

Development of Deburring Technology for Micro Drilling Burrs using Magnetic Abrasive Finishing Method

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Key words: burr, micro drilling, magnetic abrasive finishing (MAF), magnetic inductor, technology, magnetic abrasive powder, deburring.

Abstract

Introduction

The problem of removing burrs appearing at all operations of cutting is familiar. Large number of methods, tools and equipments for deburring were worked up. Many effective solutions were found. But the problem of deburring of burrs after micro drilling is not closed so far, while any interesting tendencies of its solution were found. The prevention and the minimization of burrs by the application of the drills of the special configuration is one of them [1,2]. Another interesting tendency of the problem is removing of burrs using the method of the Magnetic Abrasive Finishing (MAF) [3,4]. This method may be applied for finishing of different shape surfaces and different worked materials.

The sorts of MAF using magnetic abrasive powders (further – powder) as tools have a wide distribution. Those powders have magnetic and abrasive properties in the same time. Such powder is located with a force on a worked surface by means of the magnet inductor of the special construction. Than the magnetic inductor and workpiece perform movements each concerning other because of what the powder removes allowance, improves the roughness, removes burrs and rounds edges.

Magnet field created by the inductor is necessary to keep the powder inside of work gaps, to create an abrasive tool from the powder changing its rigidity, to create forces for fine abrasive cutting. Many magnetic inductor units for MAF are known by now. They may be based on coils or permanent magnets.

The authors present the results of their experiments on removing burrs by MAF after micro drilling and used magnetic inductor and powders.

The magnetic inductor unit and its application specifics

The researches are worked out using the electromagnetic inductor intended for finishing and deburring of plane surfaces on flat workpieces (fig. 1). The inductor uses a continuous current. The body of the inductor was fixed on the mandrel having the cone shank. The inductor is fixed with the help of this mandrel into the hole of a milling machine spindle.

The coil is located inside the inductor body, and collector ring are placed on the top plane of the body. They are intended to connect the coil with a constant-current source. Besides the sliding contact device is fixed on the spindle block of the milling machine to transfer a constant current to the coil.

The magnetic poles are located on the bottom plane of the inductor. They represent area elements of the external and internal rings: external pole S and internal pole N. The radial grooves

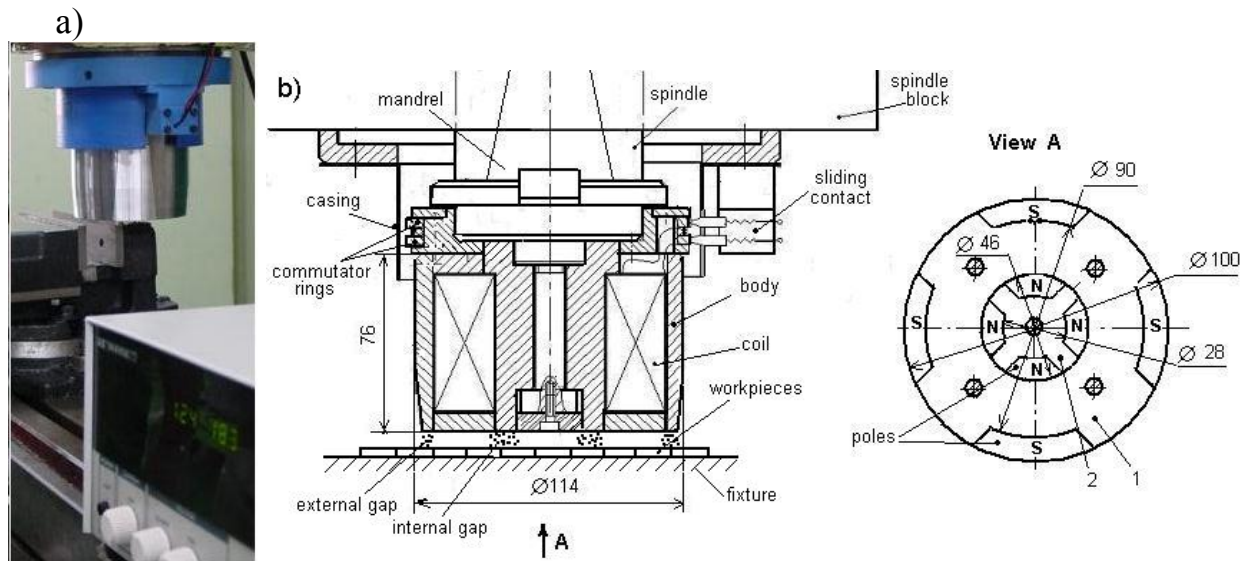


Fig.1. The general view (a) of the magnetic inductor fixing at the milling machine and its structure (b)

are made on the ring poles in order to create magnetic field thickeners and to equalize the areas of the poles. These grooves are hid by the non-magnetic lids 1 and 2, which protect the inductor internal space and support the coil simultaneously.

A fixture with workpieces is placed on a table of a machine. The gaps between the poles and worked surface of a workpiece are filled by a magnetic abrasive powder in time of finishing. We'll name these gaps as external work gap and internal work gap accordingly. The inductor has to rotate and the machine table together with fixture and workpieces has to feed in time of finishing. The next features of the showed inductor were established during researches:

1. An activity of finishing influences from a location of a workpiece concerning the way of the inductor axis. For example, if the plane ABCD is finished, its sections a, b, c will be finished with different activity (fig.2). Accordingly the different roughness, height of burrs and thickness of removed allowance will be got on these sections after MAF. The biggest activity took place on the "c" section where both external and internal poles with powder have passed above. The diagram of decreasing of the height of the burrs after micro drilling is shown on figure 2b. The drilled holes in steel samples were located on the different distances from the trajectory of moving of the inductor axis 0-0. To ways are possible to receive the homogeneity of results on a whole worked surface: to

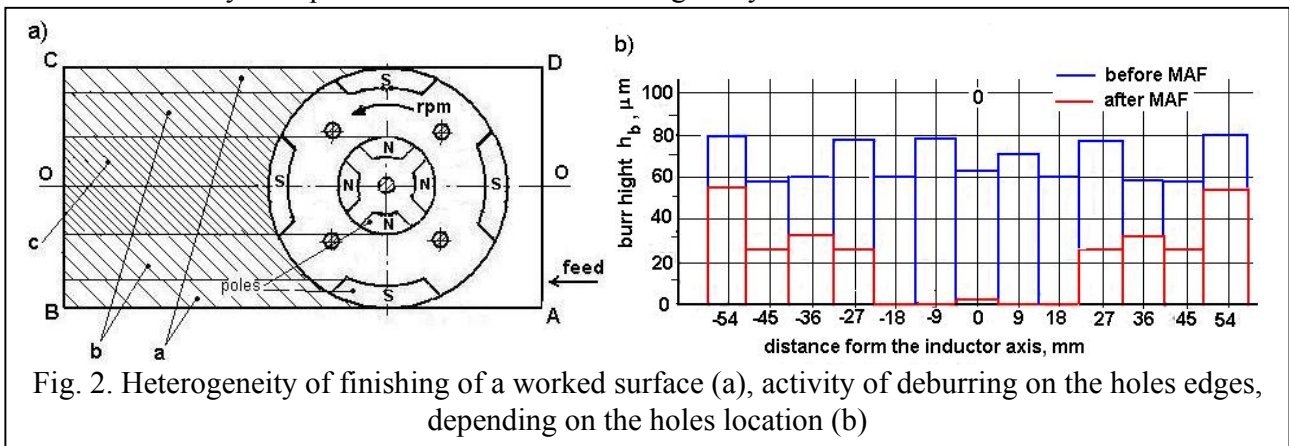


Fig. 2. Heterogeneity of finishing of a worked surface (a), activity of deburring on the holes edges, depending on the holes location (b)

locate workpieces in section “c”, or use additional movements of the inductor and workpiece in order section “c” cover whole worked surface.

2. Too results of finishing depend from: machining conditions (frequency of the inductor rotation, feed, current in the coil, height of work gaps), magnetic properties of worked material, presence of the magnetic field thickeners on the worked surface, use of a cooling water and its compound, powder properties. As for machining conditions, they are be optimized for each concrete technological operation. A cutting emulsion using is not obligatory as the temperatures acting on a worked surface are not more 150°C. But the cutting emulsion containing surface-active and reactive components may increase an efficiency of MAF in any times.

3. It is possible to receive some useful results at one MAF operation: polishing, rounding of edges, deburring, improving of surface (on hardened steels).

Comparison of magnetic abrasive powders

The magnetic abrasive powders put to the test were made by the Company “STC Reaktivelectron NAS of Ukraine”. The experiment was fulfilled at the plain samples which had dimensions allowed to locate them into the section “c” of the fixture. The samples material is steel SN45C. The powders differ in their composition, grain sizes, a location of abrasive particles an a ferromagnetic matrix (see tabl.1). A top plane of samples was exposed to finishing, and an amount of a removed allowance was controlled.

The parameters of the dependence

$$q = q_1 \cdot \tau^m, \quad (1)$$

are used for rating of abrasive properties of the powders. There are signed in the formulas (1): q , mg/cm^2 – specific allowance removed from an unit of the area of a finished surface; q_1 , $\text{mg}/(\text{min} \cdot \text{cm}^2)$ – the same, but in the first minute of the finishing; τ , min – a duration of the finishing. The parameter q_1 defines a powder cutting property and its initial productivity, and exponent m – a life of a powder portion by indirection.

The conditions of the tests were next: the machine spindle speed - 370 rpm, feed -127 mm/min, coil current -1.2 A, height of the working gap - 2mm, volume of the powder portion - 12 ml. In order to receive the dependence (1), the finishing has been fulfilled with the different table motions number: 1, 2, 4, 8 and with the corresponding durations of finishing: 0.8, 1.6, 3.2 and 6.4 minutes. The finishing was interrupted after each pointed motions number, the measurements of samples weight were made and then the finishing was continued with the same the powder portion. The results of the tests are showed on the tabl.1 and fig.3.

Таблица 1. Данные о порошках, участвовавших в эксперименте, и параметры полученных зависимостей $q = q_1 \cdot \tau^m$

#	Marking	Composite grain size ν , μm	Abrasive particles size λ , μm	Location of abrasive into composite grain	Initial productivity q_1 , $\text{mg}/\text{cm}^2 \cdot \text{min}$	Exponent m
1	Fe-TiC	500/400	20/14	In a body	0.55	0.46
2	Fe-TiC	400/300	20/14	In a body	0.54	0.48
3	Fe-TiC	180/100	20/14	In a body	0.44	0.49
4	Fe-TiC	500/400	40/28	On surface	1.09	0.44
5	Fe-TiC	400/300	40/28	On surface	0.51	0.58

6	Fe-TiC	180/100	40/28	On surface	0.47	0.59
7	Polymer-TiC	500/400	40/28	On surface	0.49	0.58
8	Polymer-TiC	400/300	40/28	On surface	0.27	0.62
9	Polymer-TiC	180/100	40/28	On surface	0.36	0.45
10	Polymer-TiC	500/400	20/14	In a body	0.44	0.64
11	Polymer-TiC	400/300	20/14	In a body	0.23	0.68
12	Polymer-TiC	180/100	20/14	In a body	0.58	0.61
13	Fe-NbC	500/400	40/10	In a body	0.45	0.60
14	Fe-NbC	300/200	40/10	In a body	0.49	0.28
15	Fe-NbC	200/180	40/10	In a body	0.60	0.46
16	Fe-NbC	100/40	40/10	In a body	0.31	0.61

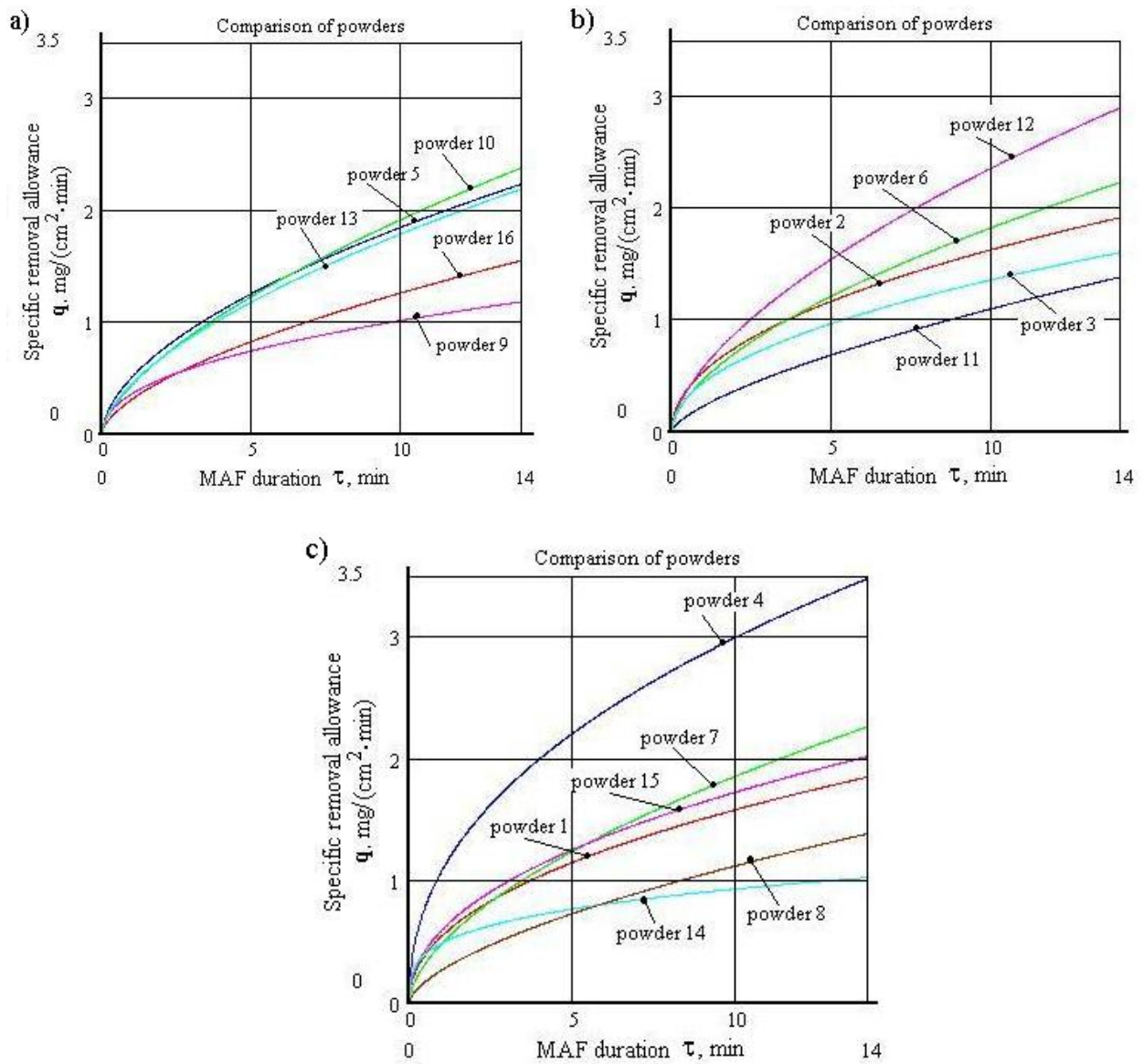


Fig. 3. The dependences $q = q_1 \cdot \tau^m$ for the compared powders

Parameters q_1 and m allowed to analyse the results of tests of powders and to discover the most interesting of them for a following experiments on deburring by the same method. The influence of a structure of the powders is shown on the table 2 and figures 4 and 5. Here we compared the powders with the same: $\nu = 500/400 \mu\text{m}$, $\lambda = 20/14 \mu\text{m}$, and location of abrasive particles in a body of a grain. The highest productivity was shown by the powder Fe-TiC, and the highest life – by the Polymer-TiC.

Табл. 2.

A structure of powder	Initial productivity $q_1, \text{mg/cm}^2\text{min}$	Exponent m
Fe-TiC	0.55	0.46
Polymer-TiC	0.44	0.64
Fe-NbC	0.45	0.60

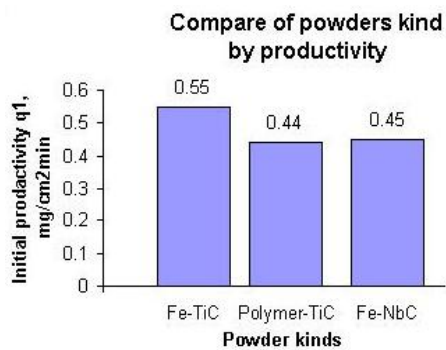


Fig. 4

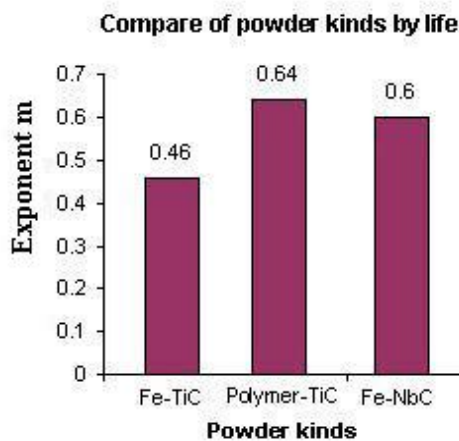


Fig. 5

Табл.3.

Sizes of grains (the powder Fe-TiC, $\lambda = 20/14$)	Initial productivity $q_1, \text{mg/cm}^2\text{min}$	Exponent m
500/400	0.55	0.46
400/300	0.54	0.48
180/100	0.44	0.49

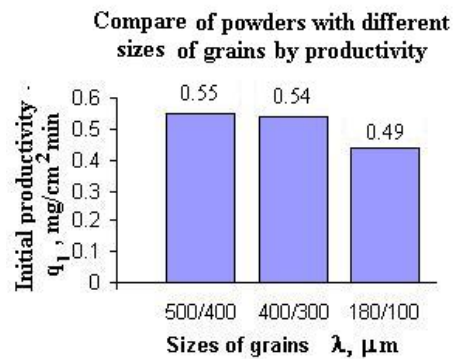


Fig. 6

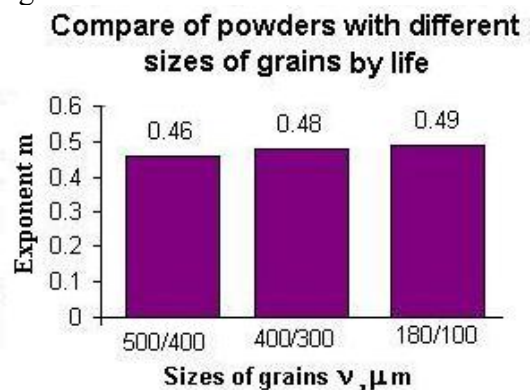


Fig. 7

Influence of the grains sizes is shown on the table 3 and figures 5 and 6. The powder Fe-TiC ($\lambda = 20/14 \mu\text{m}$, and location of abrasive particles in a body) was selected for this comparison. It is seen, that the powders have the same life, but their initial productivity is decreased as far as their grains are decreased too.

We were to use the powders where the location abrasive particles and their location on the grain of a powder had been different in the same time. The influence of both named courses together is shown on the table 4 and figures 8 and 9.

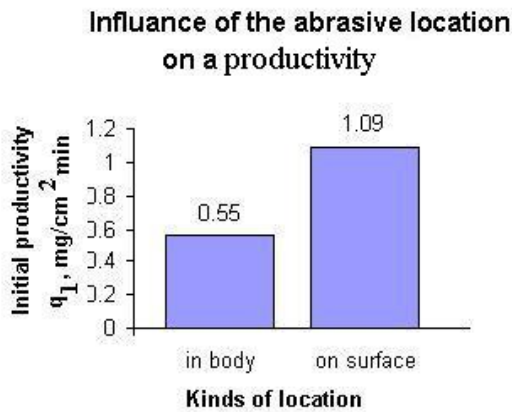


Fig.8

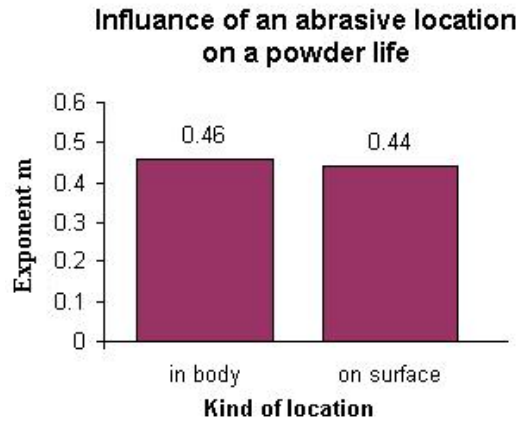


Fig.9

The location of abrasive particles on a surface of a composite grain increases the initial productivity in two times, but the life of portions of these powders was almost the same in both cases.

Deburring of micro burrs by method MAF

The powders of three structures were selected for the experiment of deburring of micro burrs on the base of the tests above: #4 Fe-TiC, #7 Polymer-TiC, #13 Fe-NbC. They had the same sizes of composite grains - $v=500/400 \mu\text{m}$. The selected powders differ from other ones by their higher initial productivity or higher life. The holes with diameter 3 mm were drilled on steel samples for the experiment by such kind, in order they could be located in section "c" of worked surface (see fig.10). Each row of the holes has its own duration of finishing during the each motion of the machine table (tab.4). The procedure of deburring is the same as in previous experiment. The feed is equal 127 mm/min.

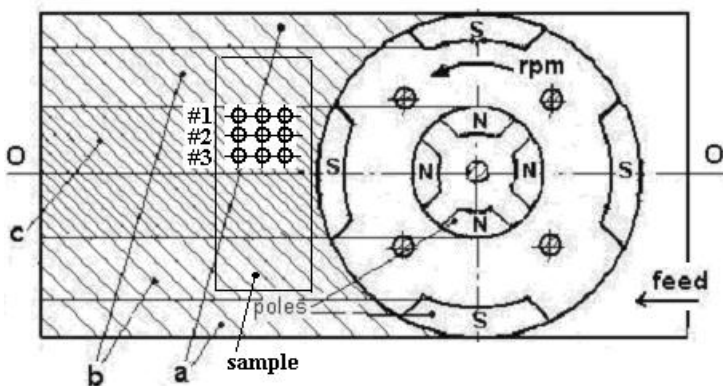


Рис.10

Табл.4

The number of holes row	The number of the table motions used in the experiment		
	1	3	7
	The real duration of deburring τ , seconds		
1	13	39	91
2	20	60	140
3	10	30	70

References

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3. Yu. M. Baron. 1.Yu. Baron. Technology of abrasive finishing in the magnetic field. - Leningrad, 1975, 128p. (Rus)
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Powder #4

Row #1	τ, c	Row #2	τ, c	Row #3	τ, c
0.133	0	0.139	0	0.161	0
0.010	13	0.014	20	0.022	10
0	39	0.001	60	0.004	30
0	91	0	140	0	70

Powder #7

Row #1	τ, c	Row #2	τ, c	Row #3	τ, c
0.159	0	0.180	0	0.056	0
0.051	13	0.068	20	0.010	10
0.018	39	0.029	60	0	30
0	91	0	140	0	70

Powder #13

Row #1	τ, c	Row #2	τ, c	Row #3	τ, c
0.143	0	0.135	0	0.145	0
0.041	13	0.024	20	0.047	10
0.016	39	0.005	60	0.007	30
0	91	0	140	0	70

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6. S-L Ko
7. Yu. M. Baron. 1.Yu. Baron. Technology of abrasive finishing in the magnetic field. - Leningrad, 1975, 128p. (Rus)
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За один ход стола под магнитным индуктором кромка каждого отверстия в ряду №1 находилась под воздействием магнитно-абразивного порошка 13 с, в ряду №2 – 20с, в ряду №3 – 10с.

Табл.4 The number of holes row	The number of the table motions used in the experiment		
	1	3	7
	The real duration of deburring τ , seconds		
1	13	39	91
2	20	60	140
3	10	30	70

Число ходов стола	1	2	4
№ ряда отверстий	Реальная длительность удаления заусенцев, с		
1	13	39	91
2	20	60	140
3	10	30	70

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9. S-L Ko
10. S-L Ko
11. Yu. M. Baron. 1.Yu. Baron. Technology of abrasive finishing in the magnetic field. - Leningrad, 1975, 128p. (Rus)
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0.016	39	0.005	60	0.007	30
0	91	0	140	0	70

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