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Influence of the input parameters on the efficiency of plaster sanding with alundum abrasive discs

D Krajcarz[1, 2], S Spadło[1] and P Młynarczyk[1]

[1] Kielce University of Technology, Division of Materials Science and Munitions Technology, Al. Tysiąclecia Państwa Polskiego 7, 25-314 Kielce, Poland

[2]E-mail: d.krajcarz@wp.pl

Abstract. The paper presents test results concerning the relationship between selected input parameters and the process efficiency for the sanding of plaster surfaces with alundum abrasive discs. The input parameters under study were the size of the abrasive grains, the force exerted by the plaster sample pressing against the abrasive disc and the no-load rotational speed of the abrasive disc. The experimental data illustrating the relationship between the process efficiency and the particular input parameters were used to select the optimum plaster sanding conditions.

1   Introduction

Sanding is used to remove excess material from wrought or cast cylindrical objects and to finish metallic and non-metallic surfaces, including gypsum plaster. In the engineering nomenclature, the terms grinding, honing, superfinish or lapping are applied to describe similar processes [1-3]. The tools used for this purpose require flexible mesh discs with resin-bonded abrasive grains ranging from 60 to 240 in size [4, 5]. The aim of the study was to determine the effect of the process conditions on the quality of plaster sanding [6, 7].

2   Experiment

The tests were conducted using Flexa abrasive discs with resin-bonded alundum (Al_2O_3) [8] grains differing in size (60, 120 and 180). The aggregates on the abrasive meshes were irregular in shape. The tests were performed using a specially developed test stand comprising a drywall sander with interchangeable abrasive discs and a system to feed a rod-like plaster sample [9] 50 mm in diameter. The test variables were the force exerted by the plaster sample pressing against the abrasive disc, the no-load rotational speed of the abrasive wheel, expressed by revolutions per minute and the size of the abrasive grains.

2.1   Test conditions

The experiments were carried out according to the Box Behnken 3x3 factorial design of experiments [10-12] (with three factors and three levels). In the experiments, the variables were: the size of the abrasive grains (Z), the force exerted by the plaster sample pressing against the abrasive disc (F) and the no-load rotational speed of the abrasive disc (n) expressed by revolutions per minute. One-factor experiments were performed for the input parameters in the predetermined ranges of variability. The design of experiments (DOE) was then generated using the DOE module of Statistica 10. Table 1 provides actual values of the input parameters and the values of the process efficiency (E_f) calculated on the basis of the experimental data.

Table 1. Design of experiments and the measurement results.

Test No.	Input parameters			Process efficiency
	Z, mesh	F, N	n, rpm	E_f, cm^3/min
1.	60	2	2250	136.92
2.	180	2	2250	75.48
3.	60	6	2250	367.97
4.	180	6	2250	210.27
5.	60	4	1500	67.67
6.	180	4	1500	41.76
7.	60	4	3000	327.08
8.	180	4	3000	203.02
9.	120	2	1500	56.07
10.	120	6	3000	105.13
11.	120	2	3000	107.05
12.	120	6	3000	367.97
13.	120	4	2250	173.16
14.	120	4	2250	178.41
15.	120	4	2250	168.21

3   Results and discussion

Table 2 shows the input parameters and the corresponding coefficients of partial correlation. The strongest linear correlation (L) was reported for the parameter $n(L)$, where $k = 0.64$. From the values of the coefficients of partial correlation it is clear that there is another significant positive correlation for the parameter F, where $k = 0.59$. The values of the quadratic nonlinear regression (Q) did not reach the level of significance $k > |0.5|$ in any of the cases.

Table 2. Coefficients of partial correlation.

Input parameter	Coefficient of correlation
$Z(L)$	-0.32
$Z(Q)$	-0.07
$F(L)$	0. 59
$F(Q)$	-0.06
$n(L)$	0.64
$n(Q)$	0.13

Figure 1 shows the relationship between the process efficiency and two parameters, i.e. the force F and the grain size Z (at $n = 2250$ rpm). From the diagram it is evident that in the analysed range of variability, the maximum efficiency is achieved for the abrasive discs with a mesh size of 60. An increase in the force F in the whole range of variability causes an increase in the sanding efficiency.
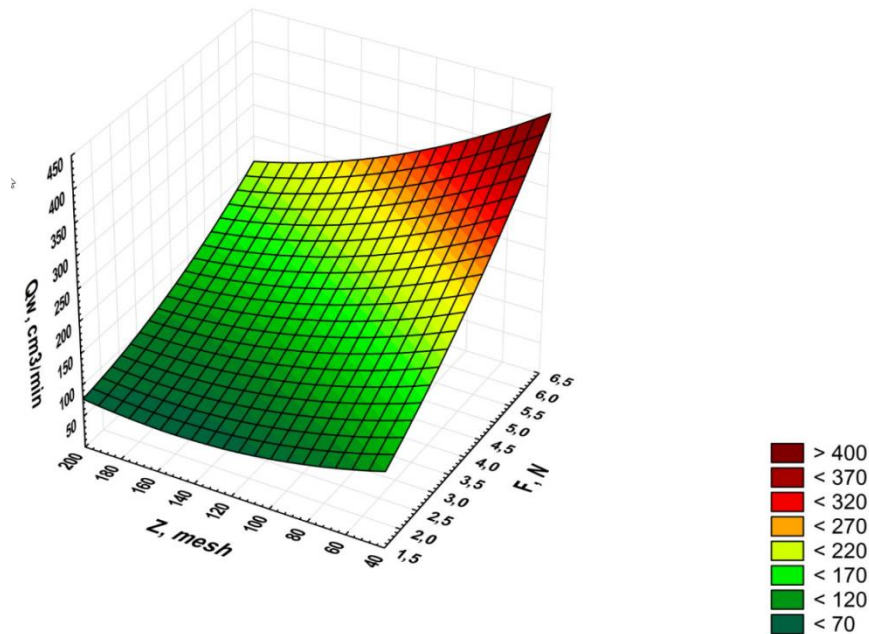
Figure 1. Process efficiency versus the force exerted F by the plaster sample pressing against the abrasive disc versus the size of the abrasive grains Z (at n = 2250 rpm).

Figure 2 shows the relationship between the plaster sanding efficiency and two input parameters: n and Z (at $F = 4$ N). As can be seen from the diagram, the process efficiency increases with increasing rotational speed n in relation to a change in the grain size in the test range. In the analysed range of variability, the maximum process efficiency is reported for the abrasive discs with a mesh size of 60.
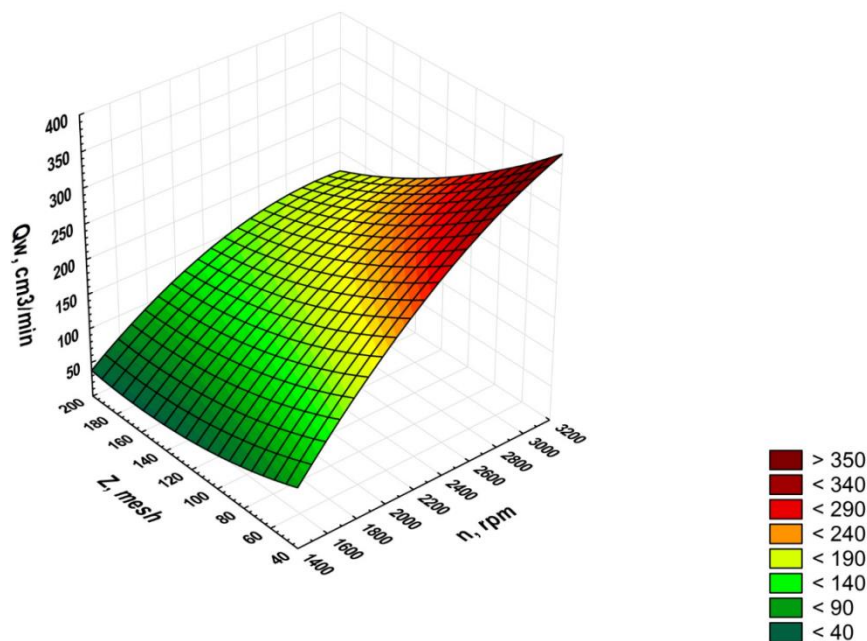

Figure 2. Process efficiency versus the rotational speed of the abrasive disc n versus the size of the abrasive grains Z (at F = 4 N).

Figure 3 shows the relationship between the efficiency of the sanding process and two input parameters: the rotational speed n and the force exerted by the plaster sample F (for $Z = 120$ mesh). From the diagram it is evident that an increase in either of the parameters leads to an increase in the process efficiency. The maximum efficiency is achieved when both parameters of the experimental design are high.
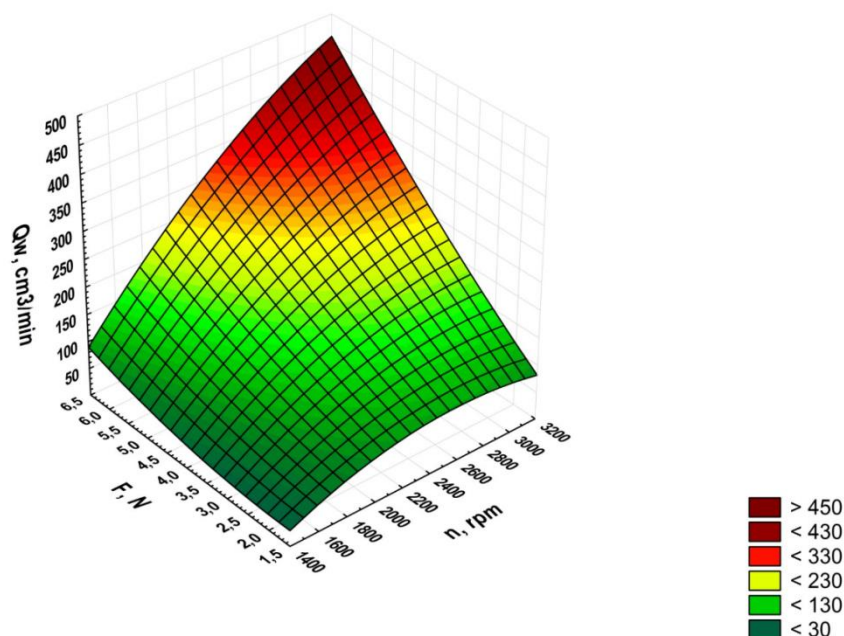

Figure 3. Process efficiency versus the force exerted by the plaster sample pressing against the abrasive disc N versus the rotational speed of the disc n (for $Z = 120$ mesh).

4   Conclusions

The values of the coefficients of partial correlation obtained for the linear regression confirm a considerable influence of the rotational speed of the abrasive disc $n(L)$ and the force exerted by the plaster sample $F(L)$ on the process efficiency (positive correlation, $k = 0.64$ and $k = 0.59$, respectively).

The coefficients of partial correlation obtained for linear regression show that the size of the abrasive grains $Z(L)$ had the least influence on the efficiency of the plaster sanding process (negative correlation, $k = -0.32$).

The values of the quadratic nonlinear regression did not reach the level of significance in any of the cases considered. For the parameters affecting the efficiency of the sanding process, i.e. the force exerted by the plaster sample $F(Q)$ and the size of the abrasive grains $Z(Q)$, the coefficient of correlation fluctuated around 0, which indicates that the relationship is practically linear.

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