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The Change of Metal Removal Rate and Surface Finish on Vibration Machining.

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Abstract

The purpose of this study is to investigate the change of metal removal rate and surface finish on vibration machining in different period of vibration machining on the same materials. This study was conducted in Don State Technical University (DSTU) in Russia. Below tabulated results show that metal removal rate decreases even if we are increasing operational time after the 1st work and surface finish continuously improving on vibration machining.

Keywords: vibration machining; working medium; micro-impact; abrasive granules.

I. Introduction

The concept of "vibration technology" appeared relatively in recent 60s, as a consequence of processes that used vibration exposure in engineering, construction, mining and other industries [1]. There was this notion among professionals working in this field to use low-frequency oscillation spectrum. It reflects the processes based on the use of vibration as acting directly on the object of processing, and (usually) to the processing medium and tools of various characteristics.

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General physical nature of the processes of vibration technology (VT) is quite complex and is associated with phenomena such as shock, cavitation, abrasion, multiple interaction of objects to be treated, the wave processes (the inter-action of shock waves with the material or medium), adhesion phenomena, and others. VT is based on such fundamental areas of physics, acoustics, shock and impact phenomena, oscillations and waves, molecular acoustics. Despite the starting (initial) of common processes based on the use of vibrations at various levels of technological research, vibrations were divided into three separate sections: infrasound (frequency f up to 10 Hz), low-frequency vibrations (f = 15-100 Hz), ultrasound (f over 1000 Hz) [1,2].

One of the important tasks of modern machining technique is to improve quality of products, increase productivity, as well as their competitiveness in the global market. To solve such problems and developing new methods, it is better to find new ways and treatments time to time. Vibration technology (VT) is nowadays one of the important machining operations for complex shape specimens and high quality surface finishing [3]. Finishing operation by using an abrasive treatment and fixed abrasive processing for simple shape parts are commonly used methods (grinding, honing, lapping, etc.). Vibration treatment, centrifugal rotary processing and turbo abrasive machining are new technologies for parts of complex forms. Methods allow combining high performance processing with high quality surface finishes for complex configuration parts. They are simple in construction equipment. Depending on the shape of the specimens can be determined the best or the worst access of contact with the particles to the different working medium. The most intensive processing occurs at sharp edges, protruded exposed surfaces, cylindrical and spherical outer surfaces. Processing in hidden pockets, holes, grooves and narrow depths occur slower and require more careful selection of the particle sizes and shapes of the working particles.

Metal removal rate in vibration machining mainly depends on the following main parameters [1,4]: vibration mode, the length of treatment, the particle size, characteristics of the working medium, the volume of the working chamber, the degree of filling, and the mechanical properties of the specimens. Among other parameters of vibration machining (VM) intensity factors are:

- the force of impact (micro-impact),
- the characteristic of the manufacturing medium,
- character of the movement (trajectory) of the working chamber,
- the working medium speed and acceleration,
- force of micro-impact,
- contact pressure, stress,
- temperature encountered in the area of the micro-impact,
- average temperature and pressure in the working chamber.

The numerical values of these parameters are as follows: velocity of the particles medium can reach 0.5 - 1 m/s; acceleration of 20 - 150 m/s^2, the power micro- impact 1.5 - 3 kg arising from this contact pressure can reach 700 - 1500 kg/mm^2, the average temperature in the chamber is typically less than 30 - 40°C [5]. The intensity of the process is evaluated principally by removal of material per unit of time depends on many factors. With the increase of the amplitude of the vibration, the metal removal process grow, due to the higher forces of micro-impact particle path length wise and the impact of their activities on the surface. When we increase the amplitude for the same period of time, working medium pass relatively large path on the specimens [6].

Mechanical properties of the material of specimens have significant effect on the metal removal rate in the following processes such as in grinding, polishing, deburring and rounding of sharp edges. Hardness (HB), and ductility (δ %) affects the intensity of metal removal rate and surface finish quality. With the increase in the hardness of the processed material, processing rate decreases. At the same hardness with increasing plasticity metal removal decreases. For example, when changing the HB from 30 to 450, respectively, of the metal removal is reduced from 2.07 to 0.19 g[1,4]. When hardness increasing, relatively decreasing metal removal rate due to the large resistance of the abrasive grains in the introduction of the metal.

The ratio of specimens and abrasive media affects the amount of metal removal rate. The fewer the specimens in a given volume of abrasive, the greater will be the removal rate of metal.

The change in metal removal rate occurs in the case, when the change in the filling of the working chamber increase. The increase in the fill of the working chamber to a certain limit (2/3 the volume of the working chamber) improves metal removal rate [7,8]. This is due to the abrasive layer height growth, which in turn increases its pressure on the specimens and abrasive granules, particularly at the moment when the latter are in the bottom of the working chamber.

2. Materials and Methods

The change of metal removal rate tested on vibrational machine type УВГ 40 by taking two types of metals (steel 45 and aluminum alloy 2024), by taking 9 amount of samples in each case and processed by using different working mediums. The metal removal rate and surface finish quality measured after each operation by using analytical balance type АД-200г and surface quality tester SURFTEST SJ 210. The vibration machining takes place in different working medium to observe the amount of metal removal rate and surface finish quality in details. The type of specimens, measuring devices, working mediums and type of vibrational machineУВГ 40 indicated below.

Figure 1: Steel and aluminum samples.

Figure 2: Working mediums.

Figure 3: Analytical balance and surface quality tester.

Figure 4: Vibrational machine type УВГ 40.

3. Results

Below tabulated data's shows how the change of metal removal rate and surface finish varies in different period of vibration machining. The machining processes checked and relevant measures taken after each works. The vibration machining takes place in different working medium with a regime of oscillation: A = 3 mm; f = 30 Hz; processing time = 2, 4, 6 hrs; by using a processing liquid - 3% solution of soda ash. Sample materials are steel 45 and aluminum alloy 2024. All specimens are used for the next operations again after taking relevant data.

These above indicated results in the tables are done in Don State Technical University (DSTU). The first table 1 are tested by using ball type working medium with D =15 mm on vibrational machine type УВГ 40. The second table 2 is tested by using cone type working medium with 20 x 20 and the third table3 are tested by using cone type working medium with 30 x 30 mm on vibrational machine type УВГ 40.

Table 1

Type of materials & № of samples		**Input parameters**		**In the 1st 2 hrs work**		**In the 2nd 4 hrs work**		**In the 3rd 6 hrs work**	
		Av. m,g.	Av. Ra,MKM	Av. removed mat. in g.	Av. Ra,MKM	Av. removed mat. in g.	Av. Ra,MKM	Av. removed mat. in g.	Av. Ra,MKM
St. 45	9	11.8450	2.76	0.0388	1.02	0.0376	0.93	0.0336	0.75
	9	11.7652	3.56	0.0384	0.84	0.0350	0.64	0.0334	0.25
Al	9	9.8216	3.26	0.0654	1.76	0.0552	1.78	0.0512	1.61
	9	9.7368	3.13	0.0634	2.00	0.0550	1.77	0.0556	1.62

Table 2

Type of materials & № of samples		**Input parameters**		**In the 1st 2 hrs work**		**In the 2nd 4 hrs work**		**In the 3rd 6 hrs work**	
		Av. m,g.	Av. Ra,MKM	Av. removed mat. in g.	Av. Ra,MKM	Av. removed mat. in g.	Av. Ra,MKM	Av. removed mat. in g.	Av. Ra,MKM
St. 45	9	9.6838	3.62	0.0386	2.13	0.0292	1.99	0.0270	0.88
	9	9.5548	2.12	0.0352	1.80	0.0294	1.92	0.0266	1.44
Al	9	11.6258	2.03	0.0206	1.69	0.0156	0.80	0.0116	0.54
	9	11.5928	2.02	0.0210	1.69	0.0154	0.97	0.0118	0.64

Table 3

Type of materials & № of samples		**Input parameters**		**In the 1st 2 hrs work**		**In the 2nd 4 hrs work**		**In the 3rd 6 hrs work**	
		Av. m,g.	Av. Ra,MKM	Av. removed mat. in g.	Av. Ra,MKM	Av. removed mat. in g.	Av. Ra,MKM	Av. removed mat. in g.	Av. Ra,MKM
St. 45	9	9.5586	2.63	0.0420	2.15	0.0312	1.73	0.0342	1.75
	9	9.4316	2.08	0.0402	1.84	0.0306	1.83	0.0344	1.98
Al	9	11.5544	2.91	0.0364	1.74	0.0252	1.62	0.0240	1.34
	9	11.5170	2.88	0.0269	1.46	0.0243	1.23	0.0240	1.11

4. Conclusion and Recommendation

As indicated in the above tabulated results, that metal removal rate decreases even if we are increasing operational time after the 1st work of operation and surface finish continuously improving on vibration machining. As previously indicated metal removal intensity depends on so many parameters as well as its surface quality and hardness (HB). In the processes of vibrational machining likewise other cold working processes hardness (HB) increasing after treatment or operations. But the amount of hardness change negligible. In the above operations surface quality highly affecting the amount of metal removal rate. These mentioned mechanical property changes decreasing metal removal rate on the surface of metals. As we have seen from tabulated data's in case of vibration machining the outcome of vibrational machining processes not depends on the amount of operating hours due to the improvement of surface quality after the 1st operation. As we see in the cases of the 1st operation results the amount of metal removal rate are high and decreasing further drastically, so in such operations we have to remark and follow such considerations in designing vibration machining.

This study contains several limitations and can be further developed concerning to the actual results in future research. In the operation of vibration machining the movement of specimens random throughout the working chamber due to this the effect of metal removal rate varies from operation to operation, because of its intensive factor differences:

1. Pressure varies in different positions of the working chamber;

2. Working medium quality;

3. Type, concentration and circulation rate of fluid used in the working chamber and others.

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