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MODELLING OF THE RADIAL AND AXIAL FORCES IN THE COLD FORMING PROCESS

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Abstract: For a cold plastic forming, the sizes of the deforming forces have an important role, because, on the one hand, help to the choosing of the technological system, due to their influence on the energetic parameters of the process and, on the other hand, the sizes of these forces influence directly the deformation's irregularity and, so the quality products obtained. In this context, this work presents modeling in MATLAB software of the radial and axial deforming forces function of the axial advance s and of the mechanical characteristics of the material represented by the after flow resistance σ_c, which appear in the cold forming process.

1. INTRODUCTION

The force's deforming size in the cold forming process constitutes one of the most important technological factors of the process, and its knowledge permits, on the one hand the adoption of the adequate machine, and on the other hand the leading of the process in the sense that we want, this size influencing a part of the quality parameters of the machined surfaces.

The forces which appear during the cold forming process by intermittent strike (hammering) are: *the normal teeth force (radial-F_n)* (the one perpendicular on the semiproducts) and the *axial teeth force-(F_a)* (the one arctangent to the contact tool-semiproducts).

2. FORCES IN THE FORMING PROCESS

At the determination of the necessary deforming force in the processing with only one roller tool, it is admitted the hypothesis that the material from the tooth space area passes only on radial direction for the forming of the teeth, being stopped the passing on axial direction [5]. The tooth in the case of this processing process is accomplished gradually, fig.1.

In the beginning the roller touches the exterior of the semiproducts, forming a small sideways beak, and in the immediately next moment it is performed the beak on the opposite (counter) plan of the tooth, the following runs moving the beaks towards the tooth axe, fig.1.

For the accomplishment of the teeth form by a certain form on the semiproducts circle (circumference), its material is plastically formed near the surface on radial and axial direction, forming spaces whose root diameter is smaller than the initial diameter of the semiproducts, and the teeth whose crest diameter is bigger than the initial diameter.

The material from the area 1 can be retrieved in area 2, laying down the condition that the material should move not only on radial direction, fig.2.

To obtain correctly the tooth profile (at the form and dimensions requested) it is imposed the determination of the forces necessary for the plastic deformation and for the mechanical work.

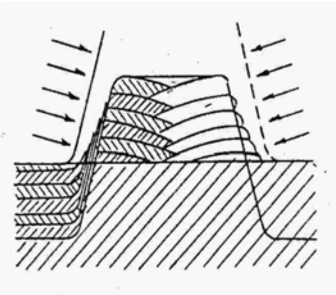

Fig.1. Performance of the tooth

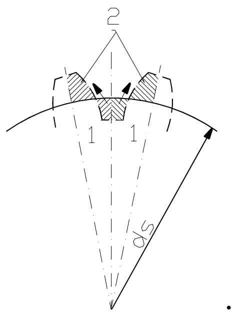

Fig. 2. Yielding of the material

It is obvious that the force which performs the movement of the material on radial direction at the machine tool is the one that interests us, that is the force F_n, and the other component, the axial force is preferable to be as small as possible.

The analytical computation of the forces in the cold forming process is performed on a simplified model [5] of the element by volume, having the section with the big basis t_2 equal with the length of the binding beam on the crown circle of the semiproducts of the radius r_s and small basis t_1 equal to the length of the binding beam's space (gap) on the radius foot circle r_f, on which act on the radial tensions σ_ρ and $\sigma_\rho+d\sigma_\rho$ and tangential tensions σ_θ fig.3.

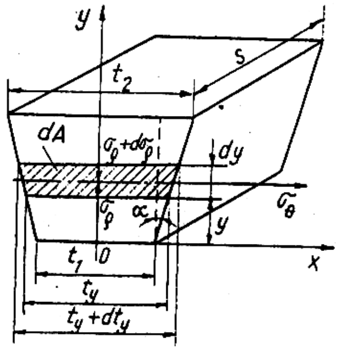

Fig.3. Determination of the deforming force [5]

The final relations of the calculation, of the components of the total (entire) force necessary to the material's deformation in view of the teeth formation are:

$$F_n=\sigma_\rho\, t_2\, s; \quad F_a==\sigma_\theta\, s\,(t_2-t_1)/(2\sin\alpha) \tag{1}$$

where σ_ρ and σ_θ are given by the relations:

$$\sigma_\rho=\int_{t_1}^{t_2}\sigma_c(dty/ty)=2\sigma_c\ln(t_2/t_1)$$

$$\sigma_\theta=2\sigma_c[1+\ln(t_2/t_1)] \tag{2}$$

and the angle α is given by the relation: $arctg\alpha=\dfrac{t_2-t_1}{2(r_s-r_f)}$

3. MODELING OF THE DEFORMATION FORCES IN THE DEFORMATION PROCESS

For the modeling of the forces, which appear in the cold forming process by intermittent strike, were performed programs synthetically presented in annex 1.

The programs for mathematical simulation of the analytical expressions of the deformation forces, function of two input parameters, the axial advance of the semiproducts s_a and the working material materialized by the flowing resistance σ_c were done in MATLAB software.

The variation graphic of the forces in the cold forming process function of the two parameters for which the mathematical simulation was performed is presented in fig.4 and fig.5.

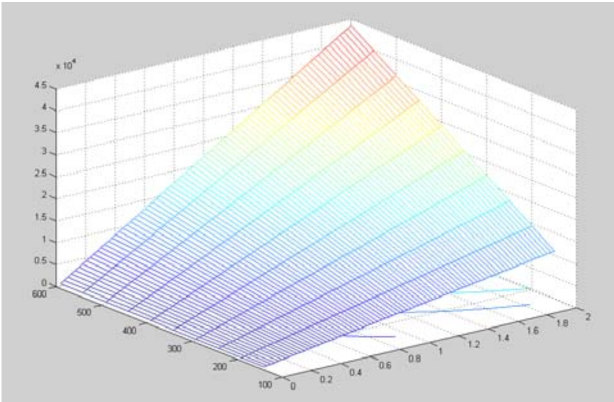

Fig. 4. F_n- function of s_a and of σ_c

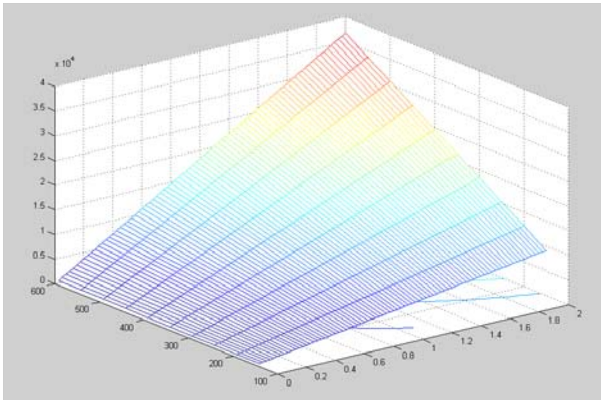

Fig. 5. F_a- function of s_a and of σ_c

APPENDIX 1

Program F_n

```
t1=1.902;
t2=3.298;
sigc=(150:50:600);
s=(0.025:0.025:2);
rs=16.8;
rf=15.75;
alf=tan((t2-t1)/(2*(rs-rf)))
[X,Y]=meshgrid(s,sigc);
n=length(s);
m=length(sigc)
for i=1:1:m
ssigc=150+(i-1)*50;
for j=1:1:n
ss=0.25*j;
sigro=2*ssigc*log(t2/t1);
fro(j)=sigro*t2*ss;
Z(i,j)=fro(j);
end;
end;
%[X,Y]=meshgrid(xx, yy);
%surf(X,Y,Z)
meshc(X,Y,Z)
```

Program F_a

```
t1=1.902;
t2=3.298;
sigc=(150:50:600);
s=(0.025:0.025:2);
```

```
rs=16.8;
rf=15.75;
alf=tan((t2-t1)/(2*(rs-rf)))
[X,Y]=meshgrid(s,sigc);
n=length(s);
m=length(sigc)
for i=1:1:m
ssigc=150+(i-1)*50;
for j=1:1:n
ss=0.25*j;
sigtet=2*ssigc*(1+log(t2/t1));
ftet(j)=sigtet*ss*(t2-t1)/(2*sin(alf));
Z(i,j)=ftet(j);
end;
end;
%surf(X,Y,Z)
meshc(X,Y,Z)
```

4. CONCLUSIONS

The deforming radial forces in the cold forming process depend on the axial advance of the semiproducts s, on the quantity of deforming material and on its characteristics represented by module m and respectively the flowing resistance σ_c . With the increase of the axial advance, and of the flowing resistance, the deforming forces increase. This thing can also be observed from fig. 2 and 3, where it was represented in MATLAB software, the variation of the deforming force components function of the advance s, and of the material characteristics represented by σ_c.

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