Ways of abrasive blasting technology development

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Abstract. Having analysed problems in abrasive blasting processing, we present solutions. To reduce the probability of failure of the abrasive blasting nozzle, it is necessary to reduce or eliminate the fact of its wear using the air layer between the inner working wall of this tool with the flow of abrasive particles. It is also preferable to remake the layout of the nozzle from solid to assembled unit in order to replace with a new part of the nozzle, which can still become wear-off because of some reasons. As a result of implementation of such abrasive blasting nozzle, there was a need to develop the method of its use. Regarding the quality control of the processed surface, it is usually carried out in such ways: visually during processing; after processing; due to certain processing modes, which are predicted to provide a given surface quality. Using the methods presenting above it is impossible to quantify the quality of the surface, especially during machining. Accordingly, the processed part in some cases returns to machining again. Therefore, it is suggested that active control should be applied, namely to measure, for example, the roughness of the resulting surface during processing. If the degree of roughness is not reached, a signal is sent to the worker or the automated system about the need to finish the surface, or change the processing modes, which will provide the desired result.

1. Introduction
Abrasive blasting of surfaces of parts is a productive and effective type of processing [1, 3, 5, 6]. It is known that surfaces can be of different shapes which is important for processing complex shaped or hard-to-reach surfaces of parts. Also, it is it is possible to process a large surface area of parts rather quickly. Other important advantages of abrasive blasting are relative simplicity of abrasive blasting processing equipment and no need for high professionalism of workers.

But at the same time, this type of processing has a number of problems [4, 7]. Abrasive blasting nozzle, through which the working mixture of abrasive and fluid, for example air passes, is subjected to rapid wear-off and replacement of worn nozzle is expensive. It is also problematic to control the quality of treated surface during processing to be more concrete it is difficulty in determine during processing if the surface has acquired the necessary quality parameters (for example roughness). Besides this type of processing is harmful to the worker because of much dust and a silicosis disease may appear.

Some of these problems can be solved in ways presented in works [2, 8, 9, 10, 11]. For example, the abrasive blasting nozzle can be made according to the design shown in figure 1. The principal difference from abrasive blasting nozzles of other designs is that the wear resistance of the internal working surface of the nozzle is achieved not by the use of super-hard materials but by the formation of air layer on the working surface of the nozzle, which prevents the contact of abrasive particles with the inner working surface during the operation of the abrasive blasting processing. Accordingly, the
The proposed special tool must be used taking into account certain rules of its use. The scheme of assembled abrasive blasting nozzle is shown in figure 2.

**Figure 1.** Developed assembled design of the abrasive blasting machine nozzle:

1. Inflow conical wide neck  
2. Porous permeable insert (acceleration zone)  
3. Housing for placing porous permeable insert  
4. Outflow conical narrow neck

- Air flow with abrasive particles – Additional air flow.

**Figure 2.** A scheme of abrasive jet processing of parts using assembled nozzle:

1. Compressor  
2. Hose  
3. Pressure gauge  
4. Receiver  
5. Regulator of air pressure of the main flow  
6. Air pressure regulator of the additional flow  
7. A mixer of abrasive and air  
8. Assembled nozzle of new design  
9. Mixture of air flow with abrasive, a working flow  
10. The surface of the workpiece.

The key point in the abrasive blasting treatment according to this scheme is the primary supply of clean air to the assembled nozzle in the radial direction, and only then the supply of the main flow of a mixture of air and abrasive which is passing along the nozzle. Also an important point in processing the surfaces of parts is the control of the processing itself. A control over the condition of the surface of the part subjected to abrasive blasting is usually done visually during the processing or determining of roughness by the classical contact method after processing. It is also possible to predict future
required surface conditions due to certain processing modes (type and size of the fraction, flow rate, distance of the working nozzle from the processing surface, etc.)

The disadvantage of the first method is the almost subjective assessment of the result of processing. The disadvantage of the second method is the possible reprocessing of the product if the condition of a surface was not achieved according to demands. The third method may not achieve the required surface quality at all because this method only predicts the result and does not guarantee it. Therefore, in order to automate the control of the obtaining surface of the part and the passage of abrasive blasting process, authors of this article proposed a special system of active control. The essence of the system is a constant analysis of the machining surface in real time with the ability to complete the surface treatment or even adjust the modes of processing to the process itself. Figure 3 shows a scheme of active control of abrasive blasting processing.

According to the scheme shown above, the 3D scanner is needed to obtain information about the condition of the newly treated area of the surface of the part. Then the information is transmitted to a computer that analyses it to determine the current surface roughness of the part. In case of disparity between the current roughness and the necessary one, the system adjusts processing modes and, if necessary, finishes an area of a surface which does not correspond to the set roughness.

The machining process itself can be performed by the employee or the automatic equipment which is controlled by a CNC system. In the first case, the employee will be given special light signals about the process and, in the second case, special commands will affect the CNC system of the equipment by adjusting its operation. It should be noted that the obtaining information about the quality of the surface is gained in a non-contact way, which does not affect the actual surface relief of the part, and therefore is reliable.

2. Methodology

To test the proposed idea, an experimental work was carried out, which consisted of the following stages:

1. Obtaining information on 3D scanning of surfaces of parts of different roughness
2. Analysis of the received information for estimation of roughness
3. Determination of the surface roughness of the parts that have been scanned using the known classical method
4. Comparison of obtained results for compliance
5. Analysing the work which was done

Therefore, sandpaper of different fractional composition was chosen as experimental surfaces of different roughness. Figure 4 and table 1 show the brand and some characteristics of the selected sandpaper. The next step was to scan (figure 5) areas of sandpaper of different fractional composition using a 3D scanner DAVID SLS-1.

Figure 6 shows a digital model of the scanned area of the sandpaper surface. It is worth noting that the maximum scanning resolution we chose was 12 μm. Then from digital models of scanned...
surfaces, crossed by 3 planes, 3 classical common profiles were obtained (figure 7). Next, to calculate the roughness of the Ra parameter, the profiles were divided (figure 8) into a certain number of parts in order to determine the coordinates of the points relative to the midline.

**Figure 4.** Klingspor sandpaper.

**Table 1.** Characteristics of 8 experimental surfaces of the chosen sandpaper.

| Type of sandpaper (ISO-6344) | Abrasive fraction size, µm | Type of sandpaper (ISO-6344) | Abrasive fraction size, µm |
|-----------------------------|---------------------------|-----------------------------|---------------------------|
| P36                         | 500…630                   | P100                        | 125…160                   |
| P40                         | 400…500                   | P150                        | 80…100                    |
| P60                         | 250…315                   | P180                        | 63…80                     |
| P80                         | 200…250                   | P240                        | 50…63                     |

**Figure 5.** The process of 3D scanning of areas of sandpaper surfaces of different fractional composition.

**Figure 6.** The obtained digital model of the surface of sandpaper with indicated scanning resolution.
After getting positive and negative height values (40 in total), according to middle line, the average value of roughness was calculated in Excel. All scanned areas (3 profiles in each area) of different types of sandpaper were analysed using this methodology. Obtained results are presented in Result section. Also, to compare the roughness parameters of the sections of sandpaper estimated by this method, they were also investigated on a special automated profilograph-profilometer (figure 9) to obtain the appropriate profiles (figure 10). The roughness of all types of researched sandpapers (3 profiles in each type of sandpaper) were estimated using methodology shown above.

![Figure 7](image7.png) **Figure 7.** Obtaining classic profiles to determine the surface roughness.

![Figure 9](image9.png) **Figure 9.** The modernized system of profilographer-profilometer model 202 of “Caliber” plant.

![Figure 8](image8.png) **Figure 8.** Preparation of the profile to estimate the Ra roughness parameter.

![Figure 10](image10.png) **Figure 10.** A sample of resulting profile which was generated in PowerGraph software.
3. Results
After performing all the necessary research and estimations, results were summarized in the graph shown in figure 11. It is also necessary to present a graph which shows the dependence of grain size to the ISO-6344 mark of sandpaper (figure 12).

Having received important data there is a need to make conclusions and tasks for future research.

Figure 11. Estimated dependence of surface roughness of abrasive paper on different grain size according to ISO P marking.

Figure 12. Average granularity of abrasive paper depending on ISO P marking.

4. Conclusion
According to the graphs shown in figure 11 and figure 12, the following conclusions can be drawn:

- Graphs of surface roughness obtained by the classical contact method, 3D scanning method and the dependence of grain size on the marking of sandpaper are almost of the same shape, respectively, and their graphs of average values are also of the same shape;
• A small offset of the roughness graph obtained by the 3D method relative to the roughness graph obtained by the classical method can be explained by the fact that the abrasive grains are attached to the sandpaper with glue, which in contact determination of roughness peels off, so roughness is “more contrasting”.

In our future work, the estimation of roughness in real time will take place without the use of a number of computer programs, and using a special mathematical algorithm which will be saved into the analyser itself.

Another important step is to establish the link between the estimated current roughness and the change of processing parameters, which will be carried out by automated control devices which are provided by the CNC system.

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