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Experimental Study of Surface Roughness in Vibro-impact Cutting of Optical Slugs

Angel Lengerov
Department of Mechanical Engineering and Technologies
Technical University of Sofia, Plovdiv Branch
Plovdiv, Bulgaria
email anlen@tu-plovdiv.bg

Sabi Sabev
Department of Mechanical Engineering and Technologies
Technical University of Sofia, Plovdiv Branch
Plovdiv, Bulgaria
email s-tu@abv.bg

Stoyan Paliiski
Department of Mechanical Engineering and Technologies
Technical University of Sofia, Plovdiv Branch
Plovdiv, Bulgaria
email st.paliyski@abv.bg

Abstract. **In the article, experimental studies were carried out with the aim of determining the influence of different modes of vibro-impact cutting modes of optical slugs on the roughness of obtained surfaces. From the results obtained during the measurements and their mathematical processing are evaluated the average sizes and intervals and the parameters of the roughness of treated surfaces.**

Keywords: roughness, surface, experimental, study, optical slug.

I. INTRODUCTION

One of the conditions for reducing the basic losses and increasing the value of the finished product is ensuring high surface quality of the optical materials, processed by cutting [1,3,10,14]. The primary task of this paper is the comparative assessment of the surface roughness, obtained both during traditional cutting and in vibro-impact cutting of optical slugs.

II. EXPERIMENTAL DETERMINATION OF SURFACE ROUGHNESS

To determine the degree of influence of the forced vibrational oscillations on the roughness of the cut workpiece, it is necessary to study the mechanism of forming the microgeometry of the processed surfaces [2,4,5,6,7,8,9,11,12,13]. Due to the mechanical interaction of the peripheral (cutting) surface of the cutting diamond disc and the workpiece, separation of particles from the processed material begins. In result, at the starting moment, micro-irregularities appear and initial roughness of the surfaces is formed.

When the disc goes into the processed workpiece, as a result of the arising friction of the surfaces, contacting the cutting disc, improvement in roughness is observed in the cut parts. The nature of the roughness change depends on: - the dominant type of wear in the frictional surface; - the conditions of friction and the duration of interaction of the side surfaces of the cutting disc and the machined workpiece.

The section of the cut surface of the workpiece, located at the beginning of the cutting disc, is subject to maximum wear over the duration of the friction, and the section at the exit of the cutting disc – to minimum wear.

The effect of the interaction between the cutting disc and the workpiece under the different vibro-impact modes affects the way, in which the cutting process proceeds, which influences on the conditions of forming the microrelief of the processed surfaces. The quality of the surfaces of the workpieces, subjected to vibrational cutting, is determined by the degree of influence of the amplitude-and-frequency oscillations, transmitted to the workpiece, and by the degree of manifestation of the polishing effect.

A number of experimental studies have been carried out in order to evaluate the roughness parameters (R_a and R_z) of surfaces of optical slugs, cut by vibration. The experimental studies were carried out in three vibro-impact modes of processing (whose technological parameters are shown in Table 1), and the roughness parameters of the treated surfaces were measured.

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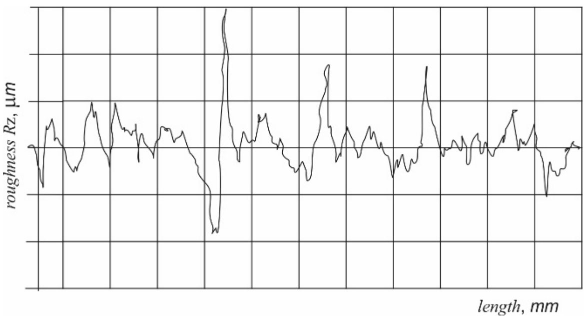
TABLE 1 BASIC PARAMETERS OF A CENTRIFUGAL VIBRATOR FOR THREE MODES OF CUTTING

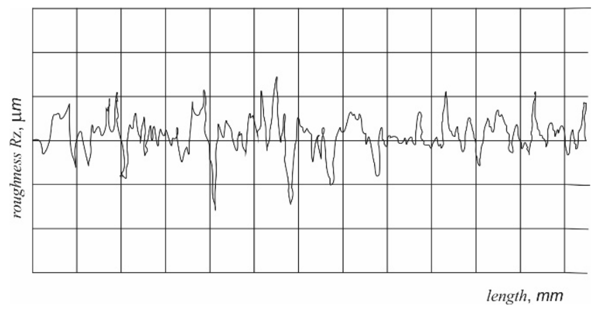
Mode of operation of the vibrator	Frequency of rotation of the electric motor shaft, min^{-1}	Frequency of vibration of the workpiece, Hz	Amplitude of vibration of the workpiece, μm	Amplitude of the vibrational velocity, m/min	Amplitude of the vibrational acceleration, m/s^2
1	2480	41,3	87,4	1,36	5,88
2	5110	85,2	32,4	1,04	9,28
3	6000	100	25,3	0,95	9,98

The measurements were made in a direction, perpendicular to the traces from the processing for all lengths from the diagonals of the sample. For all studied modes of optical slugs processing by cutting, profilograms of the sample surfaces were made, as shown in Fig. 1.

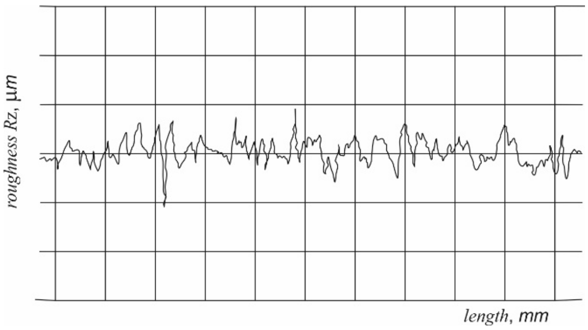
From the profilograms, taking into account the nature of the roughness height along the cut surfaces, the most expedient and optimal processing mode can be determined. Such modes (Fig. 1 c, d) prove to be the vibro-impact cutting modes 2 and 3. This is explained by the optimal combination of parameters, such as amplitude of vibrational velocity and amplitude of vibrational acceleration, primarily at a certain frequency of the forced oscillations.



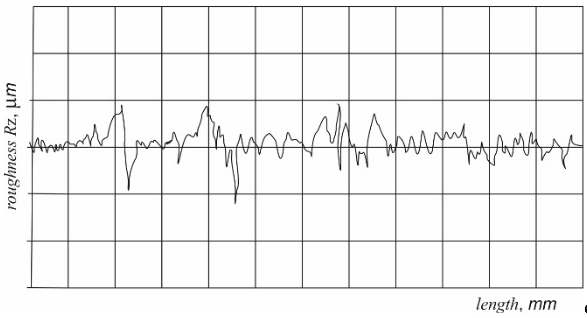
a)



b)



c)



d)

Fig. 1. Profilograms of the surfaces of the cut samples under different processing modes: a) traditional cutting; b) vibro-impact mode 1; c) vibro-impact mode 2; d) vibro-impact mode 3.

In order to clarify the degree of influence of the vibro-impact forced oscillations, implemented in the process of cutting optical slugs, the roughness parameters Ra and Rz of the machined parts of the optical samples were measured using a profilograph-profilometer. The obtained values of the Rz parameter are shown in Fig. 2.

The results of the measurements show that during vibro-impact cutting the quality parameters of the processed surfaces improve, compared to traditional cutting. The best quality was recorded for vibro-impact processing mode 2, worse for mode 3 and worst for mode 1. This is explained by the increased frequency of oscillations of the processed workpiece, which leads to a decrease in the time of dynamic impact of the single abrasive grains and the processed material of the workpiece.

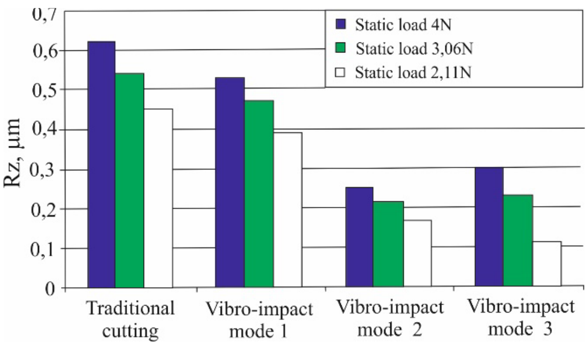


Fig. 2. Dependence of the parameter Rz of the cut surface of a brand BK7 optical workpiece on the processing mode under different static loads.

As the static load increases, the value of the Rz parameter goes up, both under normal conditions and under the influence of forced oscillations. This is due to an increase in the pressure in the contact zone between the cutting surface of the disc and the workpiece, which leads to an increase in the separation of particles from the diamond cutting disc and the cut material. The roughness of the cut surface of the sample deteriorates. In addition to taking into account the value of the parameter R_z, measurements of the parameter R_a were also made, depending on the technological and vibrational parameters of the processing (Table 2). Vibro-impact mode 1 proved to be the most favorable. Deterioration of the roughness was observed in vibro-impact modes 2 and 3, which makes them impractical for implementation.

TABLE 2 VALUES OF THE R_A PARAMETER OF THE CUT SURFACE OF THE OPTICAL SLUG

Processing mode		**No vibration**	**Vibro-impact mode1**	**Vibro-impact mode2**	**Vibro-impact mode3**
		Values of the parameter Ra (μm)			
Static load, *N*	4	0,098	0,045	0,049	0,064
	3,06	0,078	0,028	0,03	0,041
	2,11	0,06	0,01	0,02	0,03

The influence of the amplitudes of the vibrational velocity and the vibrational acceleration on the value of the parameter R_z are reflected in Fig. 3., a and b.

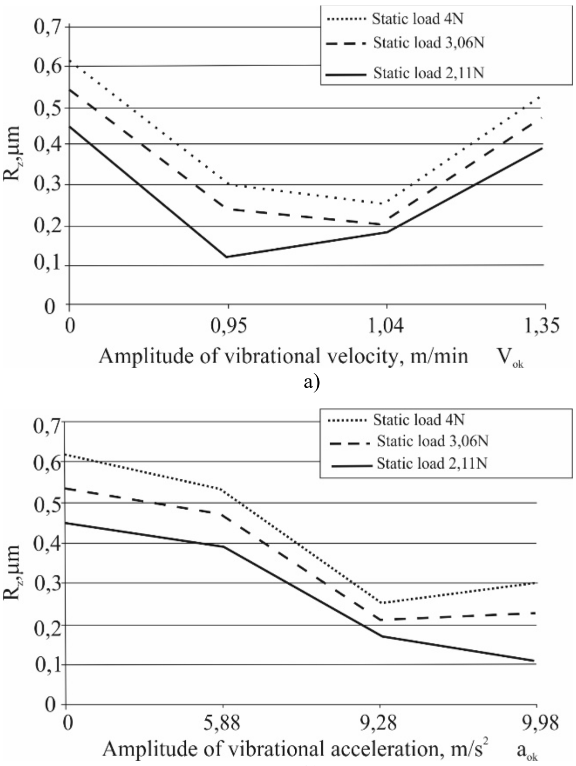


Fig. 3. Dependence of the parameter Rz μm of the optical slugs cut surfaces at different values of the static load: a) on the amplitude of the vibrational velocity; b) on the amplitude of the vibrational acceleration.

It can be seen from the Fig.3, that with an increase in V_{ok} and a_{ok}, the value of the R_z parameter decreases and reaches a minimum value at V_{ok} - $0,95 - 1,0 \;\; m/min$ and a_{ok} - $9,28 - 9,3 \;\; m/s^2$, while with a further increase in V_{ok} and a_{ok} the value increases. This indicates the existence of an optimal value of and, ensuring minimum values of the parameter R_z of the cut surface. From Fig.3 it can be seen, that the reduction of the static load value from 4 *N* to 2,11 *N* leads to improvement in machining quality, which is explained by the decreased introduction of small-sized abrasive grains into the workpiece material in the cutting zone. At the same time, the sharp decrease in the roughness affects the increase in the frequency of forced oscillations in mode 3, which causes additional polishing, due to the friction of the cut surface of the workpiece with the side surfaces of the cutting disc.

III. CONCLUSION

On the basis of the experimental studies, carried out both during vibro-impact and traditional cutting of optical slugs, it was established, that in the process of vibro-impact cutting the quality indicators of the surface roughness improve. This is explained by the additional friction between the side surfaces of the cutting diamond disc and the cut surfaces of the optical workpieces. The periodic separation of fine optical particles, caused by the oscillating vibro-impact cutting system, further contributes to improvement of the working conditions.

IV. ACKNOWLEDGMENTS

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