

## SISTEMI PER IL CONTROLLO IN REAL-TIME PER PROCESSI A VARIAZIONE LENTA

### SYSTEMS FOR THE REAL-TIME CONTROL OF SMOOTHING PROCESSES

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**Abstract – The quality of pieces and their operation reliability greatly depend on the execution technology, especially the finishing and super-finishing technology, within which the quality of the processed surface is defined (micro-hardness, roughness etc.). In order to obtain the optimum quality of the surfaces processed within the imposed dimensional and shape precision limits, a large spectrum of technological methods is used, based either on taking material samples by splintering, or by the plastic deformation of the superficial layer. Besides the obvious advantages, the processing of materials by splintering has a series of technical-economic disadvantages, namely:**

- deterioration of the microstructure of the superficial layer by interrupting the fibers of the piece;
- necessity of providing relatively large processing excesses, removed as splinters;
- incorporation of the particles of hard or extra-hard material in the superficial layer of the piece, upon its abrasive processing;
- use of machinery and tools which are complicated, expensive and with maintenance difficulties;
- necessity of a large volume of labor by highly-qualified operating personnel;
- high consumption of energy in the processing stages.

**In industrial practice, namely in the field of finishing and super-finishing, besides the methods of micro-splintering – rectification, honing, polishing, lapping, grinding, unconventional technological methods, without taking splintering samples, are becoming more and more the norm. Thus, the technologies for processing semi-finished products by cold plastic deformation represent a superior approach level, with real and efficient consequences in developing companies in the machine construction industry.**

**Key words – real-time control, smoothing process**

Plastic deformation results in the enhancement of the

micro and macro geometry of surfaces, of dimensional and shape precision (smoothing) at the same time with the enhancement of the physical-mechanical and physical-chemical properties by cold-straining of the superficial layers.

A definition of the plastic deformation phenomenon is necessary:

*Plasticity is the capability of metallic materials of changing their shape and sizes by plastic deformation, changes which take place under the influence of external forces, whose value must not lead to the destruction of the structure integrity.*

The particular aspects connected to the processing by superficial deformation (smoothing and hardening) are presented below:

1. The physical phenomenon which dominates the technological process of smoothing is that of the cold plastic deformation of the material. This phenomenon also influences the splintering processes, but in a smaller proportion. The mechanism of the plastic deformation phenomenon consists of the migration of dislocations in the sliding planes in the crystalline structure of metals. The factor which conditions mobility is their mutual interaction or the interaction with other network flaws.

2. The cold plastic deformation of the superficial layer of metals has as a main effect the occurrence of the physical phenomenon of cold-straining, which is the hardening of the surface of the finished piece.

3. The use of specific lubricants (processing liquids) during the processing stage leads to the increase of the durability of the tool and of the quality of the processed surface, by reducing friction and the wear of the tool.

4. Diamond smoothing is one of the metal processing technologies by cold plastic deformation. Unlike other plastic deformation processes, diamond smoothing displays a series of particular aspects which constitute as many technological advantages, respectively:

- Application of relatively reduced processing forces, due to the low values of the friction

- coefficients in the diamond-metal aggregate;
- High thermal stability of the diamond-metal aggregate due to the low values of the friction coefficients;
  - Long maintenance of the operation parameters of the tool due to the low wear of the tool / diamond indenter (the initial geometry is maintained during operation);
  - Relatively low valued of the diamond wear speed lead to the increase of the durability of the smoothing tool and respectively the compensation of its high cost;
  - Possibility of applying the smoothing procedure in finishing harder materials (hardness  $\leq 65\text{HRC}$ ), due to the extreme hardness of diamond;
  - Obtaining optimum surface quality due to the limited roughness of the surface of the diamond crystal.

5. In order to appreciate the efficiency of the finishing process, the most important characteristic of the geometrical state of the surface is roughness ( $R_a$ ,  $R_z$ ,  $R_{\max}$ ). The values of roughness do not provide sufficient data regarding the operating characteristics of the processed pieces, as other characteristics are also necessary, such as: carrying

capacity, microstructure and micro-hardness, resistance to wear and fatigue.

Initially carried out with enforced steel tools, cold plastic deformation methods have been perfected by the use of tools enforced with sintered metallic carbides. The use of extra-hard materials, among which diamond, in making finishing processing tools offers new application fields for the processing of extra-hard metallic materials, such as alloyed and thermally treated steels.

In the area of extra hardness (Mohs interval 9 - 10) there are numerous substances of interest for the processing of hard and abrasive materials; thus, for illustrative purposes we would like to mention numerous carbides, borides and rare earth nitrides, transition metals and other light or heavy elements. The dynamic of the process supposes the exercising of forces on the material of the semi-finished product in rotation motion, by a tool with defined geometry. The kinematics of the process is accomplished by the composition of the main rotation motion of the semi-finished product with the secondary advance motions – transversally and longitudinally – of the tool (fig. 1).

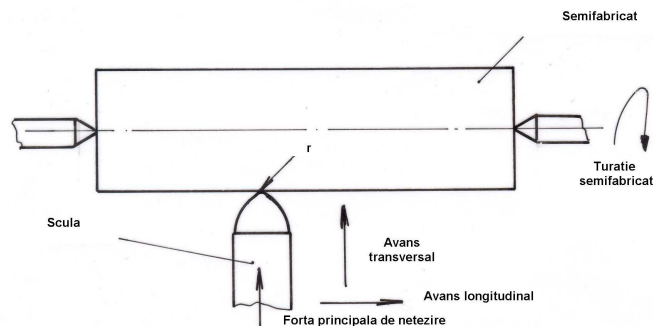


Fig. 1 Processing kinematics

The input elements of the systems are:

- Material characteristics (chemical composition and hardness);
- Initial state of the semi-finished product, respectively the surface quality achieved by the previous operation (generally facing);
- Constructive and functional characteristics of the tool: material of the active part, work geometry (cylindrical or spherical), fastening support;
- Parameters of the smoothing conditions: rotation revolution (speed) of the semi-finished product, size of the indenting force, transversal advance (penetration depth) and the longitudinal advance of the tool.

The output values are elements considered:

- Quality of the smoothed surface (roughness);
- Resulted superficial hardness.

The perturbing elements which act on the system generally are:

- Insufficient rigidity of the technological system, generated by the inadequacy of the toll machine and devices (for the fastening of the semi-finished product and tool) being used;
- Incompatibility of smoothing condition parameters used with the processing strains;
- Deficient application of the force on the tool (continuous, with shocks, etc.);
- Absence of lubrication in the smoothing area.

Process control mainly refers to *monitoring the smoothing force* in view of maintaining it within preliminary parameters. This control may be ensured

with the device for the real-time control of the smoothing process with extra-hard materials of exterior cylindrical surfaces, which may be used both as an efficient research and experimentation tool, and as working equipment with applicability in the processing industry. The device achieves both elastic-plastic deformation of a superficial layer from the material of the semi-finished product, without exceeding the flow limit, respectively

without taking splinter samples, with the help of the tool in current practice called an *indenter*, and the monitoring of the process by emphasizing the main specific parameters, among which the most important one is the smoothing force.

The principle chart of the device for the real-time control of the smoothing process with extra-hard materials of exterior cylindrical surfaces is as follows:

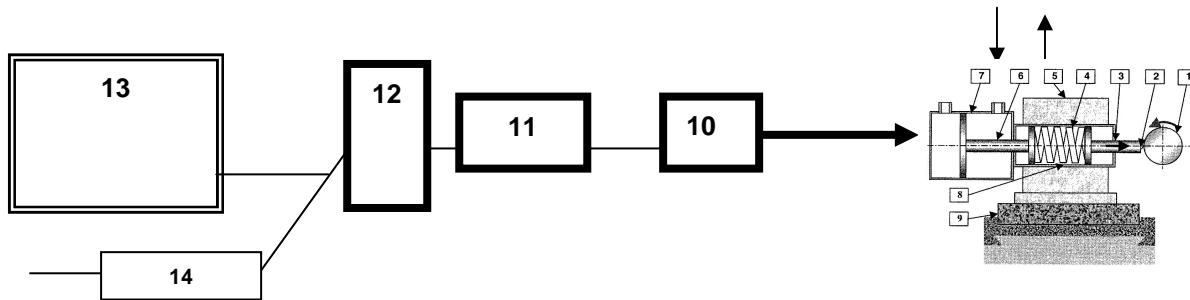


Fig. 2 – Principle chart of the device

1. Semi-finished product; 2. Tip made of extra-hard material; 3. Smoothing tool body; 4. Spring; 5. Body; 6. Rod; 7. Pneumatic cylinder; 8. Casing; 9. Sled; 10. Force cell; 11. Acquisition plate; 12. PC main unit; 13. PC monitor; 14. Printer.

The use fields relate to the precision processing of markers in the machine construction industry, chemical and oil machinery industry, aeronautics industry, metallurgic industry, etc. under conditions of superior quality and economic efficiency.

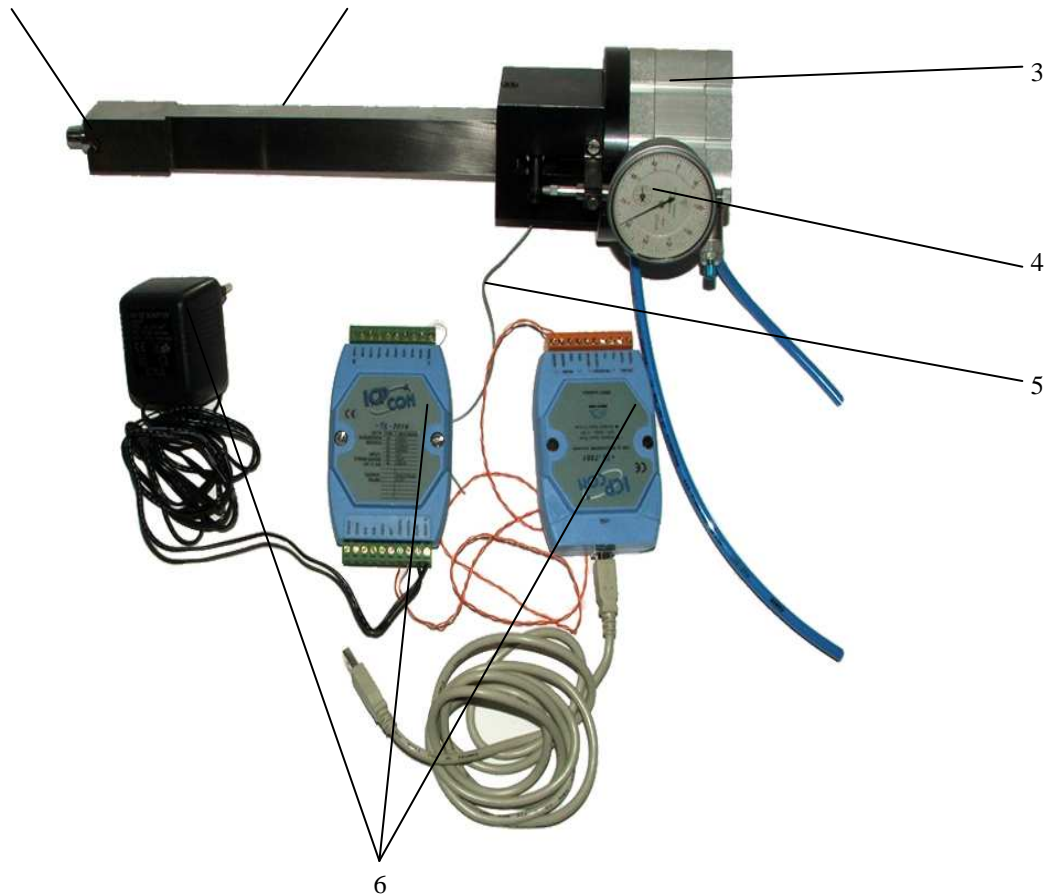
The device for the real-time control of the smoothing process with extra-hard materials of exterior cylindrical surfaces is a complex system designed on the basis of the modern principles of

mechatronics.

During the research two constructive variants for the device for the real-time control of the smoothing process with extra-hard materials of exterior cylindrical surfaces have been created:

- A – Experimental model and
- B - Prototype.

A – The *Experimental model* is presented below:



1 – Smoothing tool; 2 – Mechanical subset; 3 – Pneumatic cylinder; 4 – Dial comparer; 5 – Force cell; 6 – Subset for the acquisition, processing and display of data

Fig. 6 – Device for the real-time control of the smoothing process with extra-hard materials of exterior cylindrical surfaces partial assembly

The acquisition, processing and display of the results regarding processing dynamics (smoothing force,  $P$ , daN) are done by specialized software.

The system allows the acquisition of the signal from the force cell, the processing of the signal, the real-time display of the force and finally the generation of a page of results which may be saved or printed. Also, the software allows the saving of all the values corresponding to the experiment in the result page in a separate Excel file. The values in the result page are inputted manually, except the measured force in the section “final data” which shall be taken from the program as 3 values: maximum, minimum, medium, and a graph with its evolution during the experiment, between the moment when the START button is pushed and the moment when the STOP button is pushed. The data acquisition system is a component of the product “Device for the real-time control of the smoothing process with extra-hard materials of exterior cylindrical surfaces”. The smoothing force is achieved manually by the

operation pneumatic system. The acquisition system has two major components: hardware and software.

**Physical structure (hardware) consists of 3 components and computer:**

**1. Force sensor, force cell type, model BC 303**

**Function:** Conversion of the mechanical tension (force) in the electric signal.

**2. Signal acquisition manner, I-7016**

**Function:** Ensuring the excitation tension for the force cell and the conversion of the analogue electric signal originating from it in numerical data for the computer transmitted by the serial communication protocol RS-485.

**3. Communication interface manner, I-7561**

**Function:** communication translation on the serial RS-485 at the USB communication port of the computer.

The **Software structure** consists in the acquisition program **Monitor** may be installed and run on any PC with an operation system Windows 98, Windows ME, Windows 2000

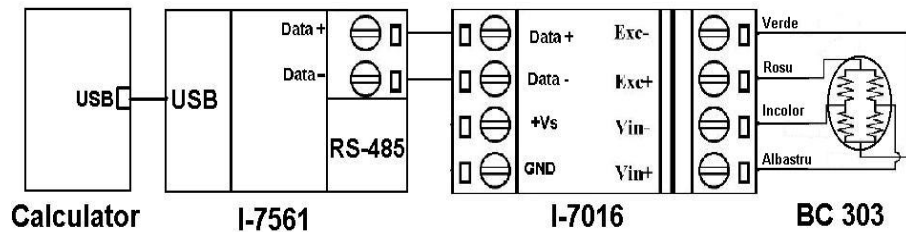


Fig. 7 Acquisition system

**Functions:**

- it processes and displays the signal originating from the force cell allowing the real-time monitoring of the processing force in the smoothing process with extra-hard materials of exterior cylindrical surfaces

At the end of a measurement it allows:

- printing of data with the printer set as default on the running computer
- creation of a report as a *jpeg* file which contains the results of the measurement for later printing
- creation/adding in an Excel file of the data in the real-time control of the smoothing process with extra-hard materials of exterior cylindrical surfaces leads to the support of this technological method as a solution for a large series of applications characterized by the following advantages:
- increase of the processing precision and production quality;
- increase of labor productivity;
- savings of raw material, materials and energy;
- increase of export availability;
- increase of the competitiveness of Romanian companies in the processing field and especially intelligent control methods;
- improvement of working conditions;
- increase of the qualification of the personnel by training and specialization courses
- creation of new jobs.

Ecologically, environment conditions shall be ensured, as there are no sources of toxic substance generation.

result page

Initially the program starts in “*Acquisition*” work mode, in which the operating force in the process may be visualized. In this stage the user manually adjusts the force in the installation until the value specific to the selected processing conditions, monitoring the variations on the graph. After it has been adequately adjusted, the proper processing of the piece may begin. The reference value of the force shall be set in the program (in field **Force** (*daN*)).

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