

## ELASTO-PLASTIC DEFORMATION FOR INNER THREADS EXECUTED BY PLASTIC DEFORMATION

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**Abstract:** When analysed in section, the stratum of plastically deformed material, shows that, no matter the way we realise the deformation of the thread the changes of structure occur on a longitudinal direction, transversal and cross the working surface. Plastic deformations are accompanied by a series of phenomena which lead almost totally to an improving of the characteristics of the threading. In exchange, the elastic deformations have negative impacts, especially for the production of the threads. Using the electronic computer, it was realised a diagram of the state of deformation in the section of a spiral of the thread which can be used quantitatively and qualitatively for the analysis of the mechanic characteristics of the threads obtained by plastic deformation.

**Keywords:** thread's plastic deformation, threading moment

### 1. PLASTIC DEFORMATION

Phenomenon's, which occur in technological process of internal, threading, through plastic deformation are multifarious (modification of fiber, changes of structure) and lead, in majority of cases, to increase of qualitative index of pieces.

The process of threading through deformation it usually made, at a temperature situated very low under the recrystallisation temperature ( $710 \div 720^{\circ}\text{C}$ ) and as a result after threading, all the alteration occurred in the structure can be easily recognized owing to plastic deformations.

It is important to be mentioned, the structural alterations of the deformed metal layer, represent one of the most important indicatives who influences the physical-mechanical and physical-chemical features of the processed pieces.

However, there are cases when the plastic deformation of the superficial layer leads to structural reticulation perishing in the deformed metal layer, fact which has negative results over the quality of the processed pieces. This phenomenon is connected with the non-observance of the processing conditions, with the material's and tool's state, etc.

The deformed layer's structure at an steel is different than for a steel (figure 1), by the fact that here appear a finer structure, because through plastic deformation, the crystals are losing their globular shape and there are more stretched in processing's direction. Thus, it is obtained a surface with a fallacious aspect, which, in most of the cases, coincides with the fibre, which the piece has to have.

Such a thickening and orientation of the crystals is superior to the initial structure where the crystals were distributed fairly heterogeneous. Their orientation after the direction of the piece's fiber is obviously superior

compared to the deformation and orientation of the crystals on the transversal direction of piece's fiber. It must be taken care about this phenomenon at the elaboration and the unfolding of the technological process.

The deformation process of the thread, leads to a larger concentration of the steel's pearlitic grains, under the action of the deformation pressure (realising in this way an overcrowding of the pearlitic grains). As a result, a general deformation of the crystal grating of the deformed metal layer, is taking place, fact, which influences directly the piece's quality.

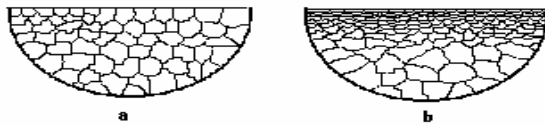


Fig.1 The crystal structure of the superficial layer  
at a steel sample:  
a-the latched sample b-the rolled sample

Analysed in section, the plastic deformed layer, shows that the deformation of the crystal grating is diminishing little by little in depth, and then completely disappears, remaining prevalent the initial structure of the metal. No matter which way the deformation is made the structure's. Although the structural alterations depend mostly of the respective material's building. alterations appear on longitudinal, transversal and perpendicular on the working surface. For instance, on a steel which has a pearlitic-ferrite structure, the plastic deformation it will be higher at the ferrite grains than at the pearlitic ones.

The thread's plastic deformation is accompanied with the cold hardening of the superficial layer. The cold-hardening phenomenon is close to the presence of the big internal tensions in the deformed superficial layer. Through cold deformation, the material suffers a cold-hardening phenomenon owing to the obstruction of the dislocations displacing on the sliding plane and the setting-up of new dislocations, who establish, also, the intensification of the tensions' domain. From the whole energy used for deformation, the largest part is turned into heat, because of the frictions, and only 20-25% is stored in the grating, increasing the internal energy of the deformed layer from the material.

The deformation's degree of the crystal grating, in the cold-hardened layer and its thickness, mostly depend on the specific average contact pressure, as well as of the features of the material. Depending on the main purpose, for which the rolled threads are made, and its material, are chosen different values of the specific average contact pressure, the action levers for this being the attack angle and the number of screw tap's edges, as well as the number of passing which from the thread is realised, this one being typical for threading rolls.

## 2. The elastic deformation

The cold plastic deformations are accompanied by elastic deformations of the metal layer, thus the dislocation and sliding phenomenon, which take place during the processing, through displacing and partial returning of the metal, create a state of residual tensions in the plastic deformed layer. This state of tension has a positive influence in the resistance of the processed piece. In the same time however, the elastic deformations of the superficial layer influence the dimensional stability of the processed piece and the tool's unscrewing moment.

The experiments which have been made noticed the fact that even the non-ferrous alloys presents considerable elastic deformations, very close to the steels' ones.

From the diagrams shown in fig.2, can be noticed that in case of obtaining of a M12 thread on a rolled steel and an aluminum alloy, owing to the presence of the elastic deformations, the unscrewing moments are fairly high and proximate closer, being situated around 50-60% from the thread's forming moment.

Between the maximum threading moment and the maximum unscrewing moment there is an angular gap, owed to the cumulating of the elastic deformations of the material and to the torsion of the threading tool. The size of this angular disparity is  $C_{\max} = 15^\circ$  for the aluminium alloys and  $C_{\max} = 17^\circ$  for steel. Owing to the plastic deformations which are taking place during the thread's processing, simultaneous or successive, depending on the proceeding or method used, inside the deformed material take place dislocations and sidings which creates a state of residual tensions.

In case of splintered threads, these tensions are focused at the ring's basement, setting up tearing points both in case of cutting requirement and (mostly) of endurance. On the other hand, for the threads made up through deformation, these tensions have a special importance, because they improve the physical-mechanical features of the processed threads.

The superficial metal layer, which is compressed through plastic deformation, represents generally a small volume compared with the piece's volume. The state of residual tensions which is created, as well as the improvement of roughness and micro hardness, make that the processed piece' surface to quire higher qualitative index, fact which influence directly the quality of the processed pieces.

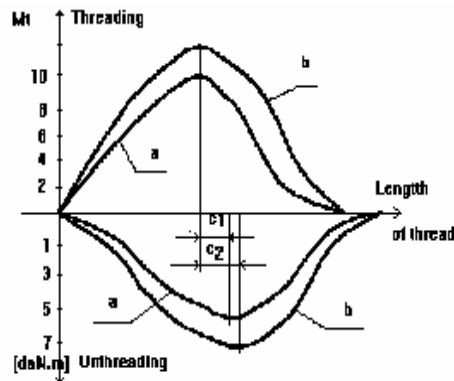


Fig. 2 The threading moment for:  
a - AlSi5Cu alloy; b - OL38 steel

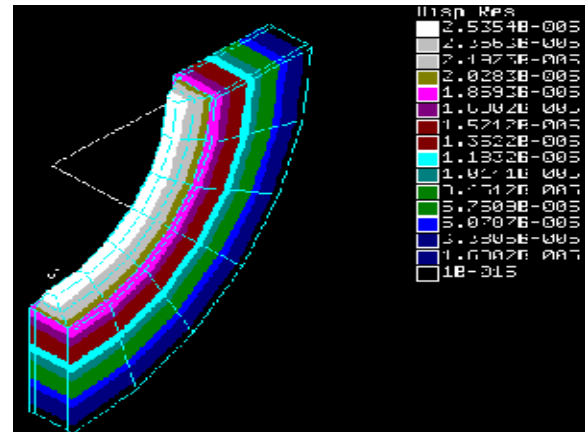


Fig. 3 The state of deformations in a screw with deformed thread

From the processing on the computer of the experimental datum, using the finite element method, it has resulted the state of deformations, presented in figure 3.

### 3. Calculus of medium diameter of the screw tap threads in terms of point of view the piece's material

As so is known, in case of this style of threading through plastic deformation, the diameter of thread's screw tap is bigger that of bore's thread. The new method of call takes into account of the elasticity of material as well as of the specific pressure of deformation and wearing out of the screw tap. The elasticity of material determines the contraction of the thread of nut. Thus, the medium diameter of thread it diminish because the elastic reversion of the material. The medium diameter of the screw tap  $d_2$  it is different by the nominal diameter of the piece's thread which an coefficient  $k$ , who takes into account of the specific pressure of deformation, in  $\text{daN/mm}^2$  and of the elasticity module of those alloy. Therefore,

$$K=f(P,E)$$

In this case, the medium diameter of the screw tap,  $d_2$ , will be:

$$d_2 = [D_{2N} (1 + \frac{P}{E}) + \Delta u]_{\Delta} \quad (1)$$

in which:  $\Delta u$  - compensation's addition of the wearing out ;  $\Delta$  - execution tolerance.  
Specific pressure of forming can be assimilated with:

$$P = \sigma_r (1 - \pi/2) [\text{dan/mm}^2] \quad (2)$$

From [1] and [2] it obtain:

$$d_2 = \{D_{2N} [1 + \frac{\sigma_r \left(1 - \frac{\pi}{2}\right)}{E}] + \Delta u\} \quad (3)$$

and for simplification the equation will write down:

$$K = 1 + \frac{\sigma_r \left(1 - \frac{\pi}{2}\right)}{E} \quad (4)$$

Thus:

$$d_2 = (D_{2N} K + \Delta u)_{-\Delta} \quad (5)$$

The size of coefficient k, after a series of determinations resulted between the following limits:

$$K = 1,0081 - 1,0125$$

The small values will be adopted for the alloys with small degree of elasticity. These it distinguishes after the siliciu percentage from chemical composition (between 1 and 3%). The compensate addition at the wearing out can't take it with acceptable accuracy, thus:

$$u = 0,02 - 0,05 \text{ [mm]}$$

The small values of  $u$  from this relation will take with enough accuracy for screw taps of those diameter doesn't surpass the limits of the interval M3 - M6, and the big values of  $u$  for screw taps in the limits M20 -M24 of those pass doesn't surpass value by 2 mm. For the precise threads, it must take also into account the contraction  $\Delta P$  according to the step of the thread and the contraction  $\Delta D_2$  according to the medium diameter (fig.4), which the relation expresses it:

$$\Delta P = 2\Delta D_2 \operatorname{tg}(\alpha/2) \quad (6)$$

Talking into consideration the radial elastic deformation, through their lumping together are obtained values between 20 and 65 % from the value of the tolerance of the medium diameter of the screw nut's thread, depending on the psihical-mecanical features of the material subdued to threading.

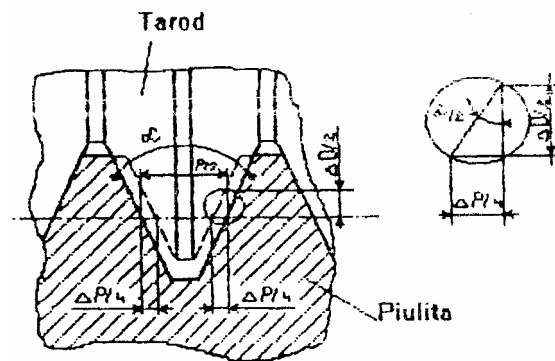


Fig.4 Elastic relapse of nut after threading

## References

- [1] I. Gavrilas, *Flattening and cold-hardening of the surfaces*, ET, Bucharest, 1981.
- [2]. Constantinescu, *Processing of experimental dates with numerical calculators*, ET, Bucharest, 1980.