The Concentration's Influence of the Abrasive Granules Particles on the Vibratory Finishing Optimization

Rouabhi, Youcef*+
Department of Mechanical & Industrial Engineering, University Mohamed Boudiaf, M'sila, ALGERIA

Lounis, Azzedine
Department of Science & Material Engineering, University of Science Technological Houari Boumediene USTHB, Algiers, ALGERIA

ABSTRACT: *The already initiated studies are based on size and forms of abrasive grains, but few studies have addressed the influence on the concentration of abrasive grains. This research has been done to remove some of the mysteries associated in the media "abrasives" or "chips" used in vibratory and barrel finishing, this process included within the functions and characteristics of media, its types and shapes, also the selection of the best grade for a given task. The present work provides guidance on the influence on the concentration of the particles (grain) of abrasive granules with the main parameters and technological indices of vibratory finishing treatment, in order to optimize abrasive granules and increase the productivity of the vibratory finishing taking into account media, which has certain characteristics, make it unique in its capabilities.*

KEYWORDS: *Particle; Concentration; Abrasive granules; Vibratory finishing.*

INTRODUCTION

The process of the vibratory treatment stemming from the Mass Finishing Technology (MFT), which is a technical term used to describe a mechanical process, chemical-mechanical or physical-chemical-mechanical in which large quantities of parts with any material natures and forms are economically treated for one or several features to improve the surface [1] and [2]. These surface improvements include: deburring, polishing, stabilization of the tensions, coatings, improved surface finish (R_a, R_z, etc.), inhibition, drying, and cleaning.

It is important to understand that these functions are not independent of each other. It is possible to have some or all of these functions in a single process mass finish [3].

The great regularity and repetition of treatment are particularly suitable for high-tech industries, aerospace, nuclear, medical, food, etc. [4]. MFT is based on four key elements, the parts, media, compounds, and equipment [5].

The quality and accuracy of the treated surface parts, the productivity of the process and the cost of the vibratory finishing are defined largely by the cutting properties of granules that are sufficient filler with wear resistance [6], [7] and [8].

Now the requirements for operations in the free abrasive granule is to apply abrasive grains, in order

* *To whom correspondence should be addressed.*
\+ *E-mail: youcefrouabhi7@gmail.com*
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to increase, that [9], which the subsequent development of the vibratory finishing process is impossible without the increase of the quality of applied abrasive granules and of further development of the theory of abrasive treatment, without a thorough study of the physical essence of an occurring process [10].

Taking into account the above-mentioned experimental studies carried out to study the process of vibratory finishing with the use of new abrasive granules. On the other hand, the use of abrasive granules shows that the effectiveness of their application is relatively low.

One of the main reasons determining such as a result is that granules are made of abrasive grains with arbitrary concentration and, as a rule, different volume in the granule's composition [11].

Consequently, many granules, due to the unfavorable concentration weakly participate in the cumulative process of cutting; known scientific work to improve this situation by studying the influence of grain [12].

The effect, as the practice shows, very positive. However, this approach provides only a partial solution to the optimization problem [13], since many factors influence such as the geometry of the cutting wedge grain, orientation, hardness, its granularity filling material and other [14].

With the study of these factors, we can obtain a greater effect of the use of each grain unit, located in the composition of the abrasive granule. Therefore, the goal of raising efficiency and optimization of abrasive grains by controlling the concentration of grains is an important factor, so also analysis of the influence of abrasive grains [15].

This analysis started with the appearance at the beginning of the century by the early work of scientific research by *Alden G.S.* (1914), *Guest J.J.* (1915), *Kurrein M.* (1917), *Chapman W.H.* (1920), *Mourdasov A.V., Babichev A.P.* with his works until nowadays and others.

MATERIALS AND EXPERIMENTAL SECTION

Materials & theoretical dependences of concentration abrasive grains

To control the regularity of the theoretical dependences describing the influence of the concentration of abrasive grains on metal, we apply the removing action from the surface of processed models. On the steady roughness parameters and on their processing time, we were used abrasive granules in the form of cones of dimension 25 mm with a diverse concentration C_g from 20 to 70%. Experimental studies use vibratory machines with the rectangular Fig. 1.a, and the circular working chamber Fig. 1.b with the processing mode: oscillation amplitude A Varying from 2 to 2,5 mm and oscillation frequency w 16,7 to 26,7 Hz.

(a)

(b)

Fig. 1: (a) Vibratory machines rectangular, (b) Circular work chamber.

The advantage of the applied equipment is the simplicity of construction, convenience of operation, universality and successfully works in many factories.

The environment of the experience

For the bindings abrasive granules we used the bundle (polyethylene-methacrylate + methylene-methacrylate), and for the filling material normal fused alumina (electro-corundum) with grain size 100 µm.

The experiments were conducted with a continuous flushing (5% aqueous solution of sodium carbonate), the material of models is steel 45 (yield strength s_s=1000 Mpa, heat processing quenching and tempering (200° C), hardness 335-345 HB).

Mathematical formulas and operational indicators of abrasive granules

The basic operational indicators of abrasive granules calculated and based on the processing of the test results obtained from empirical equations [15], the application is limited to the study of values abrasive content:

Table 1: 20% abrasive.

№	t, h	Q, g	I_m,g	P_m,g/h	R10^{-4}, g/h.cm^2	U,%/h	C_p10^{-5}, 1/cm^2	R_a, μm
1	1	0,013	16,25	16,25	0,269	0,913	0,165	3,136
2	1	0,016	16,8	16,8	0,331	0,944	0,197	2,715
3	1	0,022	19,35	19,35	0,455	1,087	0,235	2,065
4	1	0,011	10,73	10,73	0,227	0,603	0,212	2,023
5	1	0,018	10,5	10,5	0,372	0,589	0,354	2,15
a. value		0,016			0,331	0,8272	0,2326	2,4178

- Concentration of abrasive grains $C_g = (V_a / V_c) \times 100\%$

Where V_a is the Volume of abrasive grains, V_c design volume containing abrasive layer (bundle).

- Cutting capacity of abrasive grains:

$$R_{cc} = Q/t \cdot S_{mod} \;\; ; \; (g/h) \cdot cm^2 \tag{1}$$

$$R_{cc} = (r_0 + k_a \cdot V_a) \cdot 10^{-4} \tag{2}$$

Where Q is the Metal removal from the surface of the model; t processing time; S_{mod} surface area of the model; $r_0 = k_a$ empirical coefficients.

Consumption expenditure of abrasive grains:

$$Pm = Im/t \;\; ; \;\; g/h \tag{3}$$

$$P\nu = I\nu/t \;\; ; \;\; (dm^3)/h \tag{4}$$

Where Im, I_V are weight and volume respectively, of the spent working layer granules.

- Processing factor (specific material removal):

$$Cp = \left(Q/(I_m \cdot S_{mod})\right), \; \left(1/(cm^2)\right) \tag{5}$$

$$K_0 = \left(b_a - c_a \cdot V_a + q_a \cdot V_a^2\right) \times 10^{-5} \tag{6}$$

Where b_a, c_a and q_a are empirical coefficients.

- Wear resistance of abrasive granules:

$$U = Im/M(\%/h) \, , \; U = u_0 + k_a . V_a \tag{7}$$

Where u_a, k_a empirical coefficients, M is one hour of the total initial weight of abrasive granules.

- Established roughness under normal processing conditions (minimum value R_a of machined models is achieved at fixed processing modes).

Fig. 1.a vibratory machines rectangular and Fig. 1. b circular work chamber

Process loading of treatment

The experiments were carried out with freeloading models in the work chamber; the loading volume of the work chamber and models was 80% of the volume of the work chamber. As the control parameters have been taken: The mass of the models studied and the abrasive granules, the parameter's oscillation of the machine tool and a roughness of the processed surface. Before carrying out of experimental researches all granules were processed previously for 30 minutes to one hour, as well as models were processed separately for 1-2 hours. The results of the experiments are presented in Tables 1 to 5 and Graphs 1 to 5.

RESULTS AND DISCUSSION

The concept of surface preparation includes, in industrial practice, a large number of processes or processing lines, which aims to give the treated surface is particular physicochemical properties (composition, inclusion cleanliness, appearance, wettable, adhesion...) or specific mechanical or geometrical properties (roughness; surface stresses; tribological characteristics...). These properties are presented as the results of experiments in the Tables 1 to 5 and the Figs. 4 to 8.

Fig. 7 and Fig. 8 represent the results, which are visible traces of contact with the media with the surface of steel 45.

Fig. 7 Traces of contact of the media with the surface of steel 45 after 20 min before treatment (x 15)

Fig. 8 Traces of contact of the media with the surface of steel 45 after treatment

The results show:

By increasing the volume content of abrasive granule growth in its cutting capacity, is due to the increasing quantity of abrasive grains on a unit surface granule.

Table 2: 40% abrasive.

№	T, h	Q, g	I_m, g	P_m, g/h	R10^{-4}, g/h.cm^2	U,%/h	C_p10^{-5}, 1/cm^2	R_a, µm
1	1	0,079	13,3	13,3	1,632	1,293	1,227	2,729
2	1	0,077	13,7	13,7	1,5909	1,332	1,161	2,612
3	1	0,048	12,6	12,6	0,992	1,225	0,787	2,415
4	1	0,096	34,45	34,45	1,98	1,639	0,576	1,607
5	1	0,065	11,21	11,21	1,34	1,089	1,198	1,625
a. value		0,073			1,507	1,3156	0,9898	2,1976

Table 3: 50% abrasive.

№	T, h	Q, g	I_m, g	P_m, g/h	R10^{-4}, g/h.cm^2	U,%/h	C_p10^{-5}, 1/cm^2	R_a, µm
1	1	0,099	7,5	7,5	2,045	0,403	2,727	2,204
2	1	0,104	10,75	10,75	2,149	0,578	1,999	1,722
3	1	0,101	11,20	11,20	2,087	0,602	1,863	1,532
4	1	0,096	9,85	9,85	1,984	0,529	2,014	1,431
5	1	0,1	9,25	9,25	2,066	0,497	2,234	1,317
a. value		0,1			2,0662	0,522	2,1674	1,6412

Table 4: 60% abrasive.

№	T, h	Q, g	I_m, g	P_m, g/h	R10^{-4}, g/h.cm^2	U,%/h	C_p10^{-5}, 1/cm^2	R_a, µm
1	1	0,105	9	9	2,169	0,589	2,41	2,857
2	1	0,136	12,5	12,5	2,809	0,818	2,248	2,016
3	1	0,118	15,7	15,7	2,438	1,028	1,552	1,22
4	1	0,084	9,05	9,05	1,736	0,592	1,9177	1,1
5	1	0,102	11,55	11,55	2,107	0,756	1,8246	0,972
a. value		0,109			2,2518	0,7566	1,991	1,633

Table 5: 70% abrasive.

№	T, h	Q, g	I_m, g	P_m, g/h	R10^{-4}, g/h.cm^2	U,%/h	C_p10^{-5}, 1/cm^2	R_a, µm
1	1	0,025	14,10	14,10	0,517	0,923	0,366	3,278
2	1	0,018	17,65	17,65	0,372	1,155	0,211	2,963
3	1	0,014	18	18	0,289	1,178	0,161	2,53
4	1	0,014	13,8	13,8	0,289	0,903	0,209	2,13
5	1	0,013	14,5	14,5	0,269	0,949	0,185	1,94
a. value		0,0168			0,347	1,0216	0,2264	2,568

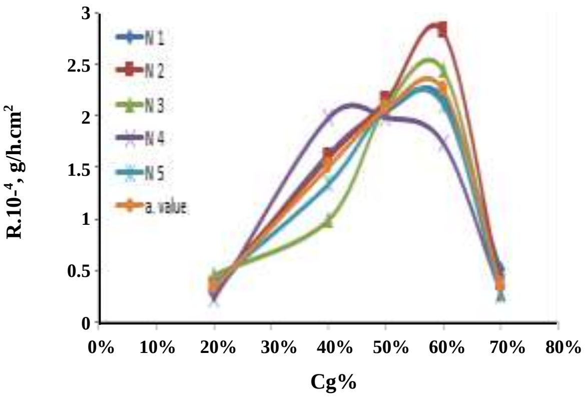

Fig. 2: Change of cutting capacity.

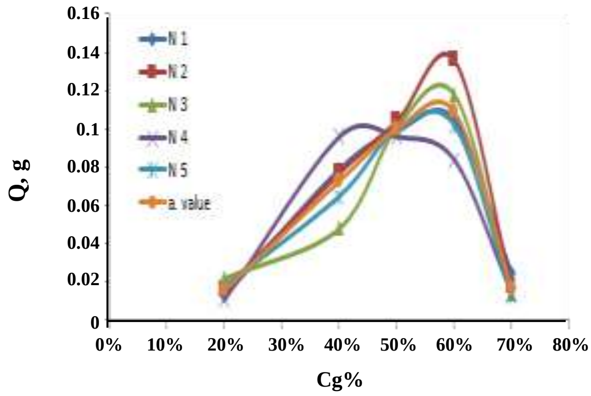

Fig. 4: Change metal-removing.

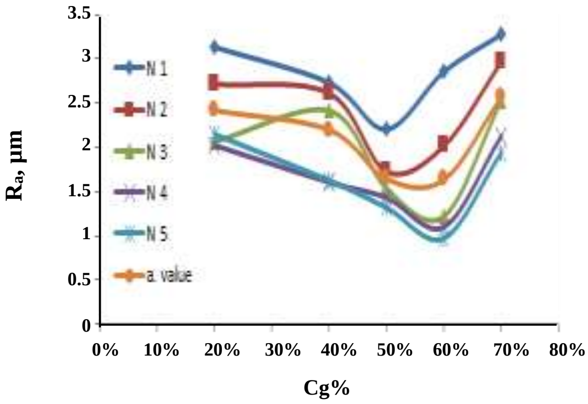

Fig. 3: Change steady roughness.

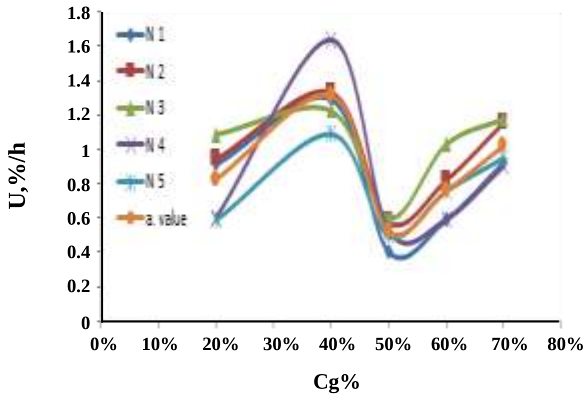

Fig. 5: Change wear resistance.

Fig. 6: Traces of contact of the media with the surface of steel 45 after 20 min before treatment (x 15)

Fig. 7: Traces of contact of the media with the surface of steel 45 after treatment.

And, when interacting with the treated surface in the work involved a greater number of grains that are accompanied by an increase in the metal removal per unit surface (see Fig. 2)

The resulting equations show that with a greater quantity of abrasive grain the wear resistance increases. This is due to the decrease in the volume of binder granules, which reduces the possibility of keeping the grains and leads to increased wear and tear (see Fig. 5).

In the study of the roughness of the processed surface is marked by some growth it increased volume content of abrasive, and under discussion of the considered indicators (the ratio of abrasive-bundle) have no relevant impact on the change of surface roughness (see Fig. 6).

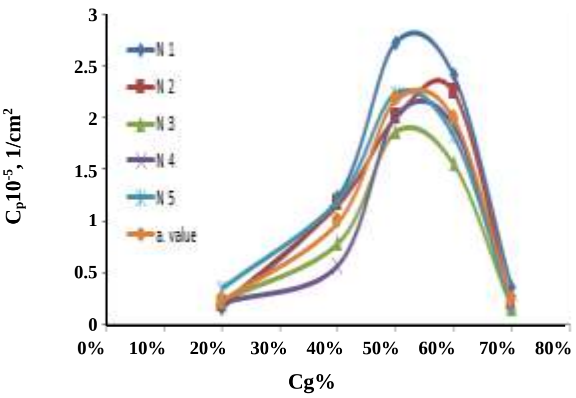

Fig. 8: Changes in the processing factor.

With the important content of the abrasive grain in granule volume its hardness increases, due to the considerable quantity of abrasive grains in a unit volume of the granules and with increased hardness, cutting capacity of abrasive grains is augmented, the wear resistance and the roughness increase also.

CONCLUSIONS

Taking into account the result of the experimental studies carried out based on the principles and provisions of the systems analysis, it solved a prominent scientific challenge with important industrial and economics major.

The basis of the mechanism of action of new non-polluting abrasive granules are developed at vibratory finishing, which includes a set of phenomenological models that take into account the character and parameters of processes in contact "granule-part," allowing to conduct a purposeful search of the optimum composition of the abrasive granules.

Analyzing the results; we can conclude that the theoretical models describing their movable of metal from the surface of machined parts, parameters of the steady roughness and the time to achieve it correctly determine the influence of the concentration of abrasive grains in the granules on the processing parameters.

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