THE USE OF VIBRATORY TUMBLING TO PRODUCE A SMOOTH SURFACE FINISH ON SPROCKET WHEELS

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Abstract

The foregoing thesis presented different viabilities of the vibratory tumbling as a processing of the finishing surface of sprocket wheels. The sprocket wheels were EN AW 2017A aluminum of alloy and they were made with the method of machining. One of sprocket wheels was subjected to a vibratory tumbling in the device Superminor SMR-D-120 of the ROLLWASH company. There were also ceramic fittings used in that process. A possibility of applying the vibratory tumbling for removing burrs, discolorations and rounding off sharp edges of sprocket wheels was being analysed. The analysis of the results (macrophotographies of the details of sprocket wheels and the achieved results of the 3D surface roughness) indicate that the vibratory tumbling achieved its earlier presented goals and it can be applied to process sprocket wheels.

Keywords: Vibratory tumbling, surface roughness, smooth surface, deburring

1. INTRODUCTION

The fine machining of produced elements, for example, in the automotive industry is an extremely important element of the technological process. If the surface of elements of motor vehicles is wrought appropriately, it has got significant influence on the product lifespan and the failure-free usage of the vehicle. In addition, sharp edges or the sharp remains of processed material (which might proceed as a result of machining) may cause cuts or damage to other parts maching with the element carried out. The development of the production technology of the machinery parts in which the traditional, manual machine tools are being replaced by numerical ones causes the necessity to search for solutions which enable fast and cheap finishing of the final product. The vibratory tumbling enables cheap and efficientfinishing processing of the product attained in the process like: milling or turning.

2. THE VIBRATORY TUMBLING

The vibratory tumbling is one of the finishing processing methods which enables to wrought a lot of elements in a single production cycle. It is mainly applied for removing burrs, rounding off sharp edges or for improving the parameters of the geometric structure of the surface [4]. The physics of this process comes down to the interplay between loose abrasive fittings and processed parts, which are placed in the vibratory tumbling container, along with the liquid which supports the process of finishing processing. Depending on applied fittings we distinguish two variants of the vibratory tumbling: removal machining with applied abrasive fittings and chipless machining, when the fittings which are smoothing the surface are acting as the factor causing plastic strains of rough peaks. The container of the vibratory tumbling is being set into the vibratory move with the intensified frequency of vibrations, thanks to which the interaction on the line of fitting is taking place- the workpiece.

3. THE RESEARCH OBJECT

The aim of this research is the possibility of the employment of the vibratory tumbling as a finishing processing of the component elements on the example of the valve train systems for engines. The subject of the study were sprocket wheels which were made with the method of machining. Those were the sample sprocket wheels which can be used in the automotive industry. Made sprocket wheels contained a lot of elements in their structure, such as drilled or milled holes. The sprocket wheels were EN AW 2017A aluminum of alloy [1]. The elements which were made with the method of machining (milling) contain many shortcomings which had influence on the final product. The defects which occurred on the elements, as result of the machining method were as follows: sharp edges and burrs, which may cause cuts among the employees who are working on the product. Moreover, these edges or burrs could lead to the damage of the belt in the drive belt, etc. Sharp edges, often after machining are rounding [2,3]. The sharp edges and discoloration incurred in the sprocket-wheels are presented in the picture (**Figure 1**). In addition, thermal influences and the influences of coolant, during the process of milling may lead to appearing of discolorations on the processing elements.

There are many methods of surface finishing processes some of them belong to the group conventional machining: grinding, mechanical polishing, suprefinishing [5,6], brushing [5] etc. and others belong to non-conventional: abrasive flow machining (AFM), electrochemical machining (ECM) [7], water jet cutting (AWJ), electrical discharge machining (EDM) or hybrid machining [8,9].

Another group of methods leads to surface quality improvement are methods related to the modification of its chemical composition [10,11,12,13].

Nowadays, many research centers conducts investigations the smoothing surface processes to increase its efficiency [14] or improve measurement or evaluations surface parameters methods.

Figure 1 Fragment of sprocket - the sharp edges and discoloration incurred in the sprocket wheel

4. THE RESEARCH

The sprocket wheel which was made with the method of machining, was subsequently subjected to the vibratory tumbling in the Superminor device SMR-D- 120 of the ROLLWASH company. The machine is presented in the picture (**Figure 2**). There were ceramic fittings used in the research. Additionally, there was a liquid used during the process, which facilitated the process of the vibratory tumbling. The frequency of vibrations during tests was 2.7 kHz. The time of the processing - 150 minutes. The choice of machine tools, applied in the industry in the vibratory tumbling, is usually made as a result of experimental attempts depending on the obtained effects. The applied vibratory tumbling aimed to remove the burrs which occurred as a result of milling, moreover, to round off sharp edges and to improve the reflectiveness (removing discolorations which appeared as a result of the influence on the local change of temperature and influences of coolant during the process of shape milling of received sprocket wheels).

Figure 2 Superminor device SMR-D- 120 of the ROLLWASH company [15]

As a result of conducted vibratory tumbling research, all the goals have been achieved. In the picture (**Figure 3**), there is presented the photography of a fragment of the sprocket wheel after completed vibratory tumbling. In this picture one can see that all the edges were blunted (rounded off).

Figure 3 The macrophotography fragment of sprocket wheel after vibratory tumbling

The surface of the sprocket wheel is characterized by scratches and the roughness. In order to compare the surfaces before and after the process of vibratory tumbling, pictures (**Figure 4a**) and (**Figure 4b**) shows those two surfaces.

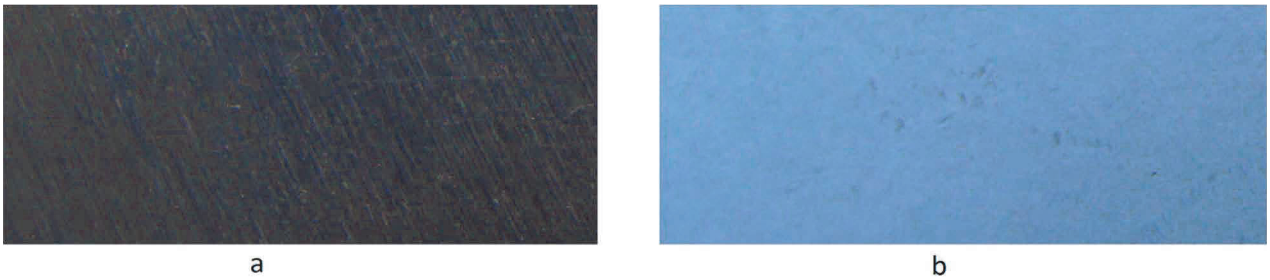

Figure 4 The macrophotography of the surface of the sprocket wheel:
a- after milling; b- after vibratory tumbling

This comparison shows that the vibratory tumbling had a beneficial impact on the surface of the sprocket wheel, because it removed the discolorations and changed the characteristics of the surface of the sprocket wheel.

The results of the measurement of 3D roughness of sprocket wheels before the vibratory tumbling and after the vibratory tumbling present in the **Table 1.**

Table 1 The summary of results of the measurement of 3D roughness of sprocket wheels before the vibratory tumbling and after the vibratory tumbling

	Sq, µm	Sp, µm	Sv, µm	Sz, µm	Sa, µm
Before the vibratory tumbling	0.4685	3.6608	3.7474	7.4082	0.3412
After the vibratory tumbling	0.7106	3.5495	7.6005	11.1499	0.5405

The parameters geometrical product specifications contained in **Table 1** and **Table 2** define according to ISO 25178. Sq parameter is the root mean square of surface roughness. Parameter Sz is the maximum height of the surface, and parameter Sv is the maximum cavity surface. Parameter highest peak area Sp is the difference between Sz and Sv. Sa parameter is defined as the arithmetic average surface height.

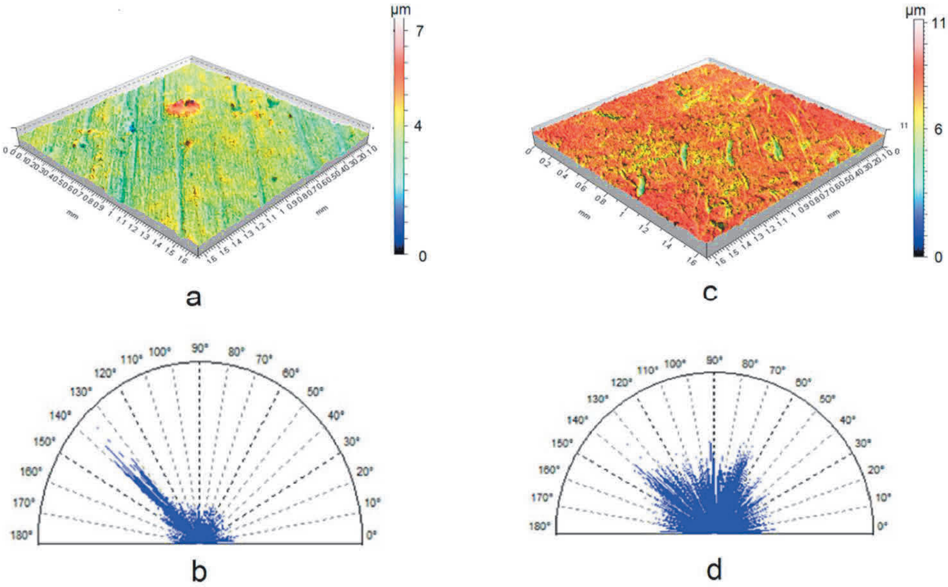

Figure 5 The summary of results of the measurement of 3D roughness of sprocket wheels: (a - profilogram, b - the chart of the directionality of roughness), the sprocket wheel before the vibratory tumbling, (c - profilogram, d - the chart of the directionality of roughness) the sprocket wheel after the vibratory tumbling

Analysing parameters of the geometric structure of the surface (measurement of 3D roughness) one can notice that the parameter of the roughness Sa after the vibratory tumbling has increased slightly from the value Sa = 0.3412 µm to the value Sa = 0.5405 µm. The measurement of the roughness also confirmed the change of the directionality of the geometric structure of the area from directional to random. The statement of results of measurements of 3D roughness was described appropriately for the sprocket wheel after the milling process in pictures (**Figure 5 a, b**) and for sprocket wheel after conducted vibratory tumbling in pictures (**Figure 5c, d**).

5. CONCLUSIONS

Analysing macrophotographies of details of elements after the machining - the milling and analysing those elements after vibratory tumbling, one can notice that the vibratory tumbling is fulfilling its role perfectly. Sharp edges after the vibratory tumbling were blunted and the discolorations were removed. Analysing the measurements of roughness one can observe that positive effects of the vibratory tumbling mentioned above, were obtained to the disadvantage of the roughness, which has dropped. The parameter of the roughness Sa did not fall radically, but only about 0.2 µm. During the analysis of the measurement of 3D roughness and the graph of directionality of the roughness, one can state that the vibratory tumbling beneficially changed the geometric structure of the surface from the directional roughness to random. The slight increase of roughness is compensated by the removal of discolorations as well as rounding off all the edges, even those which seemed to be hard to reach.

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