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Improvement of metal removal rate efficiency in vibration polishing (finishing processes)

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***Abstract*— The purpose of this study is to investigate the intensity of metal removal rate and surface finish on vibration machining of partitioned working chamber. The article presents the results of studies of metal removal rate and surface finish in different compartments of divided working chamber (partitioned in different sizes) of vibration machining. Experimental studies were carried out on a vibration machine model УВГ- 40, with a divided compartments of working chamber of the total volume 40 dm3 by using working medias of PT 15X15 with a regime of vibration: A = 3 mm; f = 33 Hz and by using a processing liquid – 1.5% solution of soda ash. The prepared samples (for each types of operations 5 samples) were placed in a working chamber of different compartments (compartments differ in size as indicated below in the fig. 1. with a division of partitioned walls) and processed accordingly for 30, 60, 90 minutes. After each treatment in different compartments, the metal removal rate Q, in g, and the surface roughness Ra, in µm, were measured by means of analytical weight AD-200 and surface roughness measuring tester SJ-210 consecutively. Samples are steel 45 and aluminum alloy AVT-1 with cylindrical shapes, steel 3sp and duralumin D16 with plate shapes. As indicated in the given below tables and chart the average metal removal rate and surface roughness varies in the processing of different compartments of the working chambers. The presented research results show that as the size of the compartment in the working chamber decreases, the metal removal rate increases and the surface roughness improves. This study was conducted in Don State Technical University (DSTU) in Rostov on Don, Russia.**

***Index Terms*— vibration processing; vibrational technology; vibration machining; working chambers; working medium; processing liquid.**

I. INTRODUCTION

The concept of "vibrational technology" appeared in the 1970s as a consequence of the development of vibration processing method, which in its content significantly differs from traditional methods of processing and characterized by a higher efficiency of productivity as well as environmentally friendly processing technologies [1].

Depending on the nature of the processing working medium, the process of metal removal rate (very small particles at a time) and its oxides on the surface of specimens or machine parts can be classified as a mechanical or chemical-mechanical treatment. Smoothing surface

rughnesses on the surface of specimens or machine parts takes place by plastic deformation.

Further improvement of the process and development of the vibrational technology can be considered as one of the universal finishing methods which have get its intensification and expansion as important methods of finishing processes.

Increasing the intensity of vibration processing is done with the changing of the parameters of the interaction processes of the working medium and specimens or machine parts in order to:

1. eliminate areas of low processing efficiency in the working chamber;
2. ensure the uniformity of processing parts of complex shapes;
3. improve surface quality and performance of machine parts;
4. increase the productivity of the process.

The intensity of metal removal rate during vibration machining depends on the intensity of mechanical, chemical-mechanical impact and the property of the material [1,2,3,4,5,6,7,8,9]. Generalized empirical equation proposed to determine the specific metal removal rate depending on various parameters:

$$q = 3{,}8 \cdot A^{1.25} \cdot HB^{-0.91} \cdot K_n \cdot K_з \cdot K_G \cdot K_d \cdot K_V, \frac{kg}{s}, (1)$$

Where *A* - is the amplitude of the vibration;
HB - hardness of the processed material;
K_n - coefficients reflecting the influence of the frequency of vibrations;
$K_з$- granularity of abrasive granules;
K_G - mass of the processing material;
K_d - granulation of the processing medium;
K_V - loading volume of the working chamber, respectively (from the tables).

The working chamber is the basic element of the machine, which determines the features of the process. By changing the shape of the working chamber, introducing additional elements (for example, intensifiers) and changing its orientation relative to the exciter (drive) it is possible to influence the intensity of the process and its results.

Below indicated figure of working chamber shows the intensification of the process due to more efficient use of transmission of vibrations to the working medium from the structural elements (walls) of the working chamber (Fig. 1.).

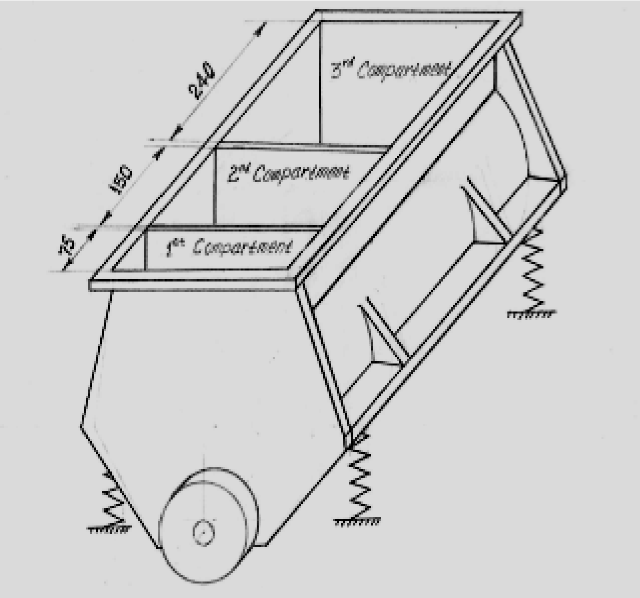


Figure 1. Experimental working chamber

Formulation justification of such a problem can serve as a well-known equation characterizing the change in the particle velocity of the working medium as it moves away from the walls of the working chamber [10].

$$V_{vwm} = V_{wc} K_v \ldots \ldots (2)$$

Where V_{wc} - is the speed of the working chamber;

$$K_v = a^l = 0{,}9877^l \ldots \ldots (3)$$

K_v- is the coefficient of particles velocity loss of the working medium as they move away from the walls of the working chamber, depends on the elastic-dissipative properties of the working medium.

a - is a constant;

l- distance from the walls of the working chamber, mm;

II. Materials and Methods

In this study the intensity of metal removal rate tested on vibrational machine type УВГ - 40 by taking four types of metals with different shapes (steel 45 and aluminum alloy AVT-1 with cylindrical shapes, steel 3sp and duralumin D16 with plate shapes) and five samples for each operations or tests. After each operation the intensity of metal removal rate measured by using analytical balance type АД-200г and surface roughness measured by surface roughness measuring tester SJ-210.

III. Results and Discussion.

Below tabulated data's & charts shows how the intensity of metal removal rate and surface roughness varies in different compartment sizes of working chamber as indicated in figure 1. of vibration machining. The vibration machining takes place by using working mediums of PT 15X15 with a regime of oscillation: A = 3 mm; f = 33 Hz; processing time 30, 60, 90 minutes; by using a processing liquid – 1.5 % solution of soda ash.

Table 1. Average metal removal rate in different compar-tments of working chamber after 30 min. processing.

Operation position	Type of material	Av. mass of samples before operations in g.	Av. mass of samples after operations in g.	Average mass of metal removal in g.
1st Compart.	St. 3sp	2,30,402	2,29,815	0,0587
	St. 45	3,12,220	3,11,750	0,0470
	D16	93,293	93,166	0,0127
	Al. AVT-1	1,02,752	1,02,624	0,0128
2nd Compart.	St. 3sp	2,32,180	2,31,836	0,0344
	St. 45	3,14,137	3,13,850	0,0287
	D16	74,083	74,021	0,0062
	Al. AVT-1	1,02,954	1,02,844	0,0110
3rd Compart.	St. 3sp	2,37,105	2,36,875	0,0230
	St. 45	3,04,958	3,04,731	0.0227
	D16	74,953	74,898	0,0055
	Al. AVT-1	1,01,894	1,01,831	0,0063

Table 2. Average metal removal rate in different compar-tments of working chamber after 60 min. processing.

Operation position	Type of material	Av. mass of samples before operations in g.	Av. mass of samples after operations in g.	Average mass of metal removal in g.
1st Compart.	St. 3sp	2,30,630	2,29,645	0,0985
	St. 45	3,12,220	3,11,296	0,0924
	D16	93,293	93,071	0,0222
	Al. AVT-1	1,02,752	1,02,369	0,0383
2nd Compart.	St. 3sp	2,32,510	2,31,615	0,0895
	St. 45	3,14,137	3,13,430	0,0707
	D16	74,083	73,940	0,0143
	Al. AVT-1	1,02,954	1,02,640	0,0314
3rd Compart.	St. 3sp	2,37,321	2,36,735	0,0586
	St. 45	3,04,958	3,04,433	0,0525
	D16	74,953	74,790	0,0163
	Al. AVT-1	1,01,894	1,01,687	0,0207

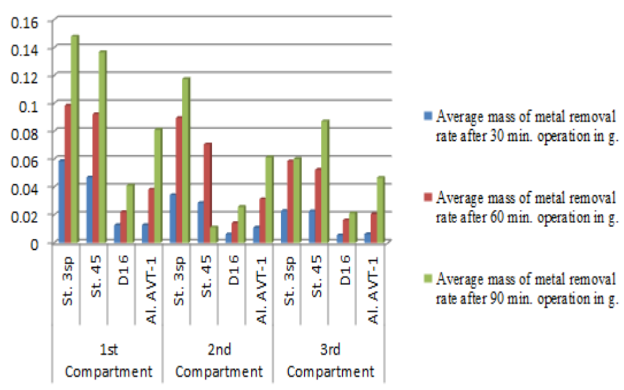
Table 3. Average metal removal rate in different compartments of working chamber after 90 min. processing.

Operation position	Type of material	Av. mass of samples before operations in g.	Av. mass of samples after operations in g.	Average mass of metal removal in g.
1st Compart.	St. 3sp	2,30,927	2,29,447	0,1480
	St. 45	3,12,220	3,10,852	0,1368
	D16	93,293	92,881	0,0412
	Al. AVT-1	1,02,752	1,01,941	0,0811
2nd Compart.	St. 3sp	2,32,610	2,31,435	0,1175
	St. 45	3,14,137	3,13,021	0,1116
	D16	74,083	73,825	0,0258
	Al. AVT-1	1,02,954	1,02,340	0,0614
3rd Compart.	St. 3sp	2,37,224	2,36,622	0,0602
	St. 45	3,04,958	3,04,086	0,0872
	D16	74,953	74,740	0,0213
	Al. AVT-1	1,01,894	1,01,430	0,0464

Table 4. Average surface roughness in different compartments of working chamber after 30, 60 and90 min. processing.

Operation position	Type of material	Av. surface roughness of samples before operations in µm.	Av. surface roughness of samples after 30 min. operations in µm.	Av. surface roughness of samples after 60 min. operations in µm.	Av. surface roughness of samples after 90 min. operations in µm.
1st Compart.	St. 3sp	1.929	12,917	12,667	0,9311
	St. 45	19,160	13,422	13,184	12,664
	D16	20,256	20,220	18,215	14,304
	Al. AVT-1	24,558	16,558	13,433	11,536
2nd Compart.	St. 3sp	19,740	13,620	12,555	0,9514
	St. 45	18,983	14,748	13,235	10,956
	D16	22,110	13,285	11,905	0,7734
	Al. AVT-1	19,450	15,103	11,605	99,655
3rd Compart.	St. 3sp	17,585	13,032	12,350	10,563
	St. 45	17,210	13,030	13,713	13,211
	D16	26,345	14,390	13,520	0,8892
	Al. AVT-1	23,110	15,802	13,113	12,299

Figure 2. Experimental results of vibration polisihing in different compartments of working chamber



IV. Conclusion

As indicated in the above tabulated results and chart average metal removal rate increases in the case of decreasing the working chambers width but the total productivity of working chambers decreasing due to less amount of specimens processing at a time. Surface roughness also improving in the case of decreasing width of working chambers. Mass of the samples has a great effect on the metal removal rate.

This study contains certain limitations and can be further developed concerning to the actual results in future research. In the operation of vibration polishing the movement of specimens greatly affected due to weight variation and low weight specimens becomes sticky to the walls, this affecting the proper circulation of the specimens and leading to irregular results. To get regular results it is necessary to take more uniform weights throughout the experiments.

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