RESEARCH ON ABRASIVENESS OF MATERIALS USED ON FINISHING METAL ALLOYS. PART I

Marius-Daniel BĂEȘU[1], Mircea CIOBANU[2]

[1]*Universitatea „Ștefan cel Mare" Suceava, marius.baesu@fim.usv.ro.*
[2] *Universitatea „Ștefan cel Mare" Suceava, mircea@fim.usv.ro*

Abstract: *In magneto-abrasive processes, the working environment consists of magneto-abrasive powder (ferromagnetic particles such as ferrite or composite powders) or from suspensions, namely ferrofluids or magneto-rheological liquids. Abrasive materials are natural or synthetic crystalline substances with high hardness, used for grinding or polishing materials. To achieve the required materials for finishing metal alloys, metal waste (steel and iron chips) granite, grinding wheels and siliceous sand waste were used. This article aims to present the logistics used to obtain the materials, study the abrasiveness of different materials and their combinations, and to determine the final roughness of the samples used.*

Keywords: *abrasiveness, roughness, abrasive materials*

1. General Introduction

The general feature, common to abrasive processes, is the use of abrasives (powders or granules) arranged in a given carrying environment. It may be possible to make different abrasive environments, which, depending on the way they are constituted, make the difference between the technological processes. [7]

Abrasive grains can be placed in a binder and compacted in abrasive bodies with well-defined forms, used in regrinding operations. This way, an abrasive environment is created, having wide spread use.

Abrasive materials are presented in form of very tough granules, with sharp edges and tips, which disengage very small chips from working areas [7].

In order to detach the chips, the abrasive grains are driven in a relative movement against the work piece, being embedded in a solid object (abrasive discs), in a liquid (suspensions, paste), in a steam shot or in a magnetic field.

In order to establish the maximum performance of these working environments and to improve the quality of the surfaces a collaboration between metallurgists and technologists is needed [1].

2. The equipment used in manufacturing and determining materials abrasiveness and roughness

2.1 Equipment used for obtaining metal powder [2], [3], [4]

In order to obtain metal powder used in magneto-abrasive materials, a ball mill has been designed (figure 1). The equipment is designed and constructed to prepare metal waste (chips etc.), in order to re-use it for finishing magneto-abrasive operations or with other purposes.

The equipment is made of a metal case (7), in which there are steel balls (17). The equipment is driven by an engine (14), which transmits rotary motion to the mill case (7) with the aid of the belt pulley (11,15) through a drive belt (13).

Through mill rotating, the balls (17) keep the same direction as the rotating movement. This movement takes place as long as the tilt angle of the load, at a given moment, stays lower than the normal slope angle on which the rolling or falling of the grinding material take place. This way, through friction and collision, the fragmentation of the material subjected to grinding takes place.

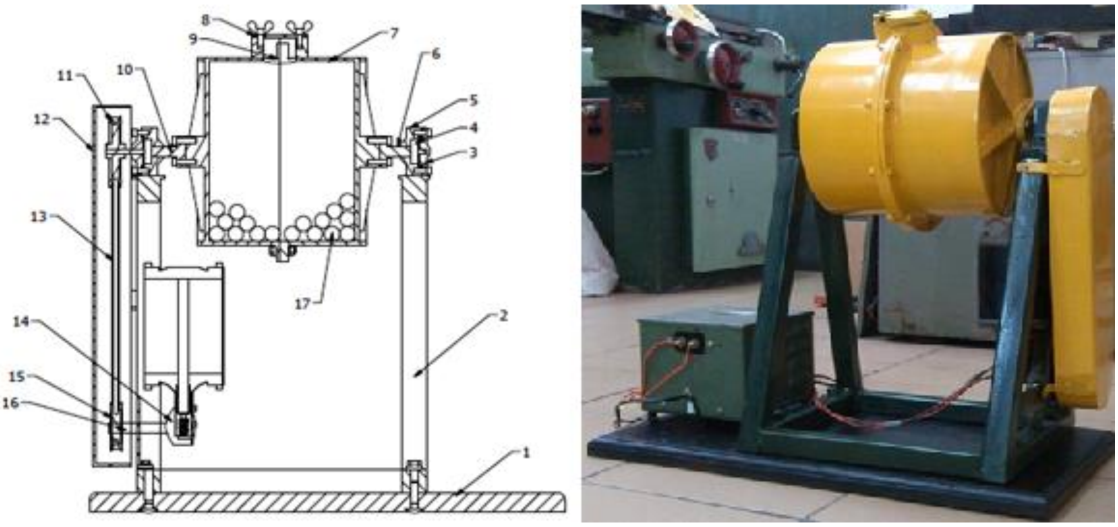

Figure 1: *Equipment for grinding metal waste (Ball mill); scheme of the ball mill: 1 – Mill bed, 2 – Frame, 3 - Bearing cover, 4 – Bearing, 5 - Bearing Support, 6-10 - Drive shafts, 7 – Mill case, 8 - Cover, 9 – Admission hopper, 11-15 – Belt pulley, 12 – Case, 13 -Drive Belt, 14 – Motor, 16 - Motor shaft, 17 – Balls*

The following factors act on the intensity and mechanism of the fragmentation process (Co, ' 97)):

- the rotation speed of the mill;
- the ratio of the diameter (D) and the length (L) of the mill case (D/L);
- the weight and diameter of the grinding material;
- the volume of material subjected to grinding;
- grinding time;
- the environment in which the grinding process takes place.

The metal waste (steel chips, iron cast) used to obtain metal powders, where taken from those resulted after cutting processes like turning, milling, drilling, grinding, broaching etc.), from various companies and from the cutting tools laboratory of the Faculty of Mechanical Engineering, Mechatronics and Management.

For a charging of m=0,750 kg of waste, 0,232 kg of metal powder was obtained in a period of time t=6 hours, using a number of 60 balls with a diameter of Ø20 mm. The mill is powered with a direct current (D.C.) motor of 24 V and an amperage of 5A.

The powder obtained was subjected to a sieving procedure using an equipment with mechanical sieving through horizontal and vertical vibration type PSS, in a time period t=15 minutes. The electromagnetic sieving device for sieves with a diameter of 200 mm, (in accordance with EN 932-5), located in the Laboratory of materials technology, it is powered by electromagnetic pulse and, because of its vibrating actions (vertical, lateral and rotating), it offers a high precision of results.

After the sieving process, metal powders, with different sizes where obtained, these being used for magneto-abrasive finishing, in combination with abrasive powder.

2.2 Equipment for studying material abrasiveness [5], [6]

For the abrasive part of the magneto-abrasive materials used for superfinishing the metal parts, the use and re-use of abrasive material waste (granite, siliceous sand and electrocorundum) from different companies was chosen. Thus, granite waste were purchased from Suceava, Radauti and the siliceous sand was purchased from Dorohoi. The waste of abrasive disks (electrocorundum) was obtained from various commercial companies from Suceava area. The abrasive waste was separated from the iron filings (the grindings) with the help of magnets. In the same manner like metal powders, the electrocorundum was sieved using the equipment described above.

In order to study the abrasiveness of granite, siliceous sand and electrocorundum powder and the mixtures of these, a device has been designed as shown in figure 2.

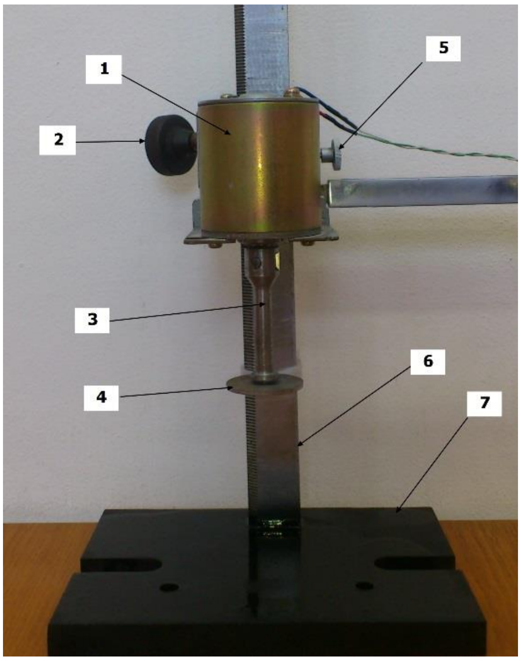

Figure 3 – *Abrading device 1. D.C. motor (12V, 1A); 2. Motor handle; 3. Threaded rod (M6); 4. Sample; 5. Locking screw; 6. Support column; 7. Base plate*

It is formed by a DC motor of 12V (1), on which rod the sample is screwed (4). The motor can be repositioned on the rod (6) in order to set the container with the powder and for immersion the sample (4) in the abrasive powder.

The samples on which the experiments were carried out, have been made of steel (OLC 45), a bar with a diameter of 45 mm (Figure 3).

For creating the samples, a normal lathe SN 320, from the multidisciplinary laboratory of the Faculty of Mechanical engineering, Mechatronics and Management was used. The cutting parameters used were as following: speed n = 500 rpm, feed s = 0.18 mm/rev, cutting depth t = 3 mm. The number of multypass is 7, the thread M6x1 was made on a lathe, using a die head.

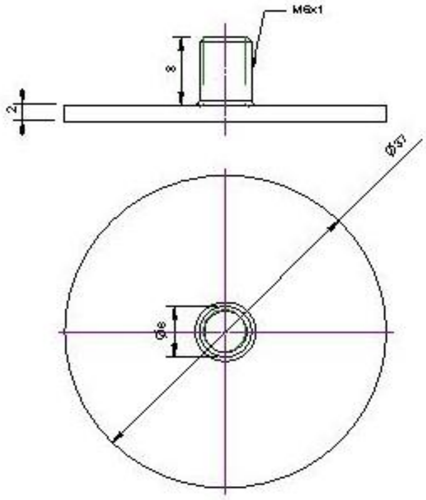

Figure 3: *Sample's scheme*

In order to study the roughness of the samples, two devices from the Faculty of Mechanical engineering, Mechatronics and Management were used: an optical scanning profilometer NANOFOCUS µSCAN LASER PROFILOMETER (figure 4) and the Mahr Perthometer S2 type [9], [10], [11].

Figure 4 – *a) Nanofocus µScan Laser Profilometer; b) Mahr Perthometer S2 type*

In order to determinate the speed of the ball mill and the abrading device, a SHIMPO DT-209X-S12 tachometer, located in Mechanical and Technologies Department from the "Stefan cel Mare" University of Suceava was used.

3. Characterizing the materials' abrasiveness. Gathering the results and obtaining the mathematical model [5], [8]

The research carried out and presented here mainly aim to determinate the extent of influence of each technological parameter on the level of final results characteristic (weight of material removed). Secondly, a determination of a mathematical correlation between the influences manifested by these parameters was aimed in such a way as to create a real possibility of control and rapid intervention in the process at the time when the one of parameters cannot be maintained at a preset value.

Taking into consideration that certain practical values (minimum value) of answers are followed, it is appropriate to establish interdependencies able to describe both the nature and the extent of the considered influences, therefore a mathematical model should be determined.

Hence the scientific literature consulted does not provide a proper mathematical solution, precise and operative in describing the interdependencies mentioned above, a mathematical model based on statistics was elaborated.

The mathematical models thus obtained will be subjected then to optimization.

In order to obtain the mathematical model a polynomial model with many variables was used:

– *independent variables*: speed (A), grain size (B), the exposure time (C);

– *dependent variable*: the quantity of removed material for each of the three materials (granite, siliceous sand and electrocorundum) and combinations between them (granite and siliceous sand, granite+electrocorundum, siliceous sand+ electrocorundum, granite + siliceous sand + electrocorundum).

In order to present in a simple manner the experiments conducted, coded variables will be used for the levels of independent variables (factors). Thus, the following notations are done:

-1 – the minimum level of a variable;
0 – the central level of a variable;
+1 – the maximum level of a variable.

The system's responses m_i (the weight of removed material) were also coded, using the following notations: i = 1 ... 63, i being the number of experiment from the matrix of experiments.

Table 1 shows the codes for independent variables, as well as the correspondence between the real values and the coded ones taken into account for establishing the model.

To create the mathematical model, the program Design Expert was used.

Tabel 1: *Symbolizing and correspondence between coded values and real values of independent variables*

Variables	***Symbols***	***The coded variables of real variables***		
		-1	***0***	***1***
Speed [*rpm*]	*A*	700	850	1000
Grain size [*mm*]	*B*	0.04	0.17	0.3
Time [*min*]	*C*	30	60	90

3.2. Characterizing the granite abrasiveness [6]

Statistical Summary found mathematical models to describe the dependent variables is presented in Table 2.

Table 2. ***Statistical summary of proposed mathematical models***

Dependent variable	***Model***	***Standard deviation [σ]***	***Regression coefficient [R^2]***	***Adjusted regression coefficient [R^2 adjusted]***
m_1	2nd order polynomial	0,0011050	0,9640	0,9573
m_2	2nd order polynomial	0,0007566	0,9680	0,9598
m_3	2nd order polynomial	0,0028440	0,9710	0,9605
m_4	2nd order polynomial	0,0010190	0,9750	0,9585
m_5	2nd order polynomial	0,0018400	0,9710	0,9662
m_6	2nd order polynomial	0,0021300	0,9550	0,9522
m_7	2nd order polynomial	0,0015490	0,9610	0,9515

For the mathematical model of the granite abrasiveness, the data were collected in accordance with Table 3,4,5,6,7,8 and 9.

Table 3. *Experimental data for granite*

Granite									
No CRT.	Speed [rpm]	Grain size [mm]	Time[min]	Removed material [g]	No CRT.	Speed [rpm]	Grain size [mm]	Time[min]	Removed material [g]
1	700	0,063	30	0.0015	32	850	71	60	0.0064
2	700	0.05	30	0.0013	33	850	0.15	60	0.0091
3	700	0.04	30	0.0008	34	850	0.2	60	0.0089
4	700	71	30	0.0029	35	850	0.3	60	0.0131
5	700	0.15	30	0.0034	36	1000	0,063	60	0.0037
6	700	0.2	30	0.0041	37	1000	0.05	60	0.0029
7	700	0.3	30	0.0046	38	1000	0.04	60	0.0021
8	850	0,063	30	0.0019	39	1000	71	60	0.0076
9	850	0.05	30	0.0014	40	1000	0.15	60	0.0095
10	850	0.04	30	0,001	41	1000	0.2	60	0.01
11	850	71	30	0.0034	42	1000	0.3	60	0.0145
12	850	0.15	30	0.0047	43	700	0,063	90	0.0041
13	850	0.2	30	0.0052	44	700	0.05	90	0.0037
14	850	0.3	30	0.0074	45	700	0.04	90	0.0025
15	1000	0,063	30	0.0021	46	700	71	90	0.0087
16	1000	0.05	30	0.0015	47	700	0.15	90	0.01
17	1000	0.04	30	0.0011	48	700	0.2	90	0.0119
18	1000	71	30	0.0039	49	700	0.3	90	0.0144
19	1000	0.15	30	0,005	50	850	0,063	90	0.0059
20	1000	0.2	30	0.0055	51	850	0.05	90	0.0046
21	1000	0.3	30	0.0085	52	850	0.04	90	0.0033
22	700	0,063	60	0.0024	53	850	71	90	0.0121
23	700	0.05	60	0.0021	54	850	0.15	90	0.0171
24	700	0.04	60	0.0014	55	850	0.2	90	0.0155
25	700	71	60	0,005	56	850	0.3	90	0.0214
26	700	0.15	60	0.0059	57	1000	0,063	90	0.0068
27	700	0.2	60	0.0069	58	1000	0.05	90	0.0051
28	700	0.3	60	0.0084	59	1000	0.04	90	0.0038
29	850	0,063	60	0.0033	60	1000	71	90	0.0137
30	850	0.05	60	0.0025	61	1000	0.15	90	0.0164
31	850	0.04	60	0.0018	62	1000	0.2	90	0.0177
					63	1000	0.3	90	0.0244

Table 4. *Experimental data for siliceous sand*

Siliceous sand									
No.	Speed [rpm]	Grain size [mm]	Time[min]	Removed material [g]	No.	Speed [rpm]	Grain size [mm]	Time[min]	Removed material [g]
1	700	0.063	30	0.0009	32	850	0.1	60	0.0041
2	700	0.05	30	0.0007	33	850	0.15	60	0.0062
3	700	0.04	30	0.0005	34	850	0.2	60	0.0060
4	700	0.1	30	0.0017	35	850	0.3	60	0.0089
5	700	0.15	30	0.0021	36	1000	0.063	60	0.0023
6	700	0.2	30	0.0025	37	1000	0.05	60	0.0017
7	700	0.3	30	0.0029	38	1000	0.04	60	0.0014
8	850	0.063	30	0.0011	39	1000	0.1	60	0.0050
9	850	0.05	30	0.0008	40	1000	0.15	60	0.0064
10	850	0.04	30	0.0005	41	1000	0.2	60	0.0068
11	850	0.1	30	0.0021	42	1000	0.3	60	0.0101
12	850	0.15	30	0.0030	43	700	0.063	90	0.0027
13	850	0.2	30	0.0033	44	700	0.05	90	0.0022
14	850	0.3	30	0.0049	45	700	0.04	90	0.0015
15	1000	0.063	30	0.0011	46	700	0.1	90	0.0058
16	1000	0.05	30	0.0008	47	700	0.15	90	0.0067
17	1000	0.04	30	0.0004	48	700	0.2	90	0.0079
18	1000	0.1	30	0.0024	49	700	0.3	90	0.0098
19	1000	0.15	30	0.0033	50	850	0.063	90	0.0039
20	1000	0.2	30	0.0037	51	850	0.05	90	0.0030
21	1000	0.3	30	0.0058	52	850	0.04	90	0.0019
22	700	0.063	60	0.0014	53	850	0.1	90	0.0081
23	700	0.05	60	0.0012	54	850	0.15	90	0.0117
24	700	0.04	60	0.0007	55	850	0.2	90	0.0106
25	700	0.1	60	0.0034	56	850	0.3	90	0.0147
26	700	0.15	60	0.0039	57	1000	0.063	90	0.0045
27	700	0.2	60	0.0045	58	1000	0.05	90	0.0032
28	700	0.3	60	0.0057	59	1000	0.04	90	0.0024
29	850	0.063	60	0.0021	60	1000	0.1	90	0.0091
30	850	0.05	60	0.0014	61	1000	0.15	90	0.0111
31	850	0.04	60	0.0010	62	1000	0.2	90	0.0121
					63	1000	0.3	90	0.0168

Table 5. *Experimental data for electrocorundum*

Electrocorundum									
No.	Speed [rpm]	Grain size [mm]	Time[min]	Removed material [g]	No.	Speed [rpm]	Grain size [mm]	Time[min]	Removed material [g]
1	700	0.063	30	0.0032	32	850	0.1	60	0.0157
2	700	0.05	30	0.0029	33	850	0.15	60	0.0225
3	700	0.04	30	0.0018	34	850	0.2	60	0.0199
4	700	0.1	30	0.0068	35	850	0.3	60	0.0326
5	700	0.15	30	0.0081	36	1000	0.063	60	0.0090
6	700	0.2	30	0.0098	37	1000	0.05	60	0.0068
7	700	0.3	30	0.0107	38	1000	0.04	60	0.0051
8	850	0.063	30	0.0039	39	1000	0.1	60	0.0187
9	850	0.05	30	0.0031	40	1000	0.15	60	0.0234
10	850	0.04	30	0.0022	41	1000	0.2	60	0.0247
11	850	0.1	30	0.0081	42	1000	0.3	60	0.0359
12	850	0.15	30	0.0114	43	700	0.063	90	0.0100
13	850	0.2	30	0.0137	44	700	0.05	90	0.0089
14	850	0.3	30	0.0182	45	700	0.04	90	0.0058
15	1000	0.063	30	0.0049	46	700	0.1	90	0.0216
16	1000	0.05	30	0.0033	47	700	0.15	90	0.0248
17	1000	0.04	30	0.0025	48	700	0.2	90	0.0295
18	1000	0.1	30	0.0094	49	700	0.3	90	0.0357
19	1000	0.15	30	0.0121	50	850	0.063	90	0.0144
20	1000	0.2	30	0.0134	51	850	0.05	90	0.0111
21	1000	0.3	30	0.0209	52	850	0.04	90	0.0079
22	700	0.063	60	0.0057	53	850	0.1	90	0.0299
23	700	0.05	60	0.0049	54	850	0.15	90	0.0425
24	700	0.04	60	0.0031	55	850	0.2	90	0.0383
25	700	0.1	60	0.0122	56	850	0.3	90	0.0531
26	700	0.15	60	0.0145	57	1000	0.063	90	0.0168
27	700	0.2	60	0.0169	58	1000	0.05	90	0.0126
28	700	0.3	60	0.0181	59	1000	0.04	90	0.0092
29	850	0.063	60	0.0078	60	1000	0.1	90	0.0341
30	850	0.05	60	0.0060	61	1000	0.15	90	0.0406
31	850	0.04	60	0.0042	62	1000	0.2	90	0.0440
					63	1000	0.3	90	0.0607

Table 6. *Experimental data for mixture of electrocorundum and siliceous sand*

Mixture of siliceous sand and electrocorundum									
No.	Speed [rpm]	Grain size [mm]	Time[min]	Removed material [g]	No.	Speed [rpm]	Grain size [mm]	Time[min]	Removed material [g]
1	700	0.063	30	0.0019	32	850	0.1	60	0.0084
2	700	0.05	30	0.0016	33	850	0.15	60	0.0011
3	700	0.04	30	0.0009	34	850	0.2	60	0.0101
4	700	0.1	30	0.0030	35	850	0.3	60	0.0132
5	700	0.15	30	0.0050	36	1000	0.063	60	0.0037
6	700	0.2	30	0.0052	37	1000	0.05	60	0.0040
7	700	0.3	30	0.0061	38	1000	0.04	60	0.0034
8	850	0.063	30	0.0023	39	1000	0.1	60	0.0084
9	850	0.05	30	0.0018	40	1000	0.15	60	0.0101
10	850	0.04	30	0.0011	41	1000	0.2	60	0.0109
11	850	0.1	30	0.0041	42	1000	0.3	60	0.0188
12	850	0.15	30	0.0063	43	700	0.063	90	0.0043
13	850	0.2	30	0.0059	44	700	0.05	90	0.0041
14	850	0.3	30	0.0081	45	700	0.04	90	0.0027
15	1000	0.063	30	0.0026	46	700	0.1	90	0.0090
16	1000	0.05	30	0.0018	47	700	0.15	90	0.0115
17	1000	0.04	30	0.0009	48	700	0.2	90	0.0166
18	1000	0.1	30	0.0048	49	700	0.3	90	0.0174
19	1000	0.15	30	0.0057	50	850	0.063	90	0.0071
20	1000	0.2	30	0.0064	51	850	0.05	90	0.0054
21	1000	0.3	30	0.0094	52	850	0.04	90	0.0045
22	700	0.063	60	0.0033	53	850	0.1	90	0.0133
23	700	0.05	60	0.0028	54	850	0.15	90	0.0211
24	700	0.04	60	0.0016	55	850	0.2	90	0.0189
25	700	0.1	60	0.0054	56	850	0.3	90	0.0256
26	700	0.15	60	0.0096	57	1000	0.063	90	0.0051
27	700	0.2	60	0.0079	58	1000	0.05	90	0.0037
28	700	0.3	60	0.0100	59	1000	0.04	90	0.0029
29	850	0.063	60	0.0034	60	1000	0.1	90	0.0090
30	850	0.05	60	0.0034	61	1000	0.15	90	0.0131
31	850	0.04	60	0.0019	62	1000	0.2	90	0.0142
					63	1000	0.3	90	0.0312

Table 7. *Experimental data for mixture of granite and electrocorundum*

Mixture of granite and electrocorundum									
No.	Speed [rpm]	Grain size [mm]	Time[min]	Removed material [g]	No.	Speed [rpm]	Grain size [mm]	Time[min]	Removed material [g]
1	700	0.063	30	**0.0020**	32	850	0.1	60	**0.0085**
2	700	0.05	30	**0.0017**	33	850	0.15	60	**0.0113**
3	700	0.04	30	**0.0010**	34	850	0.2	60	**0.0110**
4	700	0.1	30	**0.0033**	35	850	0.3	60	**0.0153**
5	700	0.15	30	**0.0053**	36	1000	0.063	60	**0.0042**
6	700	0.2	30	**0.0055**	37	1000	0.05	60	**0.0039**
7	700	0.3	30	**0.0062**	38	1000	0.04	60	**0.0032**
8	850	0.063	30	**0.0024**	39	1000	0.1	60	**0.0095**
9	850	0.05	30	**0.0016**	40	1000	0.15	60	**0.0123**
10	850	0.04	30	**0.0011**	41	1000	0.2	60	**0.0113**
11	850	0.1	30	**0.0046**	42	1000	0.3	60	**0.0192**
12	850	0.15	30	**0.0063**	43	700	0.063	90	**0.0051**
13	850	0.2	30	**0.0065**	44	700	0.05	90	**0.0046**
14	850	0.3	30	**0.0083**	45	700	0.04	90	**0.0029**
15	1000	0.063	30	**0.0023**	46	700	0.1	90	**0.0100**
16	1000	0.05	30	**0.0018**	47	700	0.15	90	**0.0134**
17	1000	0.04	30	**0.0014**	48	700	0.2	90	**0.0183**
18	1000	0.1	30	**0.0049**	49	700	0.3	90	**0.0179**
19	1000	0.15	30	**0.0061**	50	850	0.063	90	**0.0076**
20	1000	0.2	30	**0.0073**	51	850	0.05	90	**0.0060**
21	1000	0.3	30	**0.0106**	52	850	0.04	90	**0.0041**
22	700	0.063	60	**0.0030**	53	850	0.1	90	**0.0148**
23	700	0.05	60	**0.0025**	54	850	0.15	90	**0.0226**
24	700	0.04	60	**0.0016**	55	850	0.2	90	**0.0193**
25	700	0.1	60	**0.0067**	56	850	0.3	90	**0.0259**
26	700	0.15	60	**0.0091**	57	1000	0.063	90	**0.0082**
27	700	0.2	60	**0.0086**	58	1000	0.05	90	**0.0066**
28	700	0.3	60	**0.0109**	59	1000	0.04	90	**0.0050**
29	850	0.063	60	**0.0037**	60	1000	0.1	90	**0.0166**
30	850	0.05	60	**0.0033**	61	1000	0.15	90	**0.0198**
31	850	0.04	60	**0.0020**	62	1000	0.2	90	**0.0228**
					63	1000	0.3	90	**0.0323**

Table 8. *Experimental data for mixture of granite and siliceous sand*

Mixture of granite and siliceous sand									
No.	Speed [rpm]	Grain size [mm]	Time[min]	Removed material [g]	No.	Speed [rpm]	Grain size [mm]	Time[min]	Removed material [g]
1	700	0.063	30	**0.0012**	32	850	0.1	60	**0.0053**
2	700	0.05	30	**0.0009**	33	850	0.15	60	**0.0076**
3	700	0.04	30	**0.0006**	34	850	0.2	60	**0.0072**
4	700	0.1	30	**0.0018**	35	850	0.3	60	**0.0101**
5	700	0.15	30	**0.0033**	36	1000	0.063	60	**0.0025**
6	700	0.2	30	**0.0033**	37	1000	0.05	60	**0.0022**
7	700	0.3	30	**0.0038**	38	1000	0.04	60	**0.0022**
8	850	0.063	30	**0.0013**	39	1000	0.1	60	**0.0061**
9	850	0.05	30	**0.0008**	40	1000	0.15	60	**0.0082**
10	850	0.04	30	**0.0005**	41	1000	0.2	60	**0.0074**
11	850	0.1	30	**0.0028**	42	1000	0.3	60	**0.0132**
12	850	0.15	30	**0.0040**	43	700	0.063	90	**0.0033**
13	850	0.2	30	**0.0040**	44	700	0.05	90	**0.0026**
14	850	0.3	30	**0.0053**	45	700	0.04	90	**0.0017**
15	1000	0.063	30	**0.0011**	46	700	0.1	90	**0.0064**
16	1000	0.05	30	**0.0009**	47	700	0.15	90	**0.0089**
17	1000	0.04	30	**0.0005**	48	700	0.2	90	**0.0122**
18	1000	0.1	30	**0.0029**	49	700	0.3	90	**0.0120**
19	1000	0.15	30	**0.0039**	50	850	0.063	90	**0.0050**
20	1000	0.2	30	**0.0048**	51	850	0.05	90	**0.0039**
21	1000	0.3	30	**0.0071**	52	850	0.04	90	**0.0023**
22	700	0.063	60	**0.0017**	53	850	0.1	90	**0.0097**
23	700	0.05	60	**0.0013**	54	850	0.15	90	**0.0153**
24	700	0.04	60	**0.0007**	55	850	0.2	90	**0.0130**
25	700	0.1	60	**0.0045**	56	850	0.3	90	**0.0175**
26	700	0.15	60	**0.0060**	57	1000	0.063	90	**0.0053**
27	700	0.2	60	**0.0055**	58	1000	0.05	90	**0.0040**
28	700	0.3	60	**0.0073**	59	1000	0.04	90	**0.0031**
29	850	0.063	60	**0.0023**	60	1000	0.1	90	**0.0108**
30	850	0.05	60	**0.0018**	61	1000	0.15	90	**0.0131**
31	850	0.04	60	**0.0010**	62	1000	0.2	90	**0.0154**
					63	1000	0.3	90	**0.0220**

Table 9. *Experimental data for mixture of granite, siliceous sand and electrocorundum*

Mixture of granite, siliceous sand and electrocorundum									
No.	Speed [rpm]	Grain size [mm]	Time[min]	Removed material [g]	No.	Speed [rpm]	Grain size [mm]	Time[min]	Removed material [g]
1	700	0.063	30	**0.0018**	32	850	0.1	60	**0.0086**
2	700	0.05	30	**0.0016**	33	850	0.15	60	**0.0127**
3	700	0.04	30	**0.0010**	34	850	0.2	60	**0.0115**
4	700	0.1	30	**0.0037**	35	850	0.3	60	**0.0180**
5	700	0.15	30	**0.0043**	36	1000	0.063	60	**0.0050**
6	700	0.2	30	**0.0054**	37	1000	0.05	60	**0.0038**
7	700	0.3	30	**0.0061**	38	1000	0.04	60	**0.0028**
8	850	0.063	30	**0.0023**	39	1000	0.1	60	**0.0103**
9	850	0.05	30	**0.0017**	40	1000	0.15	60	**0.0129**
10	850	0.04	30	**0.0012**	41	1000	0.2	60	**0.0137**
11	850	0.1	30	**0.0045**	42	1000	0.3	60	**0.0200**
12	850	0.15	30	**0.0063**	43	700	0.063	90	**0.0055**
13	850	0.2	30	**0.0073**	44	700	0.05	90	**0.0049**
14	850	0.3	30	**0.0101**	45	700	0.04	90	**0.0032**
15	1000	0.063	30	**0.0027**	46	700	0.1	90	**0.0119**
16	1000	0.05	30	**0.0018**	47	700	0.15	90	**0.0137**
17	1000	0.04	30	**0.0013**	48	700	0.2	90	**0.0165**
18	1000	0.1	30	**0.0052**	49	700	0.3	90	**0.0198**
19	1000	0.15	30	**0.0067**	50	850	0.063	90	**0.0080**
20	1000	0.2	30	**0.0075**	51	850	0.05	90	**0.0062**
21	1000	0.3	30	**0.0116**	52	850	0.04	90	**0.0043**
22	700	0.063	60	**0.0031**	53	850	0.1	90	**0.0165**
23	700	0.05	60	**0.0027**	54	850	0.15	90	**0.0235**
24	700	0.04	60	**0.0017**	55	850	0.2	90	**0.0213**
25	700	0.1	60	**0.0068**	56	850	0.3	90	**0.0294**
26	700	0.15	60	**0.0080**	57	1000	0.063	90	**0.0093**
27	700	0.2	60	**0.0093**	58	1000	0.05	90	**0.0069**
28	700	0.3	60	**0.0106**	59	1000	0.04	90	**0.0051**
29	850	0.063	60	**0.0044**	60	1000	0.1	90	**0.0188**
30	850	0.05	60	**0.0033**	61	1000	0.15	90	**0.0225**
31	850	0.04	60	**0.0023**	62	1000	0.2	90	**0.0244**
					63	1000	0.3	90	**0.0331**

4. Conclusions

Following the analysis of the experimental data, it appears that the best material removal was done when using powders of abrasive waste (electrocorundum) a maximum quantity of material removed m = 0,0607 grams was registered , followed, in order, by a powder mixture of granite and electrocorundum (m = 0.03312 g), a mixture of granite, siliceous sand and electrocorundum (m = 0.0323 g), a mixture of siliceous sand and electrocorundum (m = 0, 0312 grams), granite powder (m = 0.0244 g), granite and siliceous sand mixture (m = 0.022005 g) and siliceous sand (m = 0.0168 g). These values were obtained at maximum speed and grain size respectively at 1,000 rpm and a grain size of 0.4mm. In other words, the impact of speed is negligible for small grains.

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