

Features of Tool Motion Trajectory during Abrasive Finishing in the Machining or Restoration of Sealing Surfaces of Pipeline-Valve Components

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Abstract—The article addresses the determination of the motion trajectory of an abrasive tool on a lapping-and-finishing machine in order to ensure the specified quality of the sealing surfaces of shut-off valve components. Mathematical relationships for calculating the points of the tool's motion trajectory are presented.

Keywords: trajectory, abrasive tool, tool-movement patterns

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INTRODUCTION

An analysis of the publications and industrial experience has shown that, in the abrasive lapping of the shut-off surfaces of pipeline-valve components, the specific features of the tool trajectories relative to the machined sealing surfaces have not been sufficiently investigated. In addition, there are no methods for determining the process parameters and surface roughness during the abrasive lapping of sealing surfaces [1–4]. The issues related to setting up the process equipment before lapping the surfaces have also not been fully addressed. All of this adversely affects the productivity and quality of the machining process and necessitates the use of appropriate technical and technological solutions.

EXPERIMENTAL

Scientists and engineers from German companies, including the Unigrind-SLIM and EFCO-HSL groups, as well as Russian scientists and specialists S.V. Seinov, A.K. Adamenkov, V.A. Polyakov, V.K. Pogodin, and others, have made a significant contribution to the development of machines for abrasive lapping of the sealing surfaces of pipeline-valve components. However, despite their originality, the machines produced by the German companies have certain disadvantages, including the relatively low power of their electric or pneumatic drives compared with those of the Russian company GAKS-REM-ARM, as well as the limited immersion depth of the spindle carrying the tool disk equipped with lapping tools. This limitation prevents high productivity and the required quality parameters from being achieved when abrasively

lapping large valve bodies of wedge gate valves with a nominal bore of $DN\ 1000\text{--}1400\text{ mm}$ and an immersion depth of $L = 1200\text{--}1400\text{ mm}$. Among the first Russian enterprises to manufacture the above-mentioned machines and develop technologies for grinding and lapping the shut-off surfaces of pipeline-valve components were GAKS-ARM-Service and GAKS-REM-ARM, a division of GAKS-ARM-Service [2–6]. Specialists from these enterprises have made a significant contribution to the setup of portable machines for abrasive lapping, the development of methods for determining the operating parameters and quality characteristics of the finishing process for sealing surfaces, and the selection of suitable abrasive materials and metalworking fluids/coolants (MWFs) [1–7].

To determine the tool trajectory, let us consider the position of point B at various time values (t). Let the initial time be ($t_0 = 0$), with a time increment of $\Delta t = 0.1\text{ s}$.

At $t_0 = 0$ (Fig. 1), let us project the position of point B onto the OX axis:

$$X_0 = R_d + R_w, \quad (1)$$

where R_d is the radius from the center of the tool disk to the tool axis (the grinding wheel or lap); R_w is the radius of the tool (the grinding wheel or lap).

Let us project the position of point B onto the OY axis, with $Y_0 = 0$.

The rotation angles φ_d and φ_w are equal to zero.

At $t_1 = t_0 + \Delta t$ (Fig. 2):

$$t_1 = 0 + 0.1 = 0.1\text{ s}.$$

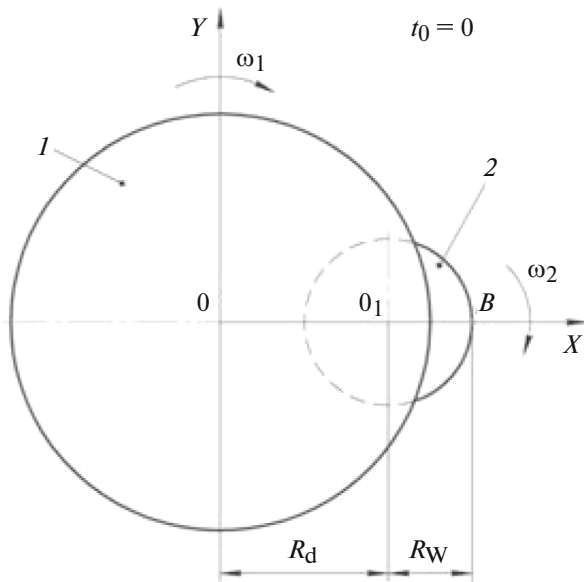


Fig. 1. Diagram for determining the tool trajectory: (1) disk on which the tool is mounted; (2) abrasive tool.

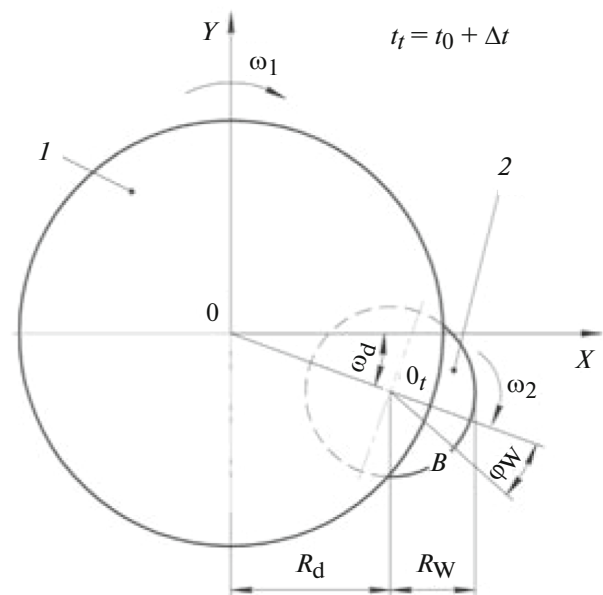


Fig. 2. Diagram for determining the tool trajectory: (1) disk on which the tool is mounted; (2) tool.

The disk rotation angle is determined as follows:

$$\varphi_d = \omega_1 t_1. \quad (2)$$

The tool rotation angle is determined as follows:

$$\varphi_w = \omega_2 t_1. \quad (3)$$

Let us project the position of point B onto the OX axis (Fig. 3):

$$X_1 = a + b. \quad (4)$$

From triangle OO_1M (see Fig. 3):

$$a = R_d \cos \varphi_d. \quad (5)$$

From triangle BO_1C :

$$b = R_w \cos(\varphi_w + \varphi_d). \quad (6)$$

Let us project the position of point B onto the OY axis:

$$Y_1 = c + d. \quad (7)$$

From triangle OO_1K :

$$c = R_d \cos(90^\circ - \varphi_d). \quad (8)$$

From triangle BO_1N :

$$d = R_w \cos(90^\circ - (\varphi_w + \varphi_d)). \quad (9)$$

By considering the two time instants t_0 and t_1 , we obtain the coordinates of point B . This makes it possible to calculate the distance traveled by the point over a given time interval:

$$\begin{aligned} \Delta l &= \sqrt{\Delta x^2 + \Delta y^2}; \\ \Delta x &= X_0 - X_1; \\ \Delta y &= Y_0 - Y_1. \end{aligned} \quad (10)$$

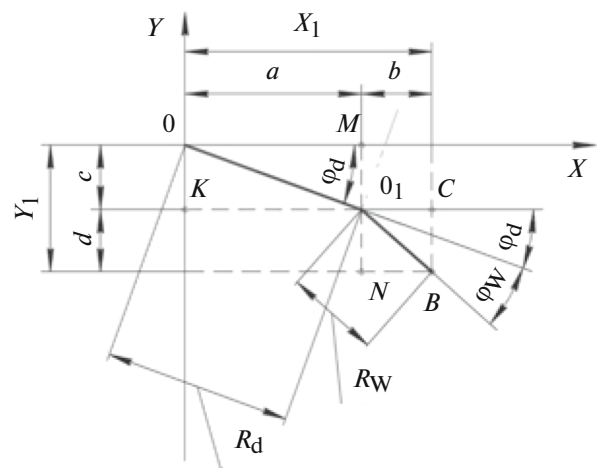


Fig. 3. Diagram for calculating the position of point B .

To determine the total distance traveled by point B , the calculation must be continued until the moment when φ_d becomes equal to 2π .

CONCLUSIONS

Thus, determining the motion trajectory of the abrasive tool is of great importance for ensuring the specified quality of the sealing surfaces of shut-off valve components. The mathematical relationships presented make it possible to control the motion trajectory of the abrasive tool in order to ensure the stability of the finishing abrasive-machining process.

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CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

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