Design optimization of tumbling media for processing mining machinery parts

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Abstract. Traditionally, in any country, mining industry is a strategic sector of the economy, for the development of which a large amount of resources necessary for the production of modern mining equipment, machinery and mechanisms are allocated. In recent years, a steady trend of technical re-equipment of mining enterprises is noted. This measure allows improving labor productivity and increasing the depth of mining due to the modernization of the existing mining equipment and the introduction of the new one; key attention being paid to the quality and reliability of the equipment produced. The current situation of the domestic mining machinery manufacturing market clearly demonstrates a strong dependence on foreign suppliers. In this case, a competent approach to the issues of import substitution in the industry, providing for the development and production of competitive domestic mining equipment that meets all the requirements and expectations of consumers, is urgently needed. As a rule, manufacturers of mining equipment use the entire machinery manufacturing cycle, ranging from blanking and to product assembly. At all stages of manufacturing, it is necessary to follow part processing technology, providing for the assurance of the required surface roughness, surface layer properties and other quality indicators. All this can be provided by a promising method of part processing – tumbling.

1 Introduction

Essentially, tumbling is mechanical action of abrasive media on a surface of a part, as a result of which each part is 3D processed all over. Tumbling allows polishing, grinding and finishing the surface of a work piece after cutting, casting, forging, welding and machining operations [1].

Casts, forgings, weld billets, which must be descaled, deburred, descuffed and given the desired roughness, are widely used in the mining equipment part production [2, 3]. The requirements for casts, forgings, cut and machined parts are specified in the industry standard "Products of mining machinery manufacturing. General specifications". All these requirements are successfully met by tumbling.

When tumbling, quartz sand, basalt or granite are used as natural tumbling media, and fragments of grinding wheels are most often used as artificial ones. The conducted

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researches and the analysis of scientific literature and practice show that the tumbling media described above have some low operational capabilities [4, 5].

At the same time, works aimed at improving the grinding performance through the use of grains of a given shape, their orientation in the tool body, the development of new tool designs and their varieties, are known [6, 7].

Therefore, tumbling media, whose shape ensures maximum processing performance, are increasingly used in order to intensify the process and improve the quality of the processed workpieces. Consequently, the work aimed at the development and manufacture of tumbling media of a given shape is highly relevant and has good future prospects.

The tumbling technology performance depends on a number of factors, among which are the method and the processing mode, as well as design and operational features of tumbling media, which may be in the form of balls, cylinders, parallelepipeds, cones, tetrahedra, etc [8-10].

The shape of the tumbling media is selected in accordance with the required quality of a surface being processed and the shape of a part. It was experimentally established that it is advisable to use media that have the shape of a cone for polishing, removing small burrs from complex parts, as well as processing grooves, slots and holes. It is better to use media that have the shape of a sphere for polishing, removing large burrs on simple parts. The cylindrical shape of tumbling media proved to be the best for polishing and removing small burrs on simple parts.

In addition to the shape of tumbling media, the processing performance is also influenced by the material of which this media are made. For example, abrasive material, granite, fragments of grinding wheels are used for roughing. Steel balls, polishing lime, fine cut chrome-tanned leather, sawdust, etc. are used for polishing.

2 Methods and research

Considering the aforesaid, a tumbling body, which has wide versatility in processing parts of various shapes, was designed. The design of this body is shown in Fig. 1.

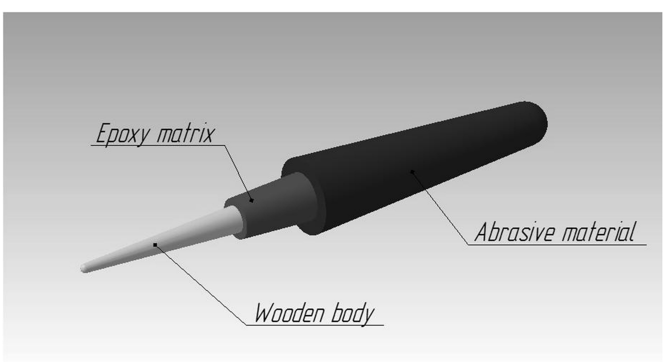

Fig. 1. Needle-shaped tumbling body.

The presented design has the following dimensions: length 10-25 mm, width - 3 mm, height - 3 mm.

The proposed needle-shaped tumbling media can be successfully applied in processing parts that have internal corners, small bending radii, narrow pockets, deep holes and other hard-to-reach places.

Tumbling bodies contain in their structure two different materials. Wood chips, which are waste production of chipboard, are used as core elements. Epoxy resin is used for binding a wood core and grinding grains. The proposed design is made of readily available materials and has a low cost.

The ratio of materials used to manufacture tumbling bodies: abrasive grain - 70%; wood chips - 25%; resin - 4%; curing agent - 1%.

Tests were carried out using a specially designed barreling unit with a horizontal axis of rotation. The unit is equipped with an electric motor with a rotational speed of up to 1500 rpm. The speed control panel is connected to the engine. The movement is communicated by means of a driving belt from the engine to the shaft, which, in turn, ensures the rotation of the barrel. To increase the efficiency of the operation, ribs are installed inside the barrel. They which do not allow the abrasive to roll down the wall, but force it to mix and move randomly.

To measure the wear of the proposed thumbing bodies, an LSE 3210 electronic scale was used; a measurement accuracy being of up to 0.01 g.

The experimental conditions were determined experimentally and include the following parameters:

- processing time is 180 min;
- the barrel rotation frequency is 80 rpm;
- the material of tested samples is 09G2S grade alloy steel.

In order to obtain the objective test data, a center-stiffener L-type part was selected. The sample has hard-to-reach angles at the points of junction and has dimensions of 70x70 mm.

The software "Image Pro Insight" was used to efficiently process, measure and analyze images for further evaluation of the amount of the ground material.

The experiment method contains the following steps:

1. Application of various kinds of dirt (paint, varnish, rust) to the sample.
2. Part processing.
3. Sample photographing.
4. Analysis of the ground material using software.

3 Results and discussion

The following experimental task was set: to investigate how well various kinds of dirt (rust, varnish, paint) are removed from a workpiece over a certain processing time.

In addition, the tumbling body durability, i.e. the ability of a resin to bind a wooden body and an abrasive grain, is also of great importance.

Below, in tables 1, 2, 3, there are data on the results of part processing using tumbling media of the proposed design, made of regular alumina abrasive grains of various grain sizes (No. 20, No. 40 and No. 100).

Table 1. The results of processing parts using tumbling media made of 13A20 abrasive grains.

Removed material, %	**Test number**				
	1	**2**	**3**	**4**	**5**
Rush	97.854	98.134	98.5318	97.456	98.143
Varnish	70.568	71.156	69.946	70.478	70.456
Paint	60.468	61.156	60.466	60.556	60.756

The average values of the removed area of dirt were: rust – 97.999%; varnish – 70.464%; paint – 60.666%.

Table 2. The results of processing parts using tumbling media made of 13A40 abrasive grains.

Removed material, %	Test number				
	1	2	3	4	5
Rush	100	100	100	100	100

Varnish	100	100	100	100	100
Paint	100	100	100	100	100

The average values of the removed area of dirt were: rust – 100%; varnish – 100%; paint – 100%.

Table 3. The results of processing parts using tumbling media made of 13A100 abrasive grains.

Removed material, %	Test number				
	1	2	3	4	5
Rush	100	100	100	100	100
Varnish	90.555	90.176	91.024	90.501	90.712
Paint	85.155	86.057	85.537	86.156	85.415

The average values of the removed area of dirt were: rust – 100 %; varnish – 90.564 %; paint – 85.534 %. Further tests of the epoxy ability to bind a wooden body and an abrasive grain were conducted. This parameter is extremely important, as it shows the ability of a body to resist the loads that act on it during processing. During the experiments, the fused abrasive alumina with grits No. 20, 40, and 100 was tested. The tumbling media, which were never used in the work, were taken. First, abrasive bodies was weighed, and then loaded into the barrel along with the part to be processed. Every 2 hours of processing, all the abrasive material that was separated from the wooden body was weighed, after which the operation was repeated. The durability of tumbling bodies is presented in Table 4.

Table 4. The durability of tumbling bodies.

Time, h	Grain size		
	20	40	100
2	2.22	2.17	2.28
4	5.81	5.55	5.87
6	7.35	7.14	6.95
8	20.54	21.11	20.34
10	55.37	53.55	55.11

After analyzing the data obtained, it can be concluded that the durability of grains No. 20, 40 and 100 is the same, taking into account the error of 5%.

The diagram of the dependence of abrasive grain binding durability on its grain size and the time of work is shown in Fig. 2.

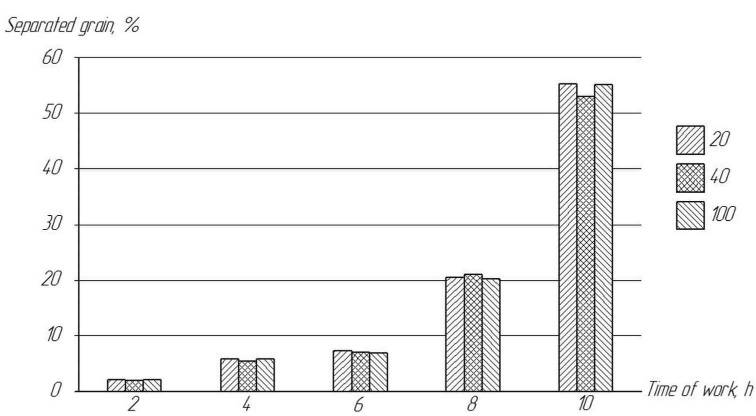

Fig. 2. The diagram of the dependence of abrasive grain binding durability on its grain size and the time of work.

4 Conclusions

Thus, the process of tumbling with the use of new media of a more rational design can provide a more efficient processing of mining machinery parts and thereby contribute to the achievement of their higher quality.

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