Development of the Device for Two-Strip Cladding with Controlled Mechanical Transfer

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Abstract. A two-tape electrodes surfacing device with controlled transfer of electrode metal is proposed. The kinematical scheme and parameters of the process were investigated. It is established that the application of the developed device allows providing a more equable distribution of thermal energy across the width of the tape electrodes and a controlled dropping of liquid metal droplets.

Introduction

Recently, various methods of controlling the formation of the penetration zone and the transfer of electrode metal into the weld pool have become widespread [1-3]. The use of mechanical methods of electrode metal forced transfer allows controlling the quality and geometric parameters of welded seams, but also significantly reducing the energy consumption for heat input into the weld pool [4, 5]. Investigation of the possibilities of this method for deposition by a tape electrode [6] has shown the promise of this method for electric arc surfacing.

In the case of using two or more electrodes, the melting conditions of the electrode metal and its transfer to the weld pool are different from the method of surfacing with one electrode, especially for different values of the feed rate of the tapes. The influence of these parameters on the transfer of electrode metal to the weld pool has not yet been studied.

The purpose of this work is to study the kinematical parameters of the process of mechanical controlled transfer during electric arc surfacing by two tape electrodes. The use of this technology makes it possible to improve the quality of the deposited layer and to reduce the specific electric energy consumption per running meter of the weld bead.

To accomplish this goal, a device [7] has been developed for surfacing with two tape electrodes, which allows increasing the range of regulation of the parameters of pulsed mechanical transfer and preventing the deformation of tape electrodes (Fig. 1).

The proposed device provides alternate reciprocating motion of the ends of tape electrodes with the optimum frequency and amplitude. Since the reciprocating motion of the ends is superimposed on a uniform motion of the electrodes supply to the bath, this allows to preserve the technological parameters of the surfacing process and the dimensions of the weld bead when it is possible to reduce the expense of the electrode metal for losses and overheating, and, accordingly, the consumed energy for melting.

Experiments and discussion

Application of the device is carried out in the following way: when surfacing tape electrodes (6) are fed into the welding bath with the velocities $V_{1,ne}$ and $V_{2,ne}$, respectively. The rotation of the eccentric (2) ensures the superposition of vertical oscillations of the ends of the electrodes to their feeding, thereby controlling the discharge of droplets from the ends of the tape electrodes. In this case, the amplitude of
the oscillations of the ends of the tape electrodes varies depending on the amount of eccentricity and the distance between the tape electrodes.

The kinematical diagram of the two-ribbon feeder is shown in Fig. 1, b (only one electrode is shown). In accordance with the scheme, the dependence of the kinematical parameters of the movement of the ends of tape electrodes is determined by the equation (1):

\[
S(t) := l_2 + e \cdot \sin(\omega t) - \sqrt{1 - \left(1 - e \cdot \sin(\omega t)\right)^2 + \left[1 - \cos(\omega t)\right]^2} + \left(1 - \cos(\omega t)\right)\] + V_{ne}t \quad (1)

where \( V_{ne} \) is the feed rate of the tape electrode.

The dependence \( S'(t) \) is described by the same equation, but the initial time instant is shifted by half the period (Fig. 2). In the case of an asymmetric arrangement of the tape electrodes relative to the eccentric, the graphs of the displacement will differ in amplitude.

Fig. 1 The device for surfacing with two tape electrodes (a) and the kinematical scheme of interaction of the cam with the tape (b): feed rollers (1); guides (2); eccentric (3); pinch rollers (4); current lead (5); tape electrodes (6)

The displacement of the ends of the tape electrodes according to (1) gives them, respectively, periodically varying values of velocities and accelerations. The molten metal located at the end of the electrode during the oscillatory motion acquires acceleration under the action of inertia in the direction...
of the bath, which facilitates its accelerated discharge into the welding bath in the form of a drop. In this case, the mass of the dropped drop will be determined by the laws of the change in the kinematical parameters of the bands, their amplitude and frequency of oscillations. In Fig. 3 shows the calculated dependence of the change in the inertia force of the electrode metal acting on the drop using the kinematical diagram of the device shown in Fig. 1. The average droplet diameter was assumed $2.6 \times 10^{-3}$ m (drop weight $6.435 \times 10^{-5}$ kg).

![Fig. 3. Time dependence of the inertia force $F_{cu}$, N](image)

Angular speed of eccentric rotation, $s^{-1}$

In Fig. 4 presents the experimental data characterizing the influence of the current, voltage, and oscillation frequency of the end of the tape electrode on the value of the melting coefficient for automatic surfacing with forced transfer of electrode metal. As can be seen from Fig. 4, when the arc voltage changes from 24 V to 30 V, the coefficient of melting of the electrode metal increases in the range from $18-23$ g/A·h, while in case of using forced oscillations with a frequency of 50 Hz it is on average 20% higher than when surfacing without using forced oscillations with similar parameters of the deposition regime.

When superimposed oscillations are used, the surfacing productivity is increased by reducing the temperature of the droplets entering the weld pool from the ends and redistributing the temperatures in the volume of the weld pool, which leads to an increase in the efficiency of melting of the tape electrodes. This is due to the fact that during the melting of the electrode metal, when forced mechanical vibrations are imposed, the end faces of the tape electrodes are uniformly fused due to the uniform
distribution of thermal energy over the width of the bands and the controlled discharge of liquid metal droplets. The use of this technology makes it possible to improve the quality of the deposited layer and to reduce the specific electric energy consumption per running meter of the weld bead.

![Fig. 4 Dependence of the melting coefficient on the parameters of the surfacing regime:](image)

1 - U = 30 V, f = 50 Hz; 2 - U = 30 V, f = 0 Hz; 3 - U = 28 V, f = 0 Hz; 4 - U = 24 V, f = 0 Hz

The developed device provides alternate reciprocating motion of the ends of tape electrodes with optimum frequency and amplitude. Since the reciprocating movement of the ends is superimposed on the uniform movement of the electrodes supply to the bath, this stabilizes the technological parameters of the surfacing process and the dimensions of the weld bead when it is possible to reduce the consumption of the electrode metal for losses and overheating, and optimizes the weld metal structure, increasing its mechanical and anticorrosion properties without additional heat treatment [8].

Accordingly, the use of additional means to increase the efficiency of the surfacing process, such as improving the protection of the weld pool [9] and the use of modern power sources [10], further reduces the level of energy consumed by the melting of the electrode and base metal.

**Conclusions**

1. A device for depositing two tape electrodes with controlled transfer of electrode metal was developed.

2. The use of the developed device allows to increase the efficiency of melting of the electrode metal (on average by 20%), to ensure its controlled transfer to the weld pool and, as a consequence, the uniformity of the height of the deposited layer and the depth of the penetration zone along the entire width of the bath.

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