

Determination of Operating Parameters during Restoration or Manufacture of Pipeline Fittings

V. A. Scriabin^a, *, N. V. Sorokina^a, and S. A. Gusev^a

^a Federal state Budgetary Educational Institution of Higher Education “Penza state University”,
Penza, 440026 Russia

*e-mail: vs_51@list.ru

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Abstract—This article describes the specifics of determining process and force parameters during lapping of ring sealing surfaces of pipeline valve bodies on flat-lapping machines. Kinematic diagrams for the finishing process have been developed.

Keywords: operating parameters, lapping, flat annular surface, kinematic diagrams, gate valves

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INTRODUCTION

In modern mechanical engineering, when restoring or machining the sealing surfaces of pipeline valve components, achieving high-quality characteristics that ensure a high degree of tightness is a pressing task. Manufacturing quality cannot be improved without improving the finishing operations of abrasive machining processes, one of which is abrasive lapping. One component with a high degree of tightness of annular sealing surfaces is the valve body of a pipeline valve (Fig. 1) [1, 2]. Lapping on a lapping machine must be preceded by grinding with abrasive wheels. After grinding, the grinding wheels in the tool blocks are replaced with lapping wheels, and sometimes, if necessary, the entire tool mounts are replaced. The metal layer removed by lapping is 0.002–0.03 mm. Lapping achieves high precision of dimensions and geometric shape (up to 0.001–0.002 mm), and surface roughness of parts up to $R_a = 0.032$ –0.02 μm .

MATERIALS AND METHODS

The grinding wheels were made of chrome-titanium fused alumina grades 91A–95A with a grain size of F60 (Z 25).

The lapping pads were made of gray cast iron SCh20 (GOST 1412–85) or steel 45 (GOST 1050–88) with self-adhesive abrasive sheets. Sandpaper material and grain size: roughing: 91A16-N (P80); 91A10-N (P120); 15A16-N (P80); 15A10-N (P120); finishing: 91AM63-N (P240); 15AM63-N (P240). The paste was made using chromium-titanium fused alumina grade 91A (92A) or white fused alumina grade 24A (25A). Table 1 shows the composition of the lapping and finishing paste [1–4].

Figure 2 shows the designs of tool blocks made of carbon and alloy steels, as well as aluminum alloys. The blocks have brackets with sockets for mounting tools. The brackets can be extended a certain dis-

Table 1. Composition of lapping paste

Component name	Content, %	Note
White electrocorundum grades 24A, 25A or chrome-titanium fused alumina grade 91A (92A)	50	Brand and grain size of the abrasive, as well as the paste’ composition, may vary depending on the material being processed and the processing conditions
Oleic acid GOST 7580–91	10	—
Litol-24 GOST 21250–87	15	—
Surfactant (soda ash)	10	—
Industrial oil I20A	15	—

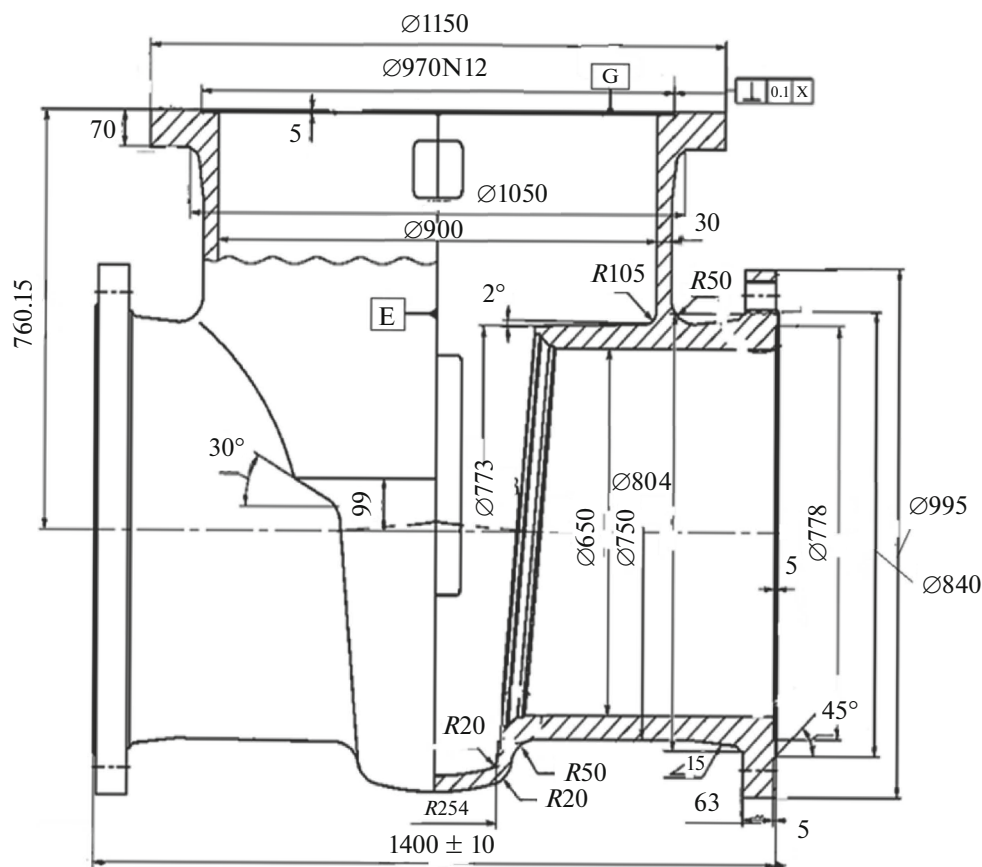


Fig. 1. The pipeline valve' body.

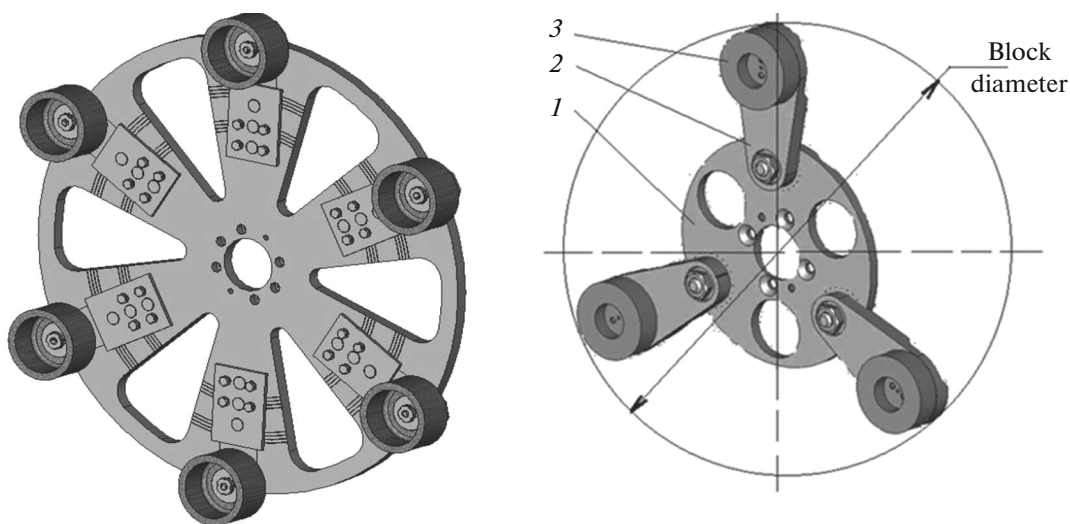


Fig. 2. Designs of tool blocks for 6 and 3 tools: (1) tool disk; (2) bracket; (3) grinding wheel or lapping wheel.

tance, allowing for the machining of parts of various diameters.

The movements of the tool blocks with tools are shown in the diagram for machining the annular surfaces of parts on a vertical surface lapping machine (Fig. 4) [5].

To determine the process parameters for machining the annular sealing surface of a pipeline valve after restoration by surfacing with a high-alloy alloy, the grinding and lapping operations are performed. When manufacturing parts, a lapping operation is performed

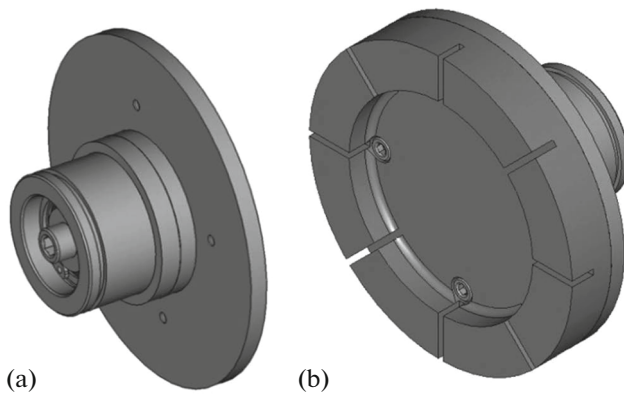


Fig. 3. Lapping lap designs: (a) design of a steel lap with self-adhesive abrasive paper; (b) design of a cast iron lap with lapping paste applied to it.

after the grinding operation. Let's consider the kinematic diagram of the combined circular motion of the tool block and lapping tools [1, 5, 6].

OA is the center-to-center distance between the center of the lapping tool and the tool block ($OA = R_{av}$).

The distance AC from the center point of block with the lapping tools positioned on it to the centerline of the annular surface of width H is zero.

Consider the motion of tool (Fig. 5), which is subject to the following loads: the driving force P_{dr} from the drive, acting at the lapping tool's center point A ; and the cutting forces (resistance), which are distributed over the annular surface.

As a first approximation, we assume that these forces are uniformly distributed over the workpiece surface.

Let's replace these forces with a single resultant force R_{result} , applying it at the center of gravity "C" of the annular surface. This force is the cutting force.

Protrusion of the lapping beyond the outer diameter of machined surface of the part Δ is determined based on the conditions of eliminating the "collapse" of the edge of the outer diameter of the annular surface D_1 in order to obtain stable machining accuracy.

$$2\Delta = d - H.$$

The cutting power during abrasive finishing of the annular surface of a workpiece is determined as follows:

$$N_{cut} = nR_{result}V_C, \quad (1)$$

where n is the number of lapping wheels or grinding wheels in the tool block; R_{result} is the resulting cutting force; V_C is the velocity of the point of application of the resistive force.

$$R_{result} = fF_{clap}, \quad (2)$$

where f is the coefficient of friction between the lapping tool and the workpiece surface; F_{clap} is the

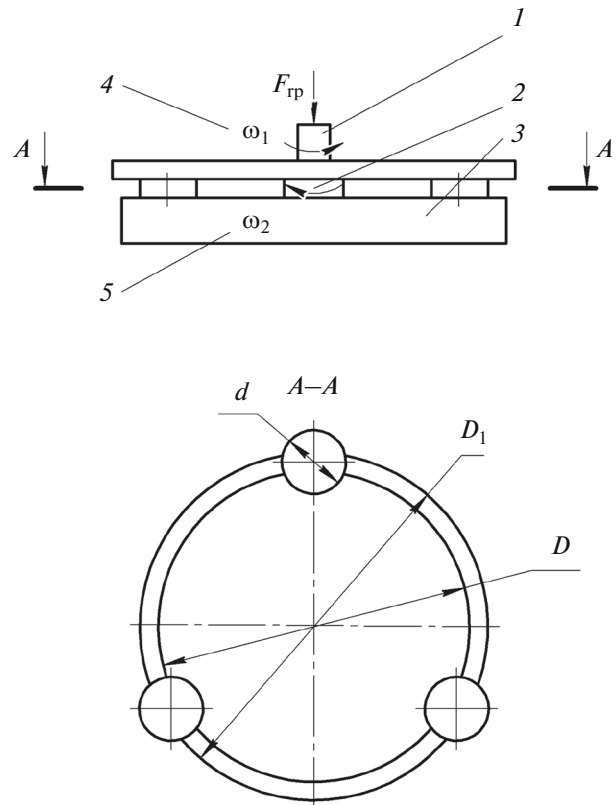


Fig. 4. Diagram of lapping annular surfaces on a vertical lapping machine: (1) spindle mandrel; (2) cast iron or steel lap; (3) workpiece; (4) angular velocity of rotation of the tool block ω_1 ; (5) angular velocity of rotation of the lap ω_2 ; D_1 —outer diameter of the workpiece's annular surface; D —inner diameter of the workpiece's annular surface; d —diameter of the lap.

clamping force of the lapping tool against the annular surface of the workpiece.

Based on production experience and production data from Russian companies engaged in lapping (abrasive finishing) technologies for flat parts, as well as from literary sources, the lapping tool's linear speed V_C ranges from 0.2 to 0.5 m/s for fine abrasive finishing, and from 0.4 to 2 m/s for rough abrasive finishing. The friction coefficient f between the abrasive tool and the workpiece surface made of cast iron or alloy steel varies in the range of 0.1–0.4. In this case:

$$N_{cut} = nfF_{clap}V_C. \quad (3)$$

During abrasive finishing, the drive power N_{drive} will be equal to the power N_{cut} developed by the cutting force R_{result} , i.e.:

$$N_{drive} = N_{cut}. \quad (4)$$

$$N_{drive} = N_{cut} = M_{mot}\omega_1 = P_{drive}V_A, \quad (5)$$

where P_{drive} is the driving force from the drive; V_A is the speed of the point of application of the driving force; M_{mot} is the torque of the machine drive motor.

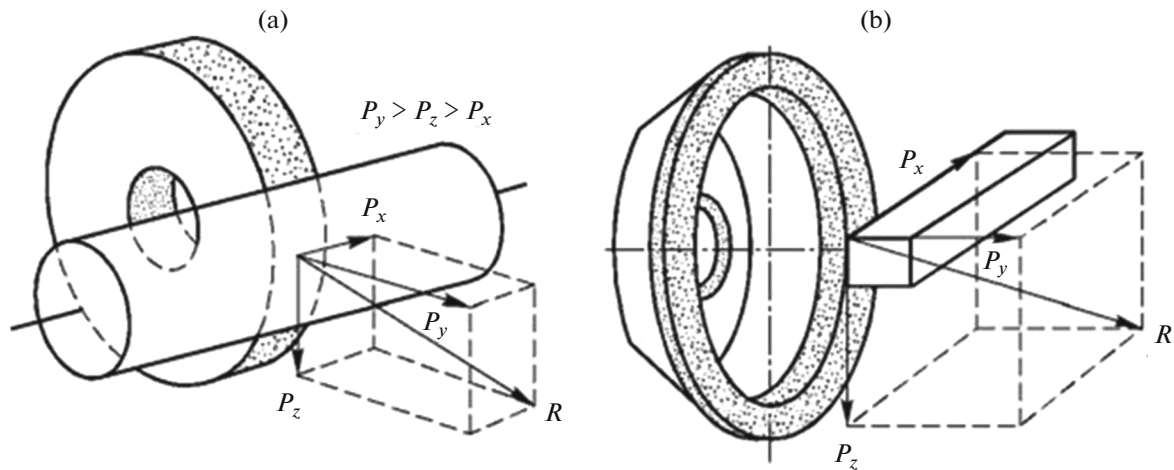


Fig. 7. Schemes of processing by the periphery and end of abrasive tools.

The linear speeds of the drive motor V_1 and the lapping tool V_2 (m/min) are determined by the relationships:

$$V_1 = \frac{\pi D_{tb} n_1}{1000}; \quad V_2 = \omega_2 r.$$

In the linear speed relationships, D_{tb} is the tool block' diameter, and r is the lapping tool radius.

The cutting force and power magnitude are of great importance for ensuring the efficiency of finishing operations when machining parts on grinding and lapping tools. Resulting cutting force on the grinding wheel and lapping tool R , as in turning, can be decomposed into P_Z (tangential), P_Y (radial), and P_X (axial (feed) components (Fig. 7).

Resulting cutting force is then determined as follows [3, 5]:

$$R = \sqrt{P_Z^2 + P_X^2 + P_Y^2}.$$

By measuring the tangential component P with a dynamometer, the empirical equations were found for both calculating the expended power N_e and the tangential component P , for flat grinding or lapping applications. When micro-cutting with a large number of abrasive grains at negative rake angles and removing very thin chips, the radial component P_X increases sharply, exceeding the tangential component P_Y by 2–3 times. The magnitude of the tangential component of the force can be determined from the power N_e :

$$P_Z = \frac{1000 N_e}{V_{wh}}, \quad (9)$$

where V_{wh} is the wheel or lapping speed; N_e is the expended power.

The power expended during grinding with the end face of a wheel or lapping is determined by the following empirical relationship:

$$N_e = C_N V^Y t^X H^Z, \quad (10)$$

where C_N , Y , X , Z are coefficients and exponents depending on the finishing conditions; H is the work-piece' surface width.

Tangential component of the cutting force P_Z during grinding with the end face of a wheel or lapping is usually small and amounts to approximately 200–500 N due to the small amount of stock being removed. During high-speed and high-power grinding, the expended power is quite high and reaches several or even tens of kilowatts due to the high cutting speed. Therefore, due to the high-power consumption of grinding, the specific energy consumption per unit of stock removal is approximately 10 times higher than with blade machining. The axial component P_X is usually not calculated due to its small value ($P_X < P_Z$), which is explained by the small plan angles of the cutting grains of the wheel [1, 5, 6].

CONCLUSIONS

The developed kinematic diagram for the abrasive finishing process of pipeline valve body sealing surfaces enabled for the first time the development of a method for calculating the operating parameters of annular sealing surfaces on a vertical surface finishing machine with a unique tool block design, which can be used for both grinding and lapping operations. These experiments conducted allow us to calculate the operating parameters of process operations and achieve the desired surface roughness on the machine when machining valve body sealing surfaces for parts made of various materials.

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CONFLICT OF INTEREST

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

REFERENCES

1. Skryabin, V.A., The processing steps in the renew of plug-forming details of pipeline fittings, *Vestnik Mordovskogo Universiteta*, 2016, vol. 26, no. 2, pp. 228–245. <https://doi.org/10.15507/0236-2910.026.201602.228-245>
2. Zverovshchikov, A.E., Enhancement of solid centrifugal-planetary machining, *Naukoemkie Tekhnologii v Mashinostroenii*, 2013, no. 7, pp. 17–23.
3. Seinov, S.V., Technologies and equipment for lapping valves seals, *Remont. Vosstanovlenie. Modernizatsiya*, 2002, no. 2, pp. 8–13.
4. Vust, J. and Claser, H., *Eine methode der Näherungswerte für Metaldichtungen der ND-Technik anhand mechanischen Ersatzmodelle-4*, Dresden: Jnt. Dichtungstag, 2004, pp. 420–444.
5. Sarda, S.P., Le Tirant, P., and Baron, G., Influence des contraintes et de la pression de fluide sur le coulement dans les rochers fissurés, *Advances of Rock Mechanics. Washington*, 2004, vol. 2, part a, pp. 667–673.
6. Orlov, P.N., *Tekhnologicheskoe obespechenie kachestva detalei metodami dovodki* (Technological Quality Assurance of Parts Using Finishing Methods), Moscow: Mashinostroenie, 1988.

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