CONTRIBUTIONS REGARDING THE ABRASIVE GRANULES WEAR OF IN THE PROCESSING SUPERFINISHING

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SUMMARY
This paper is about the study of worn-out abrasive in the processing of superfinishing the gray cast iron. The authors have accomplished theoretical and experimental researches on three sizes of granules (600, 800, 1000 meshes / inch). As a result of the experimental researches, there were established evaluation relations of the volume of worn-out material. The authors present the independent variables, the variables depending on the Fgn 700-2 and Fc 250 material superfinishing process with abrasive tools, the process functions for the superfinishing processing and the regress functions form based on an experimental project. There are some independent variables that have a negative influence on the process functions, so there must be a collaboration in order to choose the best technological solution based on the experimental results too. This paper briefly presents a research methodology and the analytical relations based on the experimental results.

Keywords: wear, processing of superfinishing, technological parameters

1 INTRODUCTION
The main objectives of this paper are: the achievement of a methodology in order to determinate the process functions using mathematical statistics; the establishment of the best experimental project, correlated with previous information, offered by the scientific literature and the authors experience; the analysis of the obtained results for their application in the products manufacturing practice.

2 THE DEFINITION OF THE PROCESS VARIABLES INDEPENDENT
In order to determinate the superfinishing process functions, according to the paper objectives, there were established the following measures as constants and independent variables:

a) constant technological parameters:
1) the nature and properties of the processed material;
2) the nature and properties of the splinter tool;
3) the nature and properties of the cooling liquid.

b) variable technological parameters:
1) the circular advance speed of the piece vs [m/min];
2) the working pressure of the tool on the processed area - p [bar];
3) the frequency of the processed head f [cd/min];
4) the processing time - tbe [s].

2.1 The circular advance speed of the piece
The circular advance speed vs (the rotation speed of the piece) at cast irons processing has the central value vs = 7,261 m/min.

The minimal and maximal values are:
vs min = 4,1 m/min and vs max = 12,86 m/min.
These three values are in a geometrical progression (table 3).

2.2 The working pressure of the tool on the processed area
The working pressure is an important parameter in the superfinishing processing. The central pressure was the one that producers recommended to the beneficiary (ATLANTIC firm to DACIA S.A.). For the Fgn 700-2 and Fc 250 cast irons processing, in the scientific literature varied values for the working pressure are recommended. That’s why p = 1,8 bar value was used as a central one in the experimental program.
The minimal and maximal values are: pmin = 1,5 bar and pmax = 2,16 bar. These three values are in a geometrical progression (table 3).

2.3 The frequency of the processed head
The frequency of the tool holder head, f, has the central value f = 1500 cd/min. The minimal and maximal values are:
f min = 1250 cd/min and f max = 1800 cd/min.
These three values are in a geometrical progression (table 3).

2.4 The processing time
The basic experimental time tbe was chosen as it follows: central value tbe = 42 s; the minimal and maximal values are:
tbe min = 15 s and tbe max = 118 s.
These three values are in a geometrical progression (table 3). The other parameters hadn’t a significant influence on the superfinishing stones wear. Their influence was studied in [3].
3 THE ESTABLISHMENT OF THE VARIABLES DEPENDING ON THE ABRASIVE TOOLS WEAR

Regarding the tools wear, the processing studies show that the tools lasting is very important (the wear value that determines the superfinishing tools lasting).

The determination of the best lasting criterion is a technical - economical problem for the processing method, which influences directly the processed area quality.

In the absence of some theoretical and experimental data, regarding the abrasive tools wear to such processing, the author has introduced the notion of worn unitary volume $V_u$, which represents the tool material volume [cm$^3$] lost through wear, in comparison with one cm$^2$ area [cm$^3$/cm$^2$].

In order to measure the worn unitary volume, we made ten measures for which we calculated the arithmetical mean.

4 THE METHODS AND MEANS USED IN RESEARCH PROCESS

The test tubes subdued to superfinishing processing are characterized by shape, dimensions and material.

The following shape and dimensions (fig.1.) are for the processing without longitudinal advance.

![Fig. 1: The samples sketch for the superfinishing without longitudinal advance experiment](image)

The test tubes dimensions were chosen with these values in order to obtain a material homogeneity from the chemical composition, as well as from the structure point of view. The homogeneity is a problem in the casting of the parts [3], [8].

![Fig. 2: The general view of experimental research stand](image)

The admitted deviations for the test tubes are in the 7th stage of precision and the rugosity $R_a < 0.8$ μm. The samples precision and quality were made by 2 steps rectification (jacking and finishing).

Considering the nature of the pieces material, very important in the engineering industry, especially the car industry, its industrial utilization, the possibilities of the experimental test tubes obtaining, the possibilities of the results extend, there were established two research materials: Fgn 700-2, STAS 6071-82, intended for the crankshaft fabrication for Dacia and Fc 250, STAS 568-82, intended for cam axis fabrication, also for Dacia.

All the test tubes made from the same material were casted from the same charge, in order to avoid the eventual composition and structure non-homogeneity. This condition was necessary for obtaining a standardized hardness for all test tubes.

The chemical composition is presented in table 1, according to Dacia prescriptions.

The mechanical characteristics are presented in table 2. Because the material hardness was not considered a process variable, it was necessary to cast the test tubes with feedhead on the entire length of the preform.

The stand for the experimental research is shown in fig.2.

<table>
<thead>
<tr>
<th>No.</th>
<th>Symbol</th>
<th>C</th>
<th>Mn</th>
<th>Si</th>
<th>P</th>
<th>S</th>
<th>Cr</th>
<th>Ni</th>
<th>Other elements</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fgn 700-2</td>
<td>3.5 - 3.7</td>
<td>0.3-0.5</td>
<td>2.1-2.5</td>
<td>&lt;0.02</td>
<td>&lt;0.02</td>
<td>0.3-0.5</td>
<td>0.5-0.7</td>
<td>-</td>
<td>P+Cg</td>
</tr>
<tr>
<td>2</td>
<td>Fc250</td>
<td>3.4-3.6</td>
<td>1-1,1</td>
<td>1.8-2.1</td>
<td>0.15</td>
<td>0.1</td>
<td>max 0.14</td>
<td>-</td>
<td>-</td>
<td>P+F+Cg</td>
</tr>
</tbody>
</table>

Table 1: The chemical composition (%) of the cast irons used at the experimental test tubes elaboration

<table>
<thead>
<tr>
<th>Material</th>
<th>$R_m$ N/mm$^2$</th>
<th>$R_{0.2}$ N/mm$^2$</th>
<th>$R_t$ N/mm$^2$</th>
<th>$A_S$ %</th>
<th>HB N/mm$^2$</th>
<th>F mm</th>
<th>$R_{comp}$ N/mm$^2$</th>
<th>$R_1$ N/mm$^2$</th>
<th>E GN/mm$^2$</th>
<th>KCU J/cm$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fgn 700-2</td>
<td>700</td>
<td>450</td>
<td>850-1200</td>
<td>2</td>
<td>230-300</td>
<td>-</td>
<td>1500-2000</td>
<td>160-200</td>
<td>175-185</td>
<td>8-20</td>
</tr>
<tr>
<td>Fc250</td>
<td>210-320</td>
<td>-</td>
<td>380-450</td>
<td>-</td>
<td>180-240</td>
<td>3-7</td>
<td>700-1000</td>
<td>-</td>
<td>110-130</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2: The Fgn 700-2 and Fc 250 cast irons mechanical characteristics
5 THE EXPERIMENTAL DATA

The experimental program was established according to the methodology [3], [5], [6], [10]. The natural as well as the coded values are presented in table 3. For each tool-material couple, it was established an experimental project after the general sketch described in table 4.

In table 4 there are four independent entrance variables, \( X_i \) \((j = 1, 2, 3, 4)\), represented by their codes (table 3), and \( X_v \), the exit values (table 4).

After processing the experimental data, there were obtained the analytical relations from table 5.

### Table 3: Independent variables with natural and coded levels for the experimental project

<table>
<thead>
<tr>
<th>No</th>
<th>( v ) [m/min]</th>
<th>( p ) [bar]</th>
<th>( f ) [cd/min]</th>
<th>( t ) [sec]</th>
<th>Abrasive tool</th>
<th>Abrasive tool</th>
<th>Abrasive tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(-1)</td>
<td>(-1)</td>
<td>(-1)</td>
<td>(-1)</td>
<td>Fgn 700-2</td>
<td>Fc 250</td>
<td>Fgn 700-2</td>
</tr>
<tr>
<td>2</td>
<td>(+1)</td>
<td>(-1)</td>
<td>(-1)</td>
<td>(-1)</td>
<td>0.012</td>
<td>0.0125</td>
<td>0.001</td>
</tr>
<tr>
<td>3</td>
<td>(-1)</td>
<td>(-1)</td>
<td>(-1)</td>
<td>(-1)</td>
<td>0.01275</td>
<td>0.0127</td>
<td>0.0011</td>
</tr>
<tr>
<td>4</td>
<td>(+1)</td>
<td>(-1)</td>
<td>(-1)</td>
<td>(-1)</td>
<td>0.01125</td>
<td>0.0112</td>
<td>0.0009</td>
</tr>
<tr>
<td>5</td>
<td>(-1)</td>
<td>(-1)</td>
<td>(-1)</td>
<td>(-1)</td>
<td>0.01125</td>
<td>0.0112</td>
<td>0.0009</td>
</tr>
<tr>
<td>6</td>
<td>(+1)</td>
<td>(-1)</td>
<td>(-1)</td>
<td>(-1)</td>
<td>0.01125</td>
<td>0.0112</td>
<td>0.0009</td>
</tr>
<tr>
<td>7</td>
<td>(-1)</td>
<td>(+1)</td>
<td>(-1)</td>
<td>(-1)</td>
<td>0.01125</td>
<td>0.0112</td>
<td>0.0009</td>
</tr>
<tr>
<td>8</td>
<td>(+1)</td>
<td>(+1)</td>
<td>(-1)</td>
<td>(-1)</td>
<td>0.01125</td>
<td>0.0112</td>
<td>0.0009</td>
</tr>
</tbody>
</table>

### Table 4: The central project for the experimental research

\[
V_u = C_{vu} v^x p^y f^z t^y, \quad \text{the coefficients and exponents are those established in table 4.}
\]

6 CONCLUSIONS

The authors established:

- the process dependent and independent variables at Fgn 700-2 and Fc 250 cast irons superfinishing processing with abrasive tools EK 600 0.613.5VKHS, F800/9N and F1000/9N;
- the experimental plans after recorded measures;
- the process functions for Fgn 700-2 and Fc 250 cast irons superfinishing processing with abrasive tools EK 600 0.613.5VKHS, F800/9N and F1000/9N;
- the general form for the regression process functions at Fgn 700-2 and Fc 250 cast irons processing with abrasive tools EK 600 0.613.5VKHS, F800/9N and F1000/9N: \( V_u = C_{vu} v^x p^y f^z t^y \), the coefficients and exponents are those established in table 4.
The authors observed that:

- the last three independent variables have a negative influence on the regression process functions

\[ V_u = C_{Vu} V_x^{p_1} V_y^{p_2} V_z^{p_3}, \]

- the regression process functions must be established by the beneficiary, in cooperation with the experts, in order to take the best technological decision;
- the frequency and the work pressure for all the experiments have the greatest influence on the regression process functions.

### Table 5: The mathematical relations of the worn unitary volume \( V_u \) after the experimental research processed with non-linear mathematics regression from which insignificant influences (\( X_1 [1], X_2 [2], X_1 [1] X_3 [3], X_1 [1] X_4 [4], X_2 [2] X_3 [3], X_2 [2] X_4 [4], X_1 [1] X_3 [3], X_1 [1] X_4 [4] \)) were eliminated

<table>
<thead>
<tr>
<th>Processed material</th>
<th>Abrasive tool symbol</th>
<th>Equations obtained through the non-linear mathematics regression method for the used unit volume [cm³/cm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fgn-700-2</td>
<td>EK 600 0613.5 VKHS</td>
<td>[ V_u = \frac{8.34688667 \cdot 10^{-7} p_{0.644581} f_{1.214} t_{be}^{0.22482}}{V_x^{0.06463}} ]</td>
</tr>
<tr>
<td>Fgn-700-2</td>
<td>F800/9H</td>
<td>[ V_u = \frac{5.0483384 \cdot 10^{-8} p_{0.668759} f_{1.17852} t_{be}^{0.33313}}{V_x^{0.00918}} ]</td>
</tr>
<tr>
<td>Fgn-700-2</td>
<td>F1000/9H</td>
<td>[ V_u = \frac{3.333325 \cdot 10^{-8} p_{0.70936} f_{1.2505} t_{be}^{0.23575}}{V_x^{0.06857}} ]</td>
</tr>
<tr>
<td>Fc250</td>
<td>EK 600 0613.5 VKHS</td>
<td>[ V_u = \frac{5.814 \cdot 10^{-7} p_{0.69652} f_{1.2794} t_{be}^{0.20801}}{V_x^{0.08003}} ]</td>
</tr>
<tr>
<td>Fc250</td>
<td>F800/9H</td>
<td>[ V_u = \frac{1.036242 \cdot 10^{-7} p_{0.67904} f_{1.14432} t_{be}^{0.27467}}{V_x^{0.05473}} ]</td>
</tr>
<tr>
<td>Fc250</td>
<td>F1000/9H</td>
<td>[ V_u = \frac{5.7538282 \cdot 10^{-8} p_{0.58922} f_{1.2794} t_{be}^{0.20801}}{V_x^{0.08003}} ]</td>
</tr>
</tbody>
</table>

7 REFERENCES


[12] **Catalogul de oferte al firmei SUPFINA