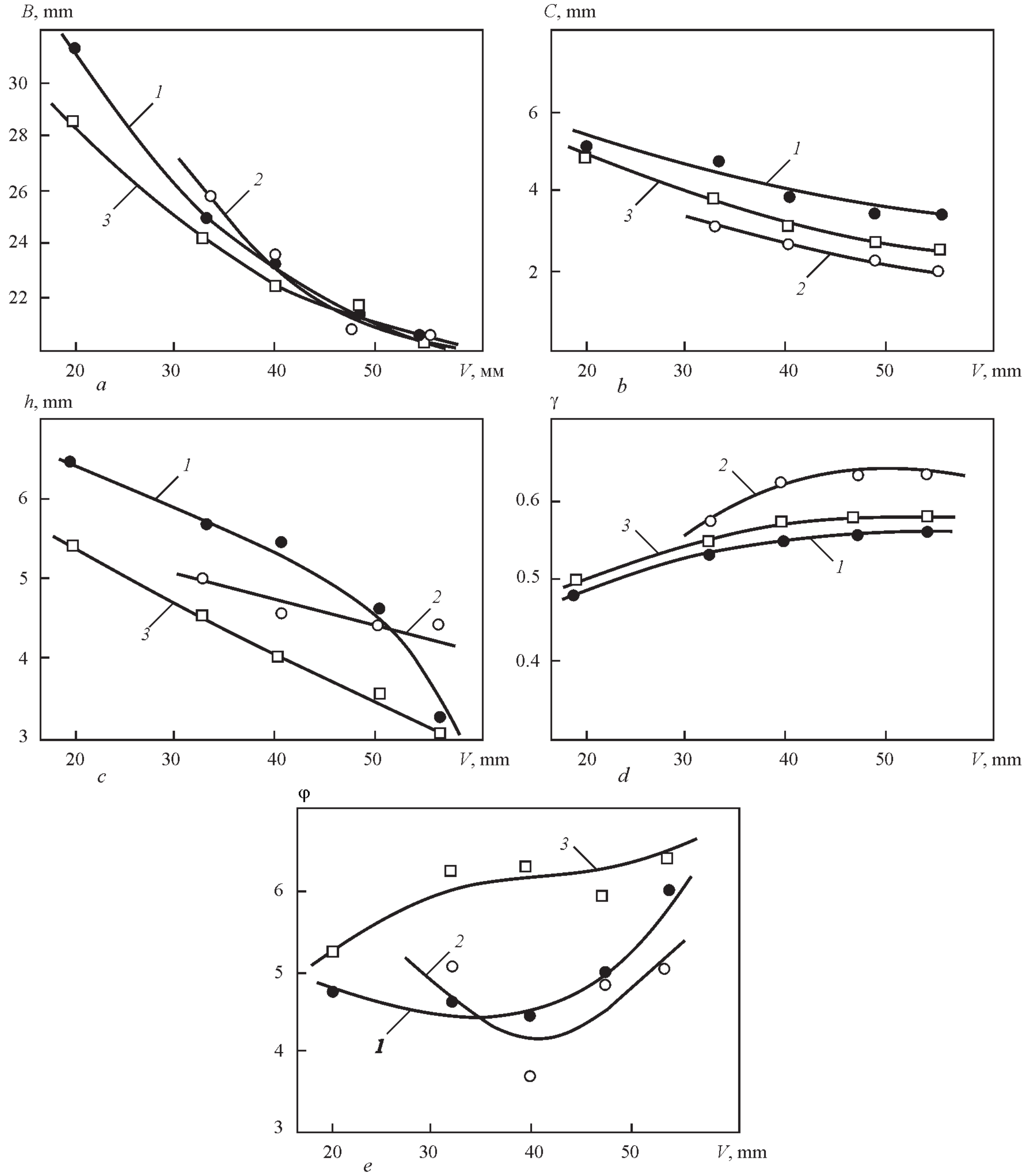


**Figure 4.** Change in geometric parameters of deposited bead: width (*a*), height (*b*), penetration depth (*c*), volume of base metal (*d*), weld shape factor (*e*), depending on change of speed in surfacing using flux-cored strips: *1* — PL-AN 101; *2* — PL-AN 111; *3* — PL-AN 179

flux-cored strip occurs at the stickout, which in its turn increases the efficiency of its melting by arc, i.e. leads to a more efficient use of the arc heat power.


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