A method for assessing the wear of sanding abrasive discs differing in the type of grains (SiC, Al2O3(95A))

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Abstract. This paper describes a method for studying the wear of abrasive mesh discs differing in the type of grains employed to sand plaster. The tests were conducted at a specially developed and constructed setup. The investigations involved analysing the influence of the basic input parameters (the size of the abrasive grains covering the disc surface, the force exerted by the plaster sample pressing against the abrasive disc and the no-load speed of the abrasive disc) on the efficiency of the sanding process. The paper also describes the structural details of the experimental setup.

1 Introduction

Sanding process is included in the "conventional" group of machining methods together with the turning, milling, drilling, etc. opposite to "non-traditional" or "non-conventional" group processes such as EDM[1,2], water jet cutting (AWJ)[3], laser cutting[4,5], microwelding[6,7] etc. The wear of abrasive discs used for plaster sanding [8,9] can be assessed by applying different forces to a rod-like plaster sample pushed through the feed sleeve. The force is dependent on the mass of the weights attached. Weights differing in mass can be attached interchangeably. A change in the force exerted by the plaster sample pressing against the abrasive disc causes a change in the level of the process intensity. The sanding process is also affected by the rotational speed of the abrasive wheel selected on the tool. The aim of this paper is to present the test method and analyse the results concerning the abrasive wear behaviour of mesh discs.

2 Description of the test stand

Figure 1 shows a diagram of the stand used in the study. The stand designed to test the wear of abrasive discs consisted of a sleeve attached firmly to the sander flange, which acted as a guard protecting the operator. The random orbit sander used for the testing was mounted tightly to the stand. Plaster samples [10-12] in the form of rods were placed in the sleeve and pushed by a pusher to touch the surface of the abrasive disc. The force exerted by the plaster sample was dependent on the mass of the weights attached to the cord (2, 4 or 6 N).

Figure 1. Stand to test the wear of abrasive discs:
1-random orbit sander, 2-feed sleeve flange,
3-mouting ring, 4-feed sleeve, 5-weight, 6-cord, 7-feed rolls, 8-pusher, 9-cord fitting system, 10-rod-like plaster sample, 11-abrasive disc.

3 Materials
The study was performed to compare two types of abrasive mesh discs 180 mm in diameter. The resin-bonded abrasive grains were silicon carbide (SiC)[13] and alundum (Al₂O₃(95A)). Figure 2 shows SEM images of the abrasive aggregates under study.

4 Input parameters selected to study the wear of abrasive discs
The experiments were conducted using a specially designed and constructed test stand to assess the wear of abrasive discs. The input parameters were predetermined on the basis of the authors’ earlier experiments, the literature data [9,14-16] and the information provided by the abrasive mesh producer.

The tests were carried out under the following conditions:
- no-load speed - 2250 rpm (average set value in the range of 1500-3000 rpm) measured for slow speeds,
- force exerted by the plaster sample, size of the abrasive grains – 120.

5 Analysis of the wear of abrasive discs
The experimental results were used to determine the abrasive wear behaviour of the mesh discs. The study involved assessing the efficiency of the sanding process as a function of time. It was necessary to determine the limit at which the process became less efficient. The measurement results are presented in Table 1.

Table 1. Measurement data.

| Layer No. | Sanding time per layer [s] |
|-----------|----------------------------|
| SiC       | Al₂O₃(95A)                 |
| 1.        | 36                         | 56                        |
| 2.        | 75                         | 127                       |
| 3.        | 114                        | 197                       |
| 4.        | 179                        | 225                       |
| 5.        | 180                        | 500                       |
| 6.        | 301                        | -                         |
| 7.        | 475                        | -                         |
Each layer of gypsum plaster [17] removed from the sample had the same volume (19.6 cm$^3$). The sanding was continued until the volumetric efficiency of the process ($Q_w$) decreased to less than 0.05 cm$^3$/s.

The comparative analysis of the abrasive meshes showed that higher efficiency of the sanding process was achieved for the discs with SiC grains. It was less than 0.05 cm$^3$/s after the removal of seven layers, with a total volume of plaster removed being 137.2 cm$^3$. For the discs with Al$_2$O$_3$ (95A) grains, the sanding efficiency decreased below the assumed value after five layers (98 cm$^3$) were removed. The tests revealed that the efficiency of plaster sanding was higher for the discs with SiC aggregates than for the discs with Al$_2$O$_3$ (95A) aggregates. Figure 3 is a graphical representation of the experimental data concerning the relationship between the efficiency of the sanding process and the sanding time per layer for four different abrasive discs.

**Figure 3.** Efficiency of the sanding process expressed as the time of removal of a predetermined volume of plaster as a function of the sanding time per layer.

### 6 Influence of the input parameters on the process efficiency

The tests to determine the influence of the input parameters on the efficiency of the sanding process were conducted according to a 3x3 factorial design (with three factors and three levels), as proposed by Box Behnken [18-19]. In the tests, the three factors were:

- the size of the abrasive grains ($Z$),
- the force exerted by the plaster sample pressing against the abrasive disc ($F$) expressed by newtons ($N$),
- the no-load rotational speed of the abrasive disc ($n$) expressed by revolutions per minute ($rpm$).

The design of experiments was generated using Statistica 10 for the ranges of variability of the particular input parameters determined in one-factor experiments. Table 2 summarises the actual values of the input parameters and the values of the sanding efficiency ($Q_w$) calculated from the experimental results.
Table 2. Design of experiments and the measurement data.

| Test No. | Input parameters | Sanding efficiency |
|----------|------------------|--------------------|
|          | Z (grit size) | F (N) | n (rpm) | Q_w (cm³/min) | Q_w (cm³/min) |
| 1.       | 60              | 2     | 2250    | 117.75        | 111.08        |
| 2.       | 180             | 2     | 2250    | 90.58         | 79.56         |
| 3.       | 60              | 6     | 2250    | 255.98        | 163.54        |
| 4.       | 180             | 6     | 2250    | 133.81        | 125.27        |
| 5.       | 60              | 4     | 1500    | 103.29        | 99.79         |
| 6.       | 180             | 4     | 1500    | 79.56         | 71.80         |
| 7.       | 60              | 4     | 3000    | 327.08        | 452.88        |
| 8.       | 180             | 4     | 3000    | 203.02        | 346.32        |
| 9.       | 120             | 2     | 1500    | 60.08         | 62.63         |
| 10.      | 120             | 6     | 3000    | 85.33         | 122.66        |
| 11.      | 120             | 2     | 3000    | 122.66        | 255.98        |
| 12.      | 120             | 6     | 3000    | 235.50        | 235.50        |
| 13.      | 120             | 4     | 2250    | 154.93        | 136.92        |
| 14.      | 120             | 4     | 2250    | 159.12        | 140.18        |
| 15.      | 120             | 4     | 2250    | 147.19        | 127.99        |

7 Results and discussion

Table 3 compares the input parameters for the two types of abrasive grains. The strongest linear correlation was obtained for the parameter \(n(L)\), which was \(k_{SiC} = 0.71\) and \(k_{Al_2O_3(95A)} = 0.80\) for SiC and Al\(_2\)O\(_3\) (95A), respectively. In no other case did the value of the linear or quadratic regression reach the level of significance \(k > |0.5|\).

Table 3. Coefficients of partial correlation.

| Input parameter | Coefficient of correlation |
|-----------------|----------------------------|
|                 | SiC           | Al\(_2\)O\(_3\) (95A) |
| \(Z(L)\)       | -0.38         | -0.18         |
| \(Z(Q)\)       | -0.18         | -0.13         |
| \(F(L)\)       | 0.41          | 0.12          |
| \(F(Q)\)       | 0.21          | 0.24          |
| \(n(L)\)       | 0.71          | 0.80          |
| \(n(Q)\)       | -0.01         | -0.37         |

8 Conclusions

From the experimental results it was possible to determine the efficiency of the gypsum plaster sanding process performed by means of abrasive wheel tools, which was expressed as a function of time. The results showed that the process efficiency and the disc durability were higher for the discs with SiC grains.

The values of the coefficients of partial correlation obtained for the linear regression confirmed a significant influence of the rotational speed of the abrasive disc \(n(L)\) on the efficiency of the sanding process (positive correlation, \(k = 0.71\) for the discs with SiC grains and \(k = 0.80\) for the discs with Al\(_2\)O\(_3\) (95A) grains).

The analysis of the values of the coefficients of partial correlation obtained for the linear regression showed that the efficiency of the sanding process was least dependent on the size of the abrasive
grains Z(L) (negative correlation, \( k = -0.18 \)) and the press load F(L) (positive correlation, \( k = 0.12 \)) for the disc with Al2O3 (95A) abrasive aggregates.

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