ISSN 1068-3755, Surface Engineering and Applied Electrochemistry, 2007, Vol. 43, No. 4, pp. 287–290. © Allerton Press, Inc., 2007.
Original Russian Text © O.Yu. Shitik, V.I. Osipenko, D.O. Stupak, 2007, published in Elektronnaya Obrabotka Materialov, 2007, No. 4, pp. 66–70.

EQUIPMENT AND INSTALLATIONS

Technique for the Determination of a Wire-Electrode Tool Shift Value During the Process of the Conical Four-Coordinate Electroerosion Treatment

O. Yu. Shitik, V. I. Osipenko, and D. O. Stupak

Cherkassy State Technological University, bul. Shevchenka 460, Cherkassy, 18006 Ukraine

Received December 20, 2006

Abstract—The problems of obtaining an exact conical surface of workpieces as a result of the displacements of the wire-electrode tool (WET) during the process of treatment from a specified position are explored in this paper. The method of determination and correlation of the real position of the cutting-wire area electrode is developed, forming the necessary inclination angle and obtaining exact conical surfaces.

DOI: 10.3103/S1068375507040102

INTRODUCTION

At the modern stage of technological development, the branch of electroerosion wire cutting takes the leading positions in the field of the precision treatment of current conducting materials.

The requirements regarding the precision of workpiece fabrication are within strict bounds, from 10 to 2 μm. Under these conditions, a significant influence on final precision of the cutting process is exerted by such a specific tool as a wire electrode, especially in terms of obtaining complex conic surfaces.

The problem consists in the complexity of a precise formation of the conic surface of a workpiece at the motion of feed drives along a projected trajectory as the result of shifts in the wire-electrode tool (WET) from a calculated position during the process of formation of a specified inclination angle [1, 2].

As a rule, for the solution of the given problem, the modern leaders (AGIE, Sodick, Mitsubishi, etc.) apply complex multiaxial systems of sensors, which, in the real-time mode, register any deviation of the wire and transfer the obtained data to the base of a system of numerical controls (NC) for the machine, allowing for the determination of both the wire inclination angle and the cutting-wire sector shift with respect to its specified position [3, 4]. Thus, it is possible to correct the trajectory of motion of the machine feed drives and, therefore, to provide a precision of the geometry of the final product.

However, taking into account the high cost of the given control systems, both the modernization and improvement of the characteristics of the electroerosion cutting machines (EECMs) made in the countries of the Commonwealth of Independent States and the development of domestic EECMs are possible provided inexpensive, maximally simple, and efficient techniques for the determination of a real WET position are developed.

THEORETICAL ANALYSIS

Figure 1 shows the scheme of a workpiece treatment with the purpose of obtaining a figure of the conical form.

Upon the formation of the specified inclination angle of the wire, as a result of the availability of the intrinsic hardness of the electrode tool, a bend in the wire axis appears, which, in the general case, takes on a wavy form. This bend leads to the appearance of the shift value $\Delta\gamma$ at each point of contact of the wire-electrode tool and the treated workpiece.

The essence of the specified problem consists in the determination of the shift value of the WET working part points from a calculated position. For the solution to this problem, it is necessary to find only two values for $\Delta\gamma$: $\Delta\gamma_{upp}$, which is the deviation in the upper plane of the workpiece; and $\Delta\gamma_{low}$, which is the deviation in the lower part; the error $\Delta\alpha$ corresponding to them (Fig. 2) should also be determined.

Having determined the values $\Delta\gamma_{upp}$ and $\Delta\gamma_{low}$, it is not difficult to find the error of the specified inclination angle of WET: a change in the inclination angle and a shift of the cutting-wire sector result in the appearance of significant errors of the obtained workpiece geometry.

Under these conditions, for the improvement of the technical-economic characteristics of the electroerosion machine and for the solution of industrial problems, it is necessary to develop and introduce special techniques, which would allow us to provide treatment precision, taking into account the WET deviations from the nominal position, on the one hand, and to make the entire industrial process cheaper, on the other hand.

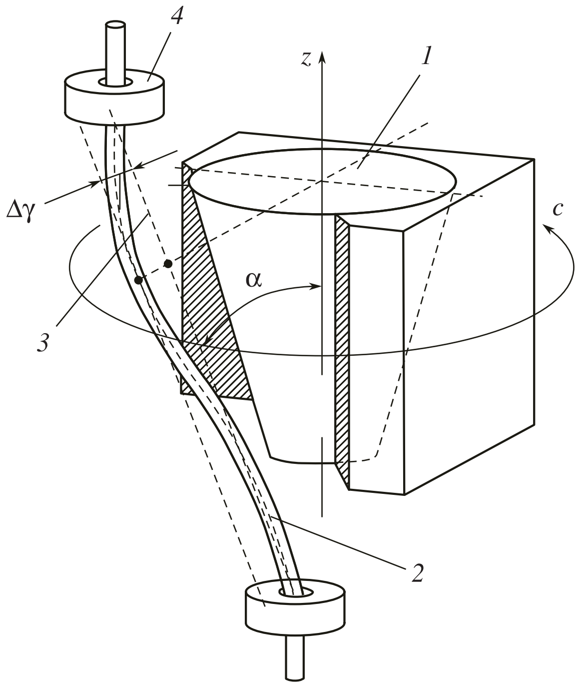

Fig. 1. Scheme of the treatment of conical surfaces by virtue of a four-coordinate electroerosion machine: *1* is the treated workpiece; *2* is the wire-electrode tool; *3* is the theoretical position of the WET axis; *4* is the system of the WET guiding; α is the specified inclination angle of the WET axis with respect to the workpiece surface; Δγ is the value of the WET shift with respect to the initial position at the point of contact with the workpiece; and *c* is the direction of motion of the electrode wire around the *z* axis.

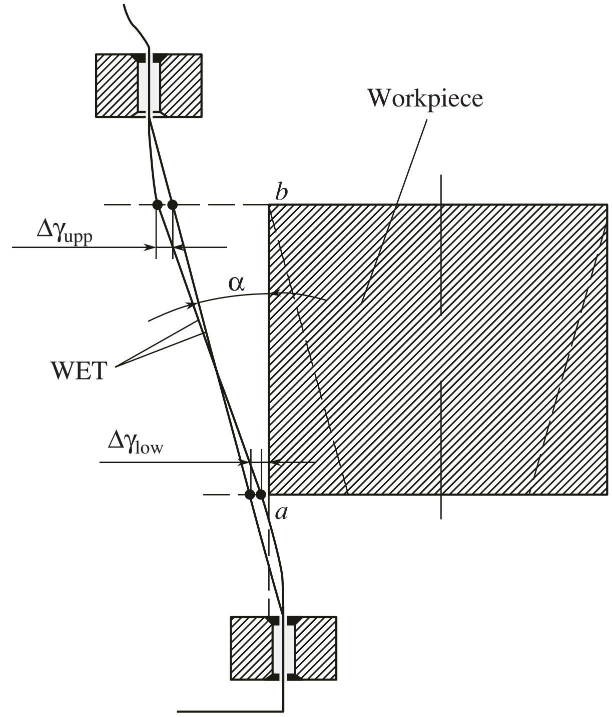

Fig. 2. Scheme of the shift of the initial WET position at extreme points of contact of the electrode and the workpiece: $\Delta\gamma_{upp}$ is the deviation value at the upper point of the contact; and $\Delta\gamma_{low}$ is the deviation value at the extreme lower point of the contact.

MEASUREMENT TECHNIQUE

In the firm "Aramis" (Cherkassy), on the basis of an essentially new four-coordinate electroerosion cutting machine *SELD-04* on linear drives, for the first time, a series of experimental measurements was carried out with the purpose of determining a precise position of a wire-electrode tool with respect to the workpiece at its conical cutoff.

The universality of the given method consists in the application of a specially designed device that imitates the treated workpiece. A characteristic peculiarity of the device is that it allows us to specify an arbitrary position of both base planes of treatment and wire inclination angles.

Directly before each experiment, all necessary measurements on the setting of the device with respect to the machine feed drives were carried out (Fig. 3).

At the first stage, the values l_1, l_2, and L were determined (Fig. 4).

The machine feed drives were positioned by virtue of NC, so that the front (cutting) edge of the WET in the point of the lower fixation of the wire in guide x_0 coincides with the ab axis of the rigidly fixed device. The WET fixation point in the upper guide was positioned from the ab axis at distance H determined by the NC system for the formation of the specified angle value α. Thus, knowing all of the necessary distances and dimensions, the following equalities may be determined:

$$H = L\tan\alpha, \quad (1)$$

$$\tan\alpha = \frac{H}{L} = \frac{H_1 - h_1}{l}, \quad (2)$$

$$H_1 = (l_1 + l)\tan\alpha, \quad (3)$$

$$h_1 = l_1\tan\alpha. \quad (4)$$

At the next stage, the machine feed drive shifted the lower guides into the point of the WET contact with the lower-end face of the device (Fig. 5). All of the coordinates of the shifts of the feed drives were registered by the machine NC.

In this case,

$$h_{1D} = x_1 - x_0. \quad (5)$$

Having symmetrically shifted the upper guides by the value –H and the lower guides into the point of the

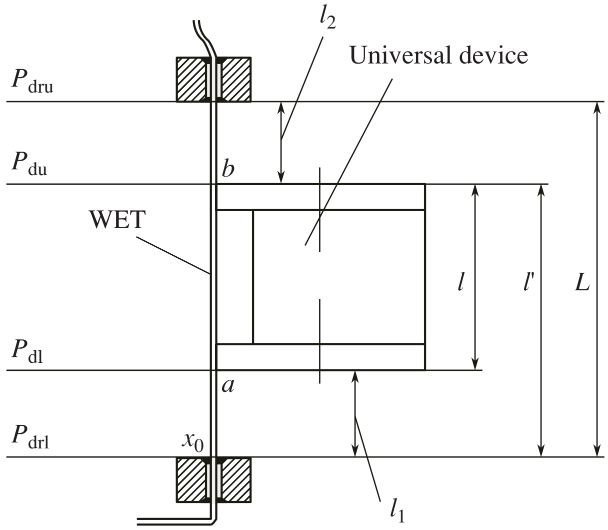

Fig. 3. Example of a scheme of a universal device setting on the four-coordinate electroerosion cutting machine SELD–04: P_{dru} is the upper plane of the drive motion; P_{du} is the upper plane of the device; P_{dl} is the lower plane of the device; P_{drl} is the lower plane of the drive motion; l_1 is the distance between the lower plane of the device and the lower plane of the drive motion; l_2 is the distance between the upper plane of the drive motion and the upper plane of the device; l is the device height; and L is the distance between the upper and the lower planes of the drive motion.

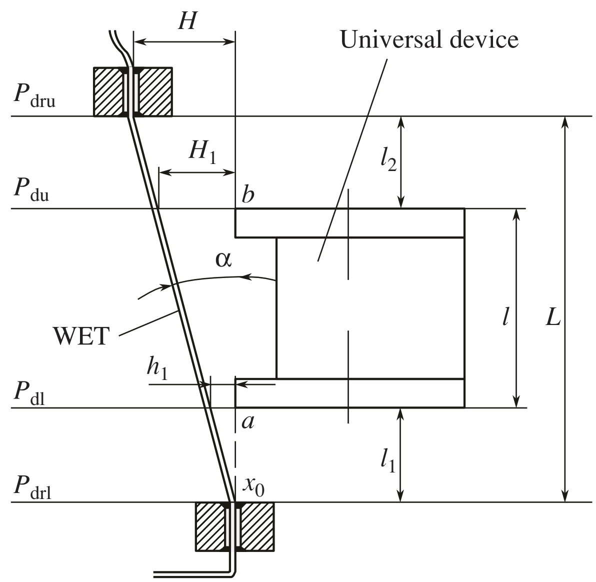

Fig. 4. Scheme for the determination of the WET position upon the formation of the inclination angle.

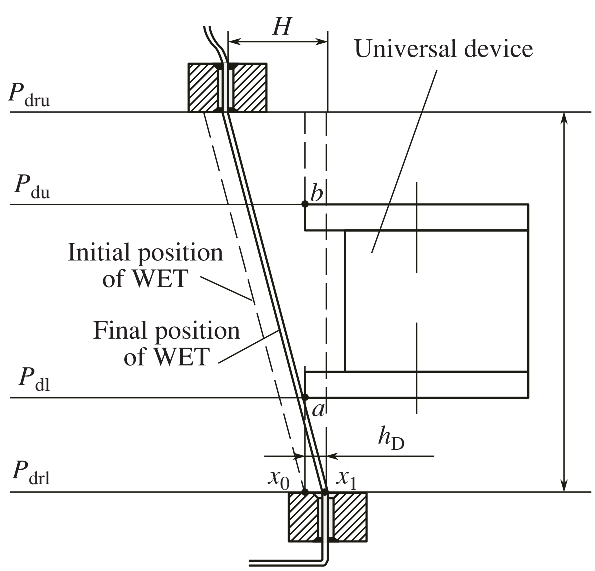

Fig. 5. Scheme of the determination of the real value of the WET shift h_D: x_1 is the obtained fixed position of the cutting edge of the WET in the lower guide.

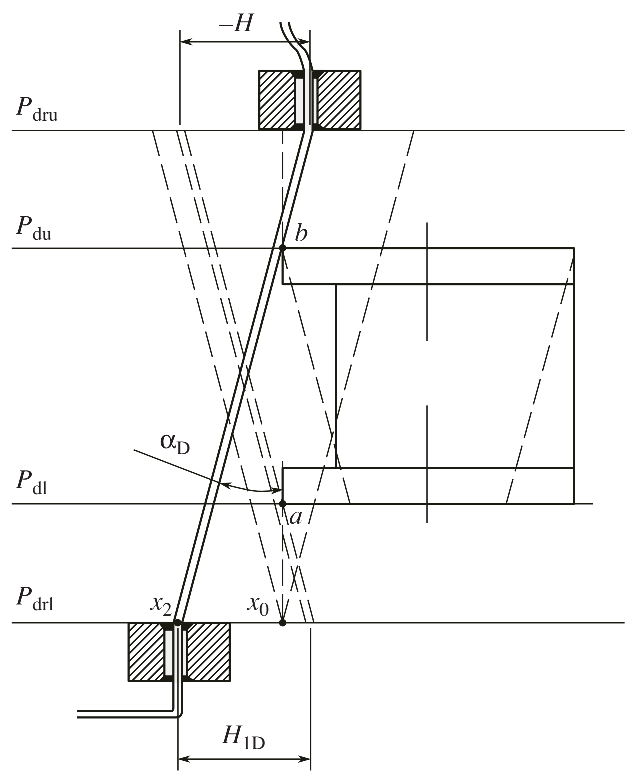

Fig. 6. Scheme of the determination of the real value of the WET shift H_{1D}.

drive contact with the upper plane of the device, we can determine the value H_{1D} (Fig. 6):

$$H_{1D} = x_0 - x_2, \quad (6)$$

and, hence,

$$\tan\alpha_D = \frac{H_{1D} - h_D}{l}. \quad (7)$$

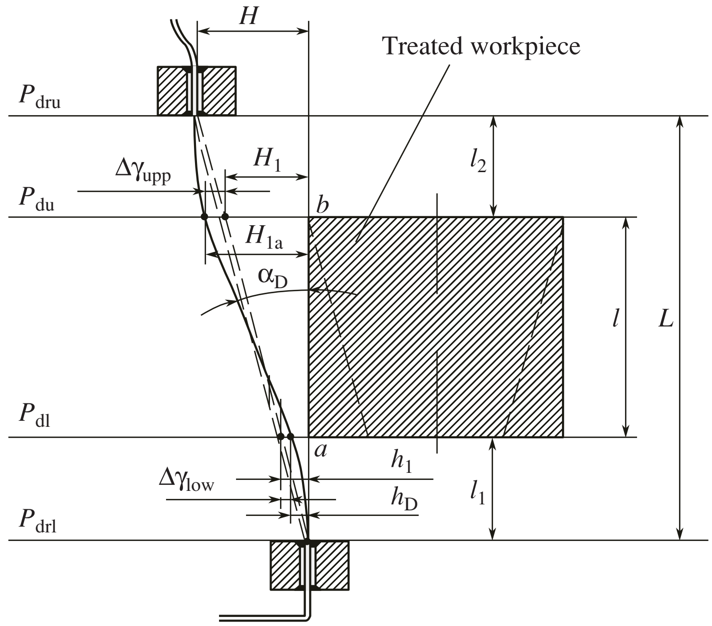

Fig. 7. Calculated and real positions of the WET upon the formation of the specified treatment inclination angle

Having obtained the values h_{1D}, H_{1D}, and α, we can estimate the deviation of the real position of the WET from the calculated one (Fig. 7):

$$\Delta\gamma_{low} = h_1 - h_D, \tag{8}$$

$$\Delta\gamma_{upp} = H_1 - H_{1D}, \tag{9}$$

$$\Delta\alpha = \alpha - \alpha_D. \tag{10}$$

Having obtained the real values of $\Delta\gamma_{upp}$, $\Delta\gamma_{low}$, and $\Delta\alpha$ using 2–4 purposeful iterations, we can select a new value for H, at which $\alpha = \alpha_D$ and $\Delta\gamma_{upp} = \Delta\gamma_{low}$ within the error of precision of the machine drive positioning. Under this condition, at the stage of the technological process projection, it is not difficult to form a trajectory of motion of the feed drives, which will compensate the wire-shift influence on the conical-surface formation precision.

CONCLUSIONS

1. The developed experimental technique allows us to determine and correct, to a precision of positioning of the feed drives of a concrete type of four-coordinate EECM, the WET position with respect to the workpieces upon formation of conic surfaces and to obtain precision for the four-coordinate treatment at the level of the two-coordinate treatment for specific types of machines, without the application of the WET position control system.

2. Due to its simplicity and universality, the determination of the WET position at the development and installation of the corresponding software may be performed automatically.

REFERENCES

1. Patent CH 681702 A5, B23H, Schneiddrahtfunkenerosionsmaschine. Mitsubishi Denki Kabushiki Kaisha, Chiyoda-ku/ Tokyo (JP), 1993.
2. Patent CH 655884 A5, B23H, Machine a teles orientables pour decoupage par electroerosion. Charmilles Technologies S.A. Geneve, 1986.
3. De Bruyr, H.E., Pekelharing, A.J., Comparison of Various Erosion Systems with Rectangular and Trapezoidal Pulse Forms, *Annals of the CTRP*, 1994, vol. 29, no. 1, pp. 103–106.
4. Jeswani, M.L., Dimensional Analysis of Tool Wear on Electrical Discharge Machining, *Wear,* 1979, 55, no. 1, pp. 153–161.