SPECIFIC CRITERIA FOR ESTIMATION OF THE MACHINABILITY OF MINERAL MATERIALS AND THE RUBBER USED AT THE MANTALS OF THE ROLLERS IN PAPER AND BAKERY INDUSTRY

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Rezumat: *Prezenta lucrare prezintă aspecte tehnologiile de prelucrare a acoperirilor valţurilor utilizate în industria hârtiei şi în industria morăritului, cu referire la abrazarea materialelor minerale şi a cauciucului dur folosite pentru acoperirea acestor valţuri. S-a insistat asupra criteriilor de estimare a prelucrabilităţii acestor materiale şi s-au propus noi criterii de apreciere specifice abrazării granitului, bazaltelor şi cauciucurilor utilizate la prelucrarea superficială a valţurilor.*

Abstract: *The present paper presents aspects concerning the technologies to manufacturing the cambered rollers used in paper industry which refers to the grinding machinability of mineral materials and rubber used that mantle for rollers. We are insisting on the estimation criteria and propose new criteria for the grinding procedure at the manufacturing of granite, basalt and rubbers used at the superficial coverage of rollers.*

Keywords: rollers with granite and rubber coat, cutting capacity, cutting machinability, estimation criteria.

1. Introduction. The Importance of the Cambered Rollers' Realisation on Grinding Machines.

The rollers of the presses from the machines to produce paper can be assimilated to balks that are deformed under the action of the proper loudness and of the supplementary charges of the pressing process. The quality of the final product (paper), and the normal functionality of the machines to manufacture paper can be negatively affected by the shaft formed by the rollers and which can produce an uneven distribution of the pressure on the width of the machine to manufacture the paper. In the specialised literature [11] it is recommended that the ratio between the shaft of the roller and its length be no bigger than 1/6000…1/7000 for the inferior roller and 1/12000…1/14000 for the superior roller. The technical solution proposed by the specialist in technology to eliminate this inconvenient

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consists in the use of rollers with variable diameters along the roller to exclude the shaft.

These rollers are named cambered, and the size of the roller „*k*" is given by the relationship (1):

(1)

Where D is the diameter of the roller at this middle and D_0 is the diameter at the terminations (fig.1).

At the rubberised rollers (with rubber mantle) because the difficulties of the diameters measurement, the notion of *peripheral camber*:

$$K_{peripheral} = \pi D - \pi D_0 = \pi(D - D_0) \quad (2)$$

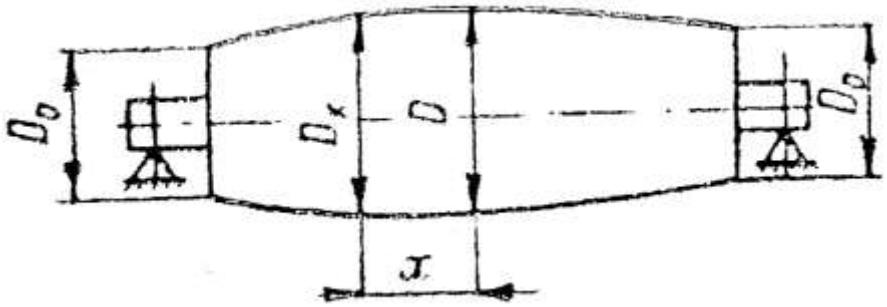

Fig.1. Definition of the magnitudes for the camber determination [11]

2. Particularities at the Rollers' Grinding.

In the Romanian industry of this field, the rollers having big dimensions for the cellulose and paper industry and for the grain mill products and bakery where made in white cast iron with a hard crust (I.M. Topleț).

Now the metallic rollers covered with an exterior layer (currently named mantle) from basalt, granite, ceramic materials or in recent times from vulcanized and hard rubber are in extension.

The manufacturing of these covering layers was made in the beginning by turning, but at the present moment the manufacturing was extended to grinding, being considered more advantageous from a technical point of view. At the Vrancart enterprise, the grinding of the rollers is made on a Russian machine-tool, respectively on the grinding machine for the exterior round grinding, model XIII-193H8 Mockba. This machine presents the following particularities: big dimensions of the worked piece D_{pmax} = 1500 mm and of the grinding tool, $D_{d\ max}$ = 900 mm; the use of the abrasive discs with the hardness level soft, medium or hard; higher rigidity of the grinding machine and a strict specialization in the roller manufacturing, fact that permits high values of the cutting depth (t_{max}= 0,8 mm) and of the longitudinal advance ($S_{l,max}$ = 80 mm/rot the piece);the positioning of the rollers on the grinding machines is made with two stem bearings sustaining the roller axes; the rotation of the roller is made by a driven group; the grinding machine is tooled up with a linear copying device helping the grinding machine the rollers; the basic time of a layer grinding (cutting) has a high level and the process can be corrected relatively easily along its process. In the dereliction of in-depth studies of the machinability (workability) of materials or of the cutting abilities of the grinding discs, the cutting regimes have a semi empirical character, and are not yet optimized, fact that justifies the approach of these problems, respectively the studies of the machinability of these new materials and the studies on the cutting ability of the grinding tools used.

Depending on the grinded material, the camber to be realized at the mantle in rubber or granite, the working times are big enough, requiring a pertinent analysis of the efficiency and of the optimization of the grinding operation.

3. Cutting Machinability.

The specialised literature gathers multiple researches concerning the definition and the establishment of the cutting machinability. All of them (or the overwhelming majority) of the researches refer to the machinability of the metallic materials, mentions being made of other materials too (ceramic, basalt, granite, rubber) but they are extremely few [4, 1, 8].

The machinability of a material or of a group of materials in the analysed case of the ceramic materials is expressed by the totality of the factors that compete to obtain a piece, considering the geometrical form, the dimensions, the quality of the worked surfaces, the functional purpose, the type and the degree of the request and, of course, the imposed conditions in which the piece will work [1, 11].

4. Criteria to Appreciate the Workability of the Materials.

Although the cutting machinability (PA) uses in part some appreciation criteria as the cutting ability of the cutting tools (CA), these two are different yet complementary notions.

Table 1. The comparative presentation of the appreciation criteria of the cutting workability (PA) and the cutting ability (CA).

No.	*Appreciation criteria of* ***:***	
	Workability (the piece)	***Cutting ability (the cutting tool)***
1.	Criterion of the resistance at the wear (the life of the cutting edges)	
2.	-	Criterion of the reliability.
3.	Criterion of the cutting forces.	Criterion of the specific consumed energy
4.	Criterion of the manufactured surface roughness.	
5.	-	Criterion of the dimensional and precision form

So, the workability by cutting (PM) refers to the worked piece, showing its behaviour in the cutting process, and the cutting ability (CA) refers to the cutting tools, conceiving the measure in which these tools satisfy, at a given moment, the imposed requirements of the cutting process. Appreciation criteria for the two characteristics PA and CA are partially common, connected to the possibilities to measure the outputs from the system MUSP.

From Table 1 it is possible to conclude that some criteria are common to the two concepts, and two criteria do not have correspondence.

Evaluation criteria of the cutting ability related to: the wear resistance or the tool life, the specific consumed energy, the roughness of the manufactured surface, the dimensional precision and form deviation, the reliability are criteria considered by the main researchers' criteria for the evaluation of the cutting ability of the cutting tools. Additionally, the main five criteria are applied individually or synergistically in the main cutting. In the case of manufacturing processes the criterion of the roughness of the manufactured surfaces and the criterion of the dimensional precision or form accuracy have a significant importance because the finality of the cutting process and because the purpose of the realization of the grinding (the procurement of surfaces with low roughness and dimensional precision at the required values).

4.1. New Criteria for the Machinability by Cutting of the Ceramic Materials and of the Rubber.

The characteristics of the manufacturing of these ceramic materials and of the rubber require the elaboration of new criteria for the appreciation of their workability or for the determination of the cutting ability of the used cutting tools (abrasive tools). Among the criteria specific for the workability at the grinding processes we can enumerate:

- the material volume removed in the time unit by a millimetre of the width of the grinding disc;
- the cutting ability of the grinding tool expressed by the material volume cut in the time unit by a millimetre of width of the grinding tool at one daN radial force;
- radial wear of the grinding disc, realized in the unit of time;
- the quality of the surface obtained by grinding in the same manufacturing conditions. [8]

The criteria shown up can be used in the case of the manufacturing by grinding of the mineral materials and of the rubber. Beside these criteria we propose new criteria as follows:

a) The criterion of the chemical stability of the cooling agent at the rubber's machining;

b) The criterion of the thermal regime at the cutting.

We propose as global indicator of the machinability by grinding the mineral materials the minimal cost of the finished manufacturing.

The cutting conditions must be chosen so that a minimal cost for the manufacturing be realized. In the same cutting conditions, the material that presents the lower price between the "n" materials will be considered the most workable.

The criterion of the dispersion coefficient of the warmth K_1 can be a recommended indicator of the workability, especially at the exterior grinding of mineral-ceramic materials [11]

Another workability indicator can be the thermal absorption (K_2 = thermal conductibility × specific warmth).

The indicators of the thermal proposed coefficients (K_1 – dispersion coefficient of the warmth and K_2 thermal absorption of the heat) are preferable because the density, thermal conductibility and specific warmth are elements that can be found in the specialised literature or can be easily determined, obtaining rapidly a first information about the workability of the analysed material. We make the determined that the workability of a material is more connected with its thermal properties than its hardness and its microstructure.

In the light of the above mentioned ideas, we propose another evaluation criterion for PM and CA, considering the integrity of the manufactured surface (the danger to have cracks) in the case of an unhappy choice (non rational) of the cutting regime, of the cutting tool or of the refrigeration liquid.

Another criterion that we propose is the criterion of the thermal conductibility; (for the manufacturing of granite and basalt having a low thermal conductibility). This criterion can be linked to the changes of the dimensions by dilatation toward the material under the superficial layer that remains undiluted, generating cracks.

We can propose the criterion of the structure's homogeneity of the worked mineral material.

For the materials based on rubber we consider that available criteria can be:

The criterion of the chemical stability at the use of the refrigeration and lubrication liquid in the cutting process refers to the chemical stability of the adequate refrigeration liquid (mineral oil in emulsion 1:50 with pH about 7...9). From the analysis of the action of the liquid, it is ascertained that the liquid does not act only as a refrigeration agent, but influences synergistically chemically and mechanically the processes of chip forming. The refrigerating liquid has an important influence on the diamond disc's wear (wear *k*) that can be expressed by an empirically established relation [3, 11]

(3)

Where: *c* is a wear constant factor, $n = 3$ and *f* is a refrigeration coefficient.

Because the hardness, high fragility and friability, the mineral materials are included in the category of the difficult workable materials, and at the grinding phenomena are not completely elucidated. In the specialised literature there are relatively few data about the technological parameters for the manufacturing of the mineral materials and about the way in which they are influencing the technological processes and the cutting parameters. Generally, we can find only

the influences of some physical and mechanical parameters that make references to the characteristics and forms of the grinding discs, the structure of the worked material, the refrigerating liquid, etc.

Another criterion is that of the elastic deformation of the active surface on the grinding disc. The cutting ability of a diamond disc is determined by the elastic properties of the system in its entirety.

The temperature criterion in the cutting area is very important, having a complex character. In relation with thermal aspects it is possible to develop many ideas, respectively it is possible to consider various indexes defined on the basis of different mechanisms. So, it is possible to analyse the thermal regime criterion, or the thermal conductibility in the cutting process criterion (the existence of a dependence between the quantity of warmth disengaged in the cutting process by a précised material and the decrease of the tool quality as temperature increases).

It is known that the temperature in the cutting area depends on the nature of the manufactured material (referral at basalt, granite, etc.).

A relationship is determined by Schallbroch and Schaumann [11]:

(4)

Where the value of the constant K depends on the nature of the tool and piece material; n is an exponent with values comprised between 20…30; θ is the temperature in C^o.

An appreciation criterion in the case of round or plane grinding of the mineral-ceramic materials can be the grinded specific volume V_{sp}, in mm^3 / mm.s, that depends to the cutting ability of the diamond disc (deteriorated by the specific cutting volume of the grinding disc), by the parameters of the cutting regime (peripheral speed of the grinding disc, speed of the piece, depth of cut, feed at grinding and disc characteristics (granulation, bonds, the mode of the disc realization, etc.) [11].

5. Determination of the Global Index of the Workability.

Groups of specialists from UPB including E. Străjescu, C. Minciu, Şt. Enache, I. Tănase, C. Opran, S. Croitoru, M. Zamfirache, etc. have shown in an important number of papers the possibility to use a global index of the machinability. Such

an index can be considered similar to the index used for the characterization of the technical level of the layouts on the basis of the utility principle Von Neumann-Morgenstern, applied under the form of the prediction Cobb-Douglass.

So, the global index of the workability can be presented as:

$$i \{g,\ldots,i\}=S_2 j \{1,2\ldots,m\}=E \quad (5)$$

6. Conclusions and Research Directions.

The main conclusions resulting from the general study concerning the determination of the materials workability, the criteria to appreciate the workability and from the particular study concerning the workability by grinding the mineral materials and the rubber, including their respective appreciation criteria are presented below:

- it is possible to determine a global index of the workability able to synthetically reflect all the evaluation criteria for workability; these indexes are unique and objective if the determination of the priority indexes is based on the exploitation coasts;

- the determination of the partial indexes is made using functions known in a great number in the specialised literature for the main materials used in machine construction industry: functions “tool life”, functions “tool wear”, functions “cutting forces”, functions “dissipated power in cutting”, functions “roughness of the cutting tools and of the manufactured surface of the piece”, etc.

- the global workability index depends on all the parameters of the cutting process;

- the proposed method helps to establish the workability of different materials or the workability in different cutting conditions, representing an essential factor for the improvement of the manufacturing by cutting;

- to consider a standardized index, it is necessary that the parameters of the cutting process and which is made the workability establishment be standardized too; so it is possible to compare materials without appealing to a standardized

material tested in standard conditions, existing the possibility to choose a material among a group of materials existing at the disposal of the user; in such a situation, it is possible to arbitrarily choose a reference material, in cutting conditions properly selected and not imposed by the standard;

- it was chasing the realization of a synthesis of the evaluation criteria for the workability by cutting, insisting on the grinding proceeding.

All the criteria from the presented known grinding procedures were re-evaluated, reconsidered and applied to the mineral materials or to the rubber grinded, reflecting synthetically all the criteria for the evaluation of the workability. At the known criteria, we proposed new ones, specific for the new materials (basalt, granite, rubber).

As a direction to pursue researches in the field of grinding mineral materials and rubber, it is necessary to elaborate standards concerning the evaluation methods for the workability by cutting, similar to the methods established for steels: STAS 12797/1-90; STAS 12797/2-91; STAS 12797/3-91. An important research is also made for the workability of rubber, the information in the specialised literature being very scarce.

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