INVESTIGATION METHODS OF LONG-RANGE DEFORMATION FORCES FOR FORMING OF DIFFERENT PROFILE USING COLD PLASTIC DEFORMATION

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Abstract: This technical paper propose to present the theoretical investigation methods and experimental one for deformation forces measurement of different profile using cold plastic deformation.

1. Theoretical evaluation of deformation forces for forming exterior grooves

The general scheme is shown on figure 1.

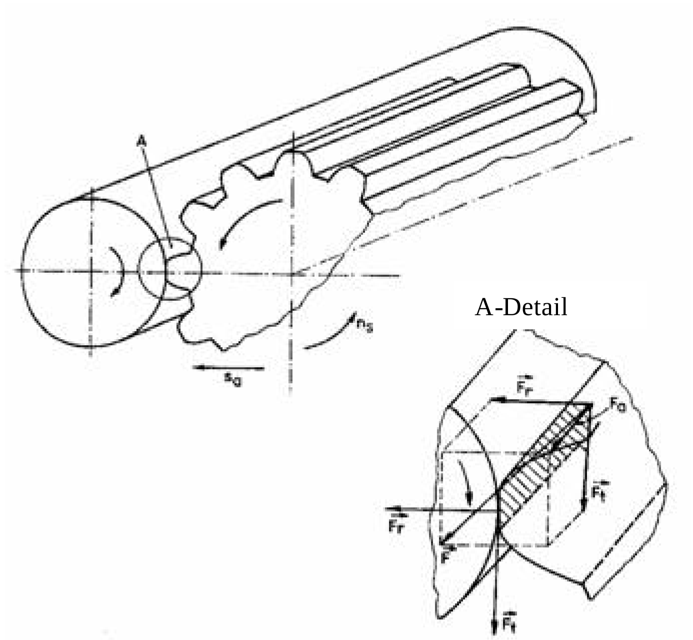

Figure 1 The general scheme of long-range deformation forces

1.1 Theoretical evaluation of deformation forces using a reduce volume element

From calculus made using the figure 2 result the tangential force relation:

$$F_t = 2 s_c \left[1 + \ln\frac{l_2}{l_1}\right]\frac{(l_2 - l_1)}{2\sin a} l \quad [\text{N}] \qquad (1)$$

The deformation forces must to be copying with contact length contact value L_c.

$$F_t = L_c \cdot 2 s_c \left[1 + \ln\frac{l_2}{l_1}\right]\frac{(l_2 - l_1)}{2\sin a} l \qquad (2)$$

and

$$F_r = L_c s_c A_r \qquad (3)$$

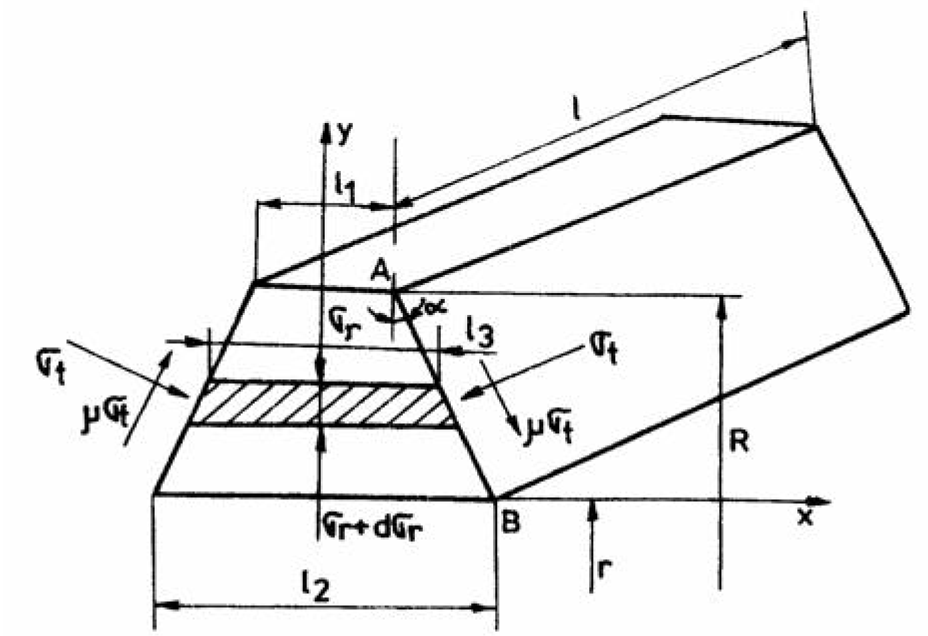

Figure 2 The simplified model of volume element

1.2 The deformation forces evaluation using slip lines (figure 3)

The relation for the radial force obtained is as follow:

$$F_r = 2p \cdot \frac{h\cos(90 - a_1)}{\cos a_1} = 2ph\frac{\sin a_1}{\cos a_1} = 2ph \cdot tga_1 \qquad (4)$$

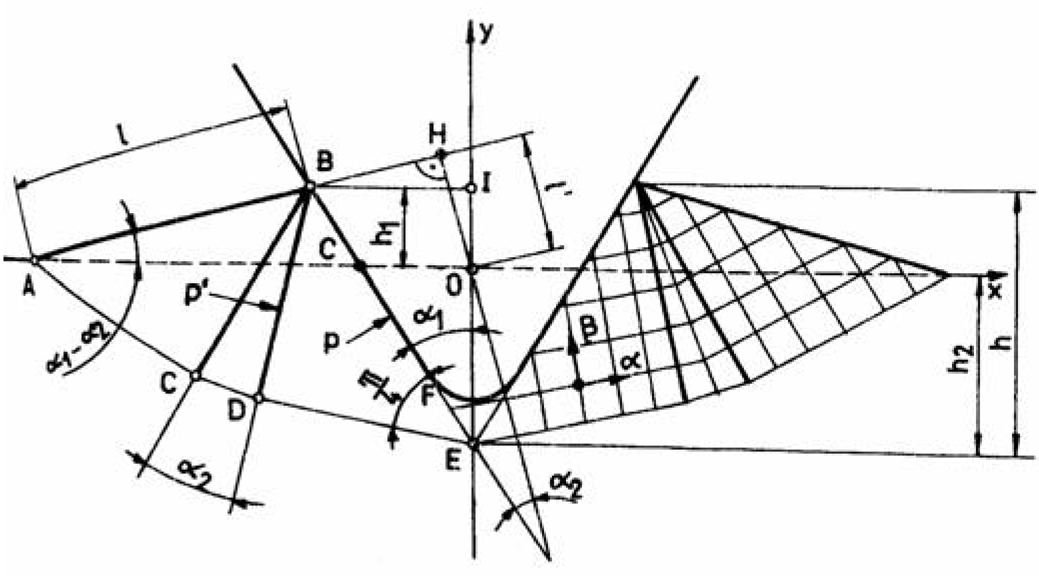

Figure 3 The slip lines field after the tool penetration

1.3 The evaluation of minimal and maximal deformation forces (figure 4)

After we made the calculus the maximum and minimum forces are:

$$p_{max} = \frac{F_{i\,max}}{Rscd} = \frac{f(R_m)}{R_{scd}} \qquad (5)$$

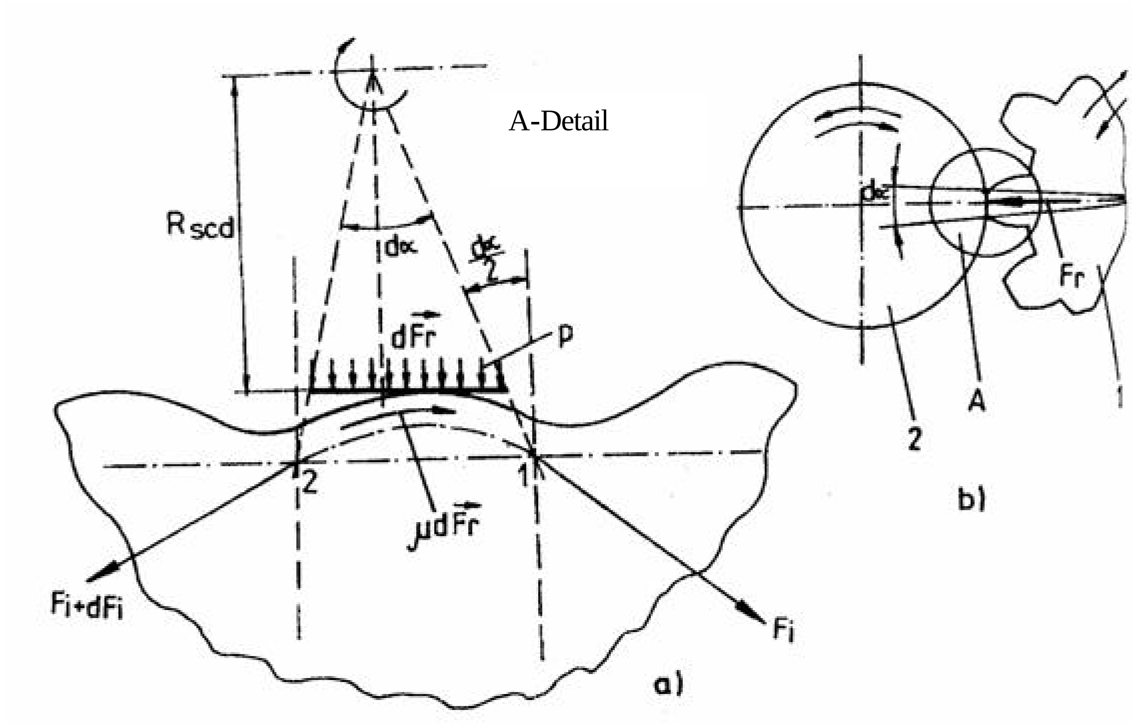

Figure 4 The determination scheme of half-finish product deformation

$$p_{min} = \frac{F_{i\,min}}{R_{scd}} = \frac{f(R_c)}{R_{scd}} \qquad (6)$$

where: R_m is the ultimate strength of half finish product material, [N/mm^2]; R_c is the ultimate yield of half finish product material, [N/mm^2];

The plastic deformation is available if:

$$F_i^1 \succ f(R_c) \text{ and } F_i^2 \prec f(R_m) \qquad (7)$$

and more result:

$$\frac{f(R_m)}{f(R_c)} \succ e^{ma_{12}} \qquad (8)$$

Could be written other forms for maximum and minimum force, such as:

$$F_{\max} = p_{\max} S_c = \frac{f(R_m)}{R_{scd}} S_c \quad \text{[N]} \qquad (9)$$

$$F_{\min} = p_{\min} S_c = \frac{f(R_c)}{R_{scd}} S_c \quad \text{[N]} \qquad (10)$$

where S_c is the contact surface between deformation tool and half-finish product, [mm^2].

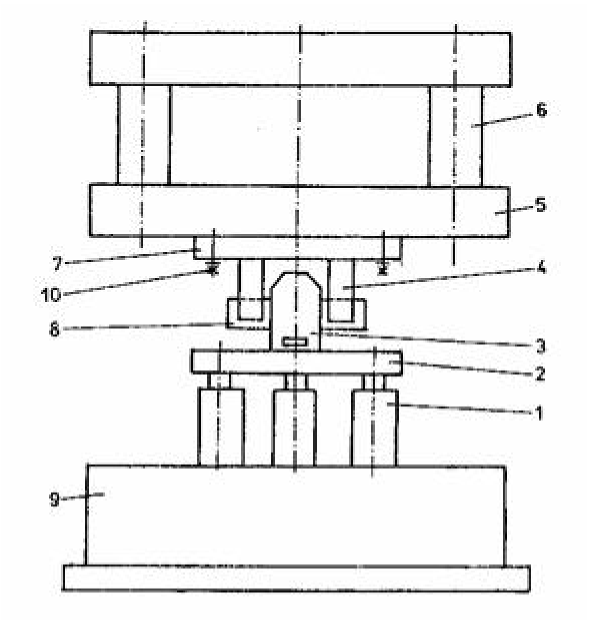

Figure 5 The calibration equipment

2. The measurement equipment
2.1 The calibration equipment

The equipment used is shown on the figure 5 with the main parts: threshold rigid plate (2); block bearing (3); the prisms system (4); sleeper (5); columns (6); plate (7); clutch shaft (8); box bed (9); screws (10);

Using the results obtained we can draw the interpolation and calibration curves (figure 6).

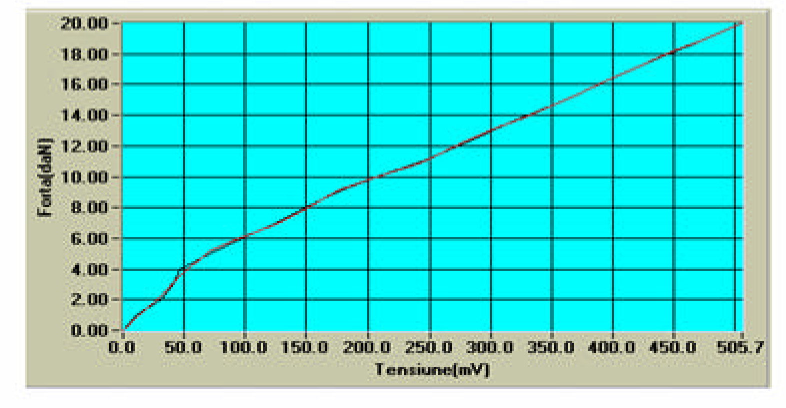

Figure 6 The interpolation and calibration

2.2 The measurement equipment of deformation forces

For the measurement circuit (figure 7) was used the complete seal axle assembly, where: R_2, R_3 are under the compression process, and R_1, R_4 are the temperature compensators.

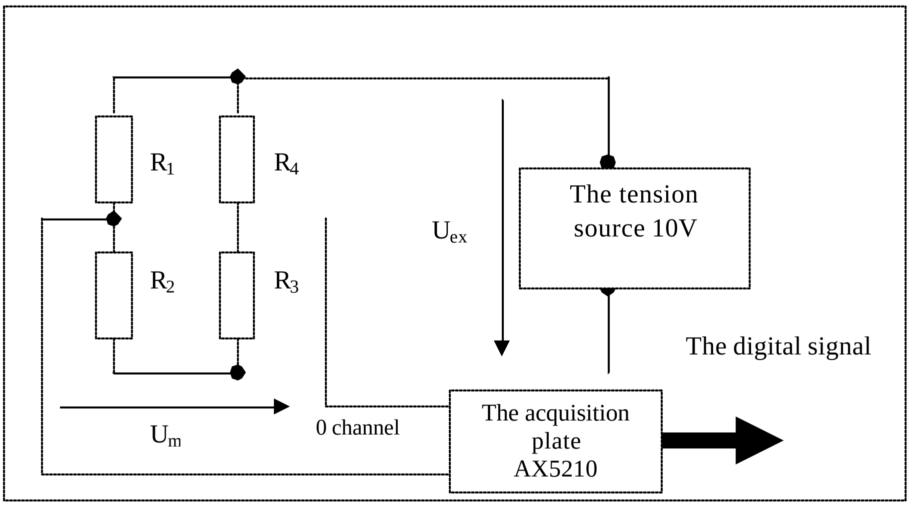

Figure 7 The measurement circuit

2.3 The virtual measurement instrument

The virtual instrument was create using LabWindows program interface and Borland C++ software compiling for data acquisition system AX5210 and has two working possibilities:

-acquisition on static regime;
-acquisition on dynamic regime.

The virtual instrument has the following bank configuration:

-the configuration bank (figure 8)
-the calibration bank (figure 9)
-the acquisition bank using the static regime (figure 10)

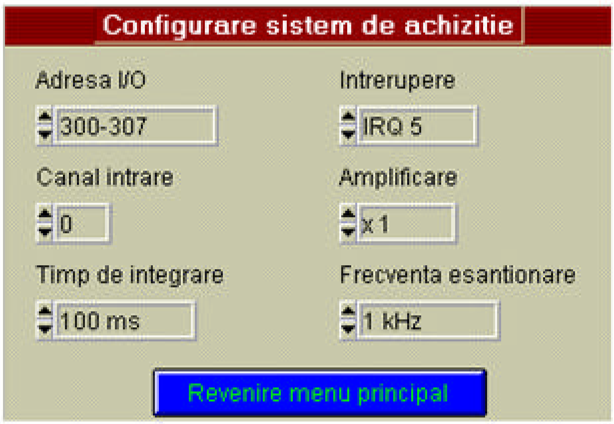

Figure 8 The configuration bank

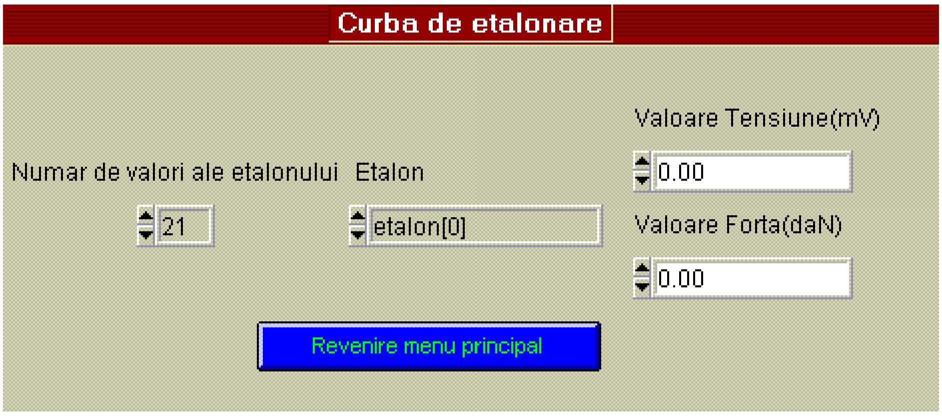

Figure 9 The calibration curve selection

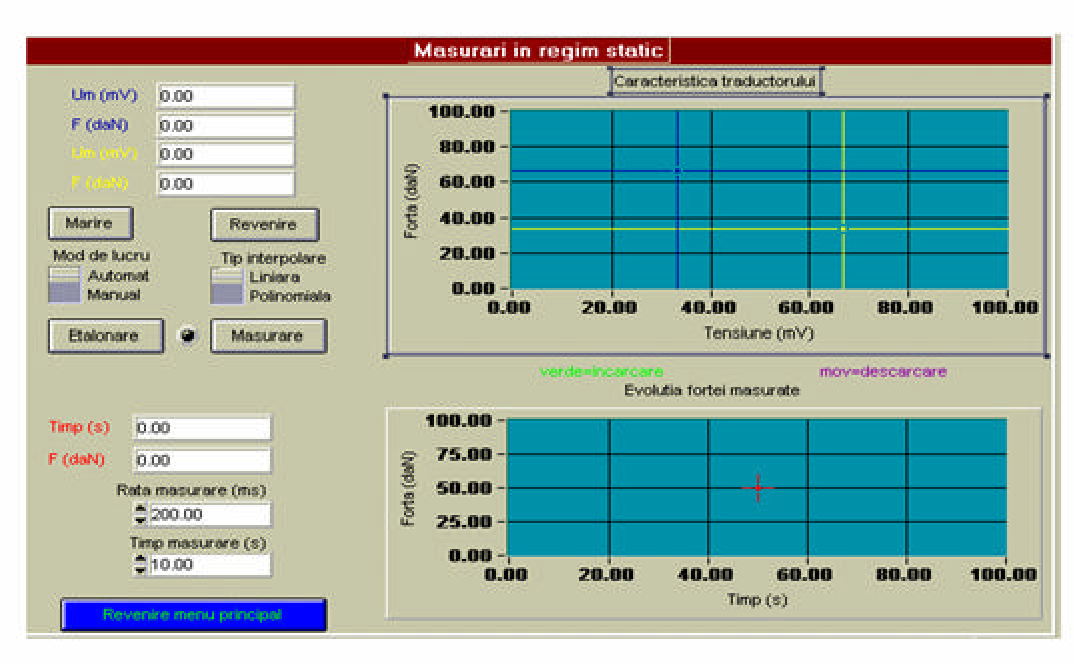

Figure 10 The static regime bank

3. References

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