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Analysis of the dressing process using stationary dressing tools

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Abstract

Grinding process is a very important process in machining industry to manufacture high quality part. The correct preparation of grinding wheel involves dressing process taking importance to optimize grinding process. Due to the different dressing tools types, it is very difficult to find the most adequate tool for a particular application. In this work, a systematic analysis of stationary multipoint and blade dressing tools have been carried out attending to the influence of dressing parameters in wheel performance and in its wear. The obtained results reflect the importance of a correct choosing both of the dressing tools and dressing parameters.

Keywords: grinding; dressing; performance; wear; wheel

1. Introduction

Grinding process is a very important machining process that is characterized by the high quality of ground parts and by its capability to machining hard materials. One of the most important aspects in the process is the grinding wheel. Dressing process is employed to regenerate the abrasive capability of the grinding wheel once it has loose it due to the excessive wear after having worked some time.

There are a lot of types of dressers in the industry including static and rotary ones or single point multipoint and needle ones [1]. This variability in dressers types make very difficult to analyze their performance systematically. This

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fact reflects in the grinding industry where the choosing of the correct dresser and adequate dressing parameters for a particular application is one of the most important and difficult aspect to be defined [2].

This way, is very difficult to find in the specialized bibliography references analyzing the influence of the dressing parameters in the process performance. One of the first works that can be found in bibliography is the work by Inasaki and Okamura [3]. In that work the authors analyzed the influence of dressing parameters in grinding process when dressing with single point stationary dressers using acoustic emission. Their results showed that the most important parameter was the feed speed (v_{fd}) employed in dressing process. Additionally they tried to correlate the acoustic emission signal with the obtained roughness in the ground surface.

The results obtained by Inasaki and Okamura [3] were later confirmed by Coelho et al. [4] in a later work in which the authors could correlate the acoustic emission, the wheel sharpness and the dressing parameters. They conclude that for high values of both v_{fd} and a_d, the wheel sharpness increases.

In a very extensive work Shi et al. [5, 6] analyzed the blade dresser behavior attending to the influence of dressing parameters on wheel performance and dresser wear. They firstly defined the dressing wear ratio and used it to evaluate the wear suffered by dresser. They found that the dresser wear was dependent of the value of chosen dressing parameters so the wear trends were different for high values of ad and v_{fd} comparing with those obtained for low a_d and v_{fd} values.

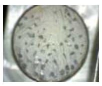
Linke and Klocke along two works [7, 8] made a complementary study to that made by Shi et al [5, 6] and confirmed the different trends of dresser wear depending on the values adopted by dressing parameters.

The analyzed works reflect the importance of the dressing process in grinding performance but the big variability of the dressing tools existing in the industry makes very difficult to have a general idea of the process behavior. In this work the performance of different dressers type is going to be analyzed attending to two different factors, the influence of dressing parameter in the process performance and the wear of the proposed dressers. In this case multipoint and blade stationary dressing tools will be analyzed. Taking into account the industrial importance of this kind of dressers the author thinks that the contribution of this work has a very big relevance both from scientific point of view and from the industrial one.

2. Materials and methods

The analysis of the performance of static dressers will be done in two steps. The first step will consist of an experimental work focused on the analysis of the dressing parameters in the dressing process and in the quality of the ground part. For this purpose an industrial case is chosen and six types of static dressers are analyzed. The proposed dressers can be seen in the Table 1. Dressers 1 to 5 (D1-D5) are multipoint dressers in which diamond grains are inserted in the metallic matrix of the dresser. The sixth one (D6) is a blade dresser in which the diamonds are square section needles inserted in the metallic body of the diamond. The tests have been carried out in a BLOHM Orbit 363 CNC surface grinding machine. The reference of the employed grinding wheel for the experimental work is: 4MBA 46G12V489P20P (400x40x203.2).

Table 1. Dressers employed for the experimental analysis.

	D1			D2	
	Type	Multi-point		Type	Multi-point
	Dimensions	20 x 7		Dimensions	20 x 6
	D3			D4	
	Type	Multi-point		Type	Multi-point
	Dimensions	Ø13		Dimensions	Ø17
	D5			D6	
	Type	Blade tool		Type	Blade tool
	Dimensions	20		Dimensions	20

For each selected dresser different values of depth of cut (a_d) and feed speed (v_{fd}) are chosen. The proposed tests can be seen in Table 2 and they have been done for each proposed dresser. In each test 4 dressing passes have been carried out measuring the power consumption during process with a Load Controls-UPC power measurement device installed in the grinding machine.

Table 2. Test for the experimental analysis of the influence of dressing parameters in grinding process.

Test nº.	1	2	3	4	5	6
ad [mm]	0.05	0.05	0.05	0.1	0.1	0.1
vfd [mm/min]	60	500	850	60	500	850

After the dressing process, a workpiece has been ground (GG30 cast iron, 200x500x40). Grinding parameters employed in the process can be seen in Table 3. In this case, the power consumption and the ground part roughness have been measured during and after the grinding process respectively.

Table 3. Parameters of grinding process

Parameter	Value
a_e [mm]	0.02
v_w [mm/min]	20
v_s [m/s]	35
v_f [mm/min]	252

Parameter	Value
Qw' [mm^3/mm•s]	6.7
qs	105
Passes	3
Spark off passes	5

The second step of the analysis will be focused on the wear suffered by the dressers after several dressing passes and its influence on the quality of the ground parts. This way, for given dressing parameters (Table 4), up to 1,000 dressing passes will be carried out. After the next 350 dressing passes, the wear suffered by the diamond will be measured (using a micrometrical dial gage). This process will be repeated every 50 dressing passes up to reach 1,000 dressing passes.

Table 4. Dressing parameters for the wear test.

a_d [mm]	v_s [m/s]	v_{fd} [mm/min]
0.1	35	252

3. Discussion of results

Firstly, the results obtained in the analysis of the dressing parameters are going to be presented. This way, in the Fig.1 the results corresponding to the power consumption in each case are shown. The results corresponding to the 1 to 3 tests are shown in Fig.1a, and the results for the tests 4 to 6 are shown in Fig.1b.

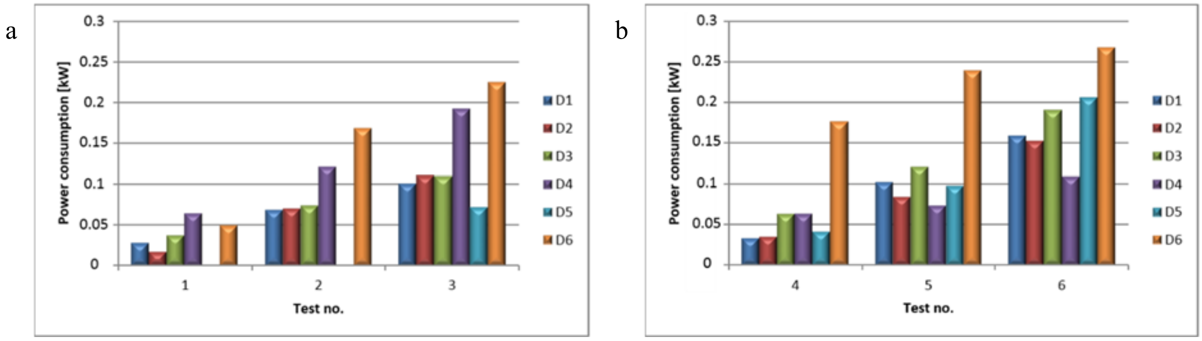


Fig. 1. Results of dressing power consumption (a) tests 1-3 (b) tests 4-6.

As it can be seen two clear tendencies can be shown in these results. On the one hand, the multipoint dressers (D1 to D5) show similar power consumption with very low differences between them. On the other hand, the blade dresser (D6), where the diamonds are needles, presents higher power consumption during dressing (over 100% higher in most cases). Several conclusions can be obtained from these results, first of all, for a same type of employed diamonds (grains in this case), the behavior of the geometry (different shapes circular or rectangular sections) of the dresser attending to the dressing power consumption has no influence in the process performance. However if the type of diamond form and shape is changed the power consumption varies quite a lot. From these results it could be concluded that higher power consumption could generate a higher mechanical damage in the wheel for the later grinding process affecting to the quality of the ground part or to the life of the grinding wheel.

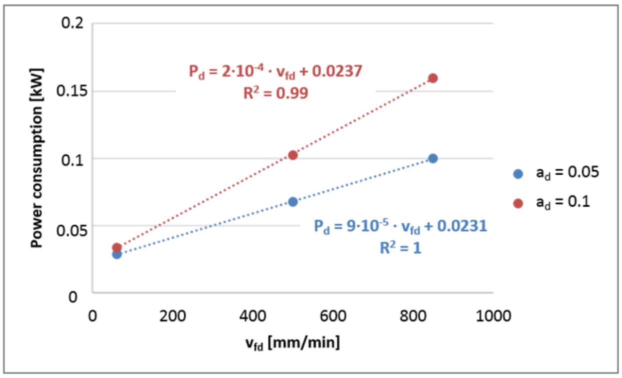


Fig. 2. Power consumption for D1 dresser.

In addition the variation of the dressing parameters has a great influence on the power consumption during dressing. This way the increase of depth of cut (a_d) and/or feed speed (v_{fd}) implies the increase of power consumption during process. In Fig.2 the results for D1 are shown. As it can be seen the mathematical interpolation gives a completely linear relationship between the feed speed increase and the power consumption increase. This tendency cannot be confirmed by the analysis of the influence of depth of cut (a_d) because not enough experimental tests have been carried out. Anyway, for higher the feed speed is, the higher the influence of the depth of cut in consumed power is. The tendency observed in all cases confirms these results.

The results of power consumption during the grinding process with the parameters shown in Table 3, are shown in Fig.3. As it can be seen the results are highly dependent of the dressing parameters but not of the type of dresser, this way the obtained power consumption consume during grinding is quite similar in all the cases (except for the test 4 for D1 and D2 and test 3 for D2, D3 and D4). This fact implies that for static dressers the process performance depends mainly in the selected dressing parameters.

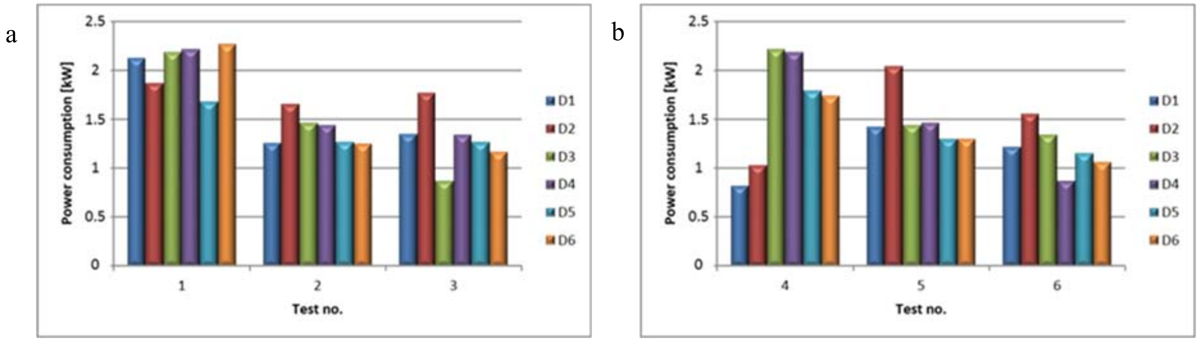


Fig. 3. Results of grinding power consumption. (a) tests 1-3; (b) tests 4-6.

Analyzing the influence of the mentioned dressing parameters, in general it can be seen that when the higher the feed speed is, the lower the power consumption during grinding process is. These results are coherent with the idea of that a more aggressive dressing parameter imply a high sharpness grinding wheel leading to low power consumption and poor surface quality parts and non-aggressive dressing parameter imply low sharpness grinding wheel leading to high power consumption and good surface quality parts.

In Fig.4 results corresponding to D5 are shown. As it can be seen, the depth of cut (a_d) has no influence on the wheel performance. The feed speed (v_{fd}) however, has a very big influence noting that for a higher v_{fd}, lower power consumption. In addition the results for the D5 presented show that once a determined value of the v_{fd} is reached the power consumption does not decrease. This tendency is observed in most cases analyzed. Anyway, the values for the depth of cut (a_d) employed in this work are quite high for dressing process, it would be interesting to analyze the process performance for low values of a_d.

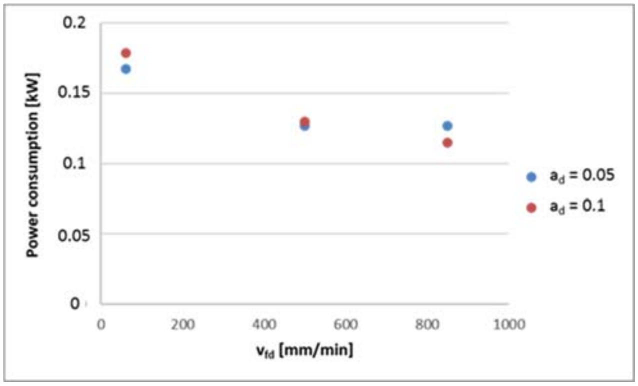


Fig. 4. Power consumption evolution during grinding for D5.

Finally the results corresponding to the roughness on the ground part are presented. In Fig.5, the results are shown as in previous cases. Results corresponding to tests 1 to 3 are shown in Fig.5a and the results corresponding to the tests 4 to 6 in Fig.5b. The most relevant aspect to be underlined is that for D5 the obtained value for Ra is quite higher than in other cases. The shape of this dresser is similar to the D6 ones but being a multipoint dresser, this is, this dresser tries to combine two different types of dresser, the results according to the obtained roughness is not good. In addition D1 and D2 present similar values of Ra and the difference between them is quite small. However, D3 and D4 present more variations of Ra values according to the dressing parameters. These results reflect that the shape of multipoint dressers is quite important for the Ra achieved in the ground part. D6 presents a behavior similar to D3 and D4 but having bigger variation in Ra. This way it can be concluded that depending on the shape a multipoint dresser can modify the wheel performance attending to the Ra reached and that for blade dressers the obtained Ra is a bit higher than with multipoint dressers.

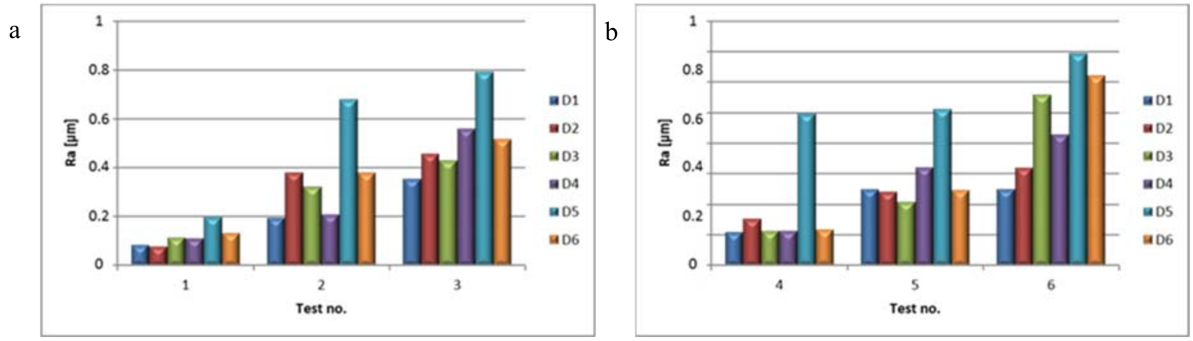


Fig. 5. Results of surface roughness of ground part. (a) tests 1-3, (b) tests 4-6.

Attending to the results of the wear of the dressing tests, in Fig.6, the obtained Dressing Ratio for each dresser is presented. The dressing ratio is defined as the value obtained by dividing diamond wear rate and removed wheel material. As it can be seen, D5 presents a wear ratio much higher than the other ones, This fact together with the roughness results reflects the poor quality of the proposed dresser. Taking into account the other results it can be concluded that the difference between them is not relevant so the decision on taking one or another dresser must be adopted taking into account the performance analyzed in previous results of influence of dressing parameters on the quality of the ground part.

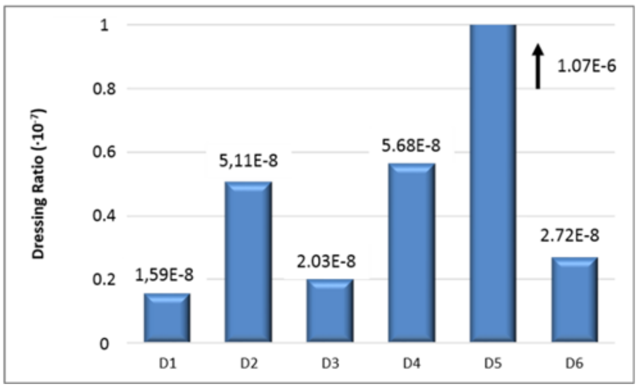


Fig. 6. Dresser dressing ratio for each case.

4. Conclusions

The main conclusions obtained in this work are the following ones:

- Attending to the power consumption during dressing depends mainly of two parameters: the type of dresser (multipoint or blade dresser) and the dressing parameters. Blade diamond presents higher power consumption during grinding than multipoint ones and for higher v_{fd} or a_d values, higher power consumptions are observed.

- Attending to the performance of the wheel in the later grinding process, it can be seen that the power consumption is quite similar for all the dressers employed so the type of dresser is not an important parameter in this field.

- The roughness obtained in the grinding process however is highly dependent on the grinding parameters, type of dresser and its shape. This way rectangular multipoint dressers present a low variation roughness results, whereas the round multipoint dressers present more variable but still low roughness results. Finally blade dresser show higher variability depending on the dressing parameters and, in general higher roughness results than multipoint dressers.

- The wear of the diamonds present similar tendencies and its value, for multipoint dressers, is mainly dependent of the quality of the bonding material. In the case of blade tool its wear is mainly dependent of the quality of employed diamond.

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