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# THE OPTIMUM DOMENIUM OF COLD PLASTIC DEFORMATION DEGREE OF SOME ALL PURPOSE STEELS

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## ABSTRACT
*The present paper has an object the evaluation the structural hardening of some low carbon steels, an increase of the resistance characteristics, and using for the analysis the determination of Vickers hardness. The field of research is represented by round steels, for witch, hardening can lead mainly to important increases in the flowing limit.*
*Cylindrical samples made of low carbon steel have made submitted to tests of deformation by pressing along the generatrix between plane tools. The deformation degree has been established according to the reduction in diameter ($\varepsilon_d$)*
**Keywords**: deformation, degree, diameter

## 1. FOREWORD
One of the ways of increasing the resistance characteristics of construction unalloyed, low carbon steels, is hardening by cold plastic deformation.
Industrial bar hardening is achieved at present by means of two technological processes, namely:
- by drawing;
- by twisting.

This paper also took into consideration a third means of hardening, i.e. a plastic deformation by rolling round sections along a generatrix, method which presents several advantages both concerning the investment costs and its turning into account on building sites, especially for concrete steels.
In following this target, on analyzed the influence of the deformation degree of round sections rolled along the generatrix, upon resistance properties and the formation of distortion areas. The research is based on the values of Vickers hardness determined in the samples cross-sectional deformed and cut.

## 2. EXPERIMENTS
The begining of the study presents the results obtained with extrasoft steel submitted to traction, by determining the conventional characteristics curve, the flow curve and the plasticity coefficients. The study is extended in this article over the way deformations respectively hardening are produced with round cross sectional samples compressed along the generatrix under different degrees of deformation ( $\varepsilon_d$).
The samples having a diameter of 35 mm and a length of 40 mm, have been worked out of industrial laminates.
Before being manufactured, the samples have been annealed to 925 $^oC$
The degrees of deformation corresponded to a reduction of the cross-section by: 0.3%; 5 %; 10%; 20 %; 22 %; 30 %, and a sample has been deformed along two perpendicular directions by 20%.
After deformation, the samples have been cut across at half length, prepared and tested by determining their hardness in different points equally placed from each other.

The minimum and maximum hardness of each sample, the average line and column hardness, as well as the number of tests on each sample are given in Table 1.

*Table 1. Hardness of extrasoft steel deformed by compression*

| $\varepsilon_d$, % | No. of tests | HV Hardness | | |
|---|---|---|---|---|
| | | Average | Mimimum | Maximum |
| 0.3 | 113 | 115 | 103 | 137 |
| 5.0 | 77 | 128 | 103 | 148 |
| 10.0 | 113 | 150 | 137 | 167 |
| 15.0 | 87 | 160 | 134 | 168 |
| 20.0 | 91 | 166 | 143 | 168 |
| 22.0 | 91 | 166 | 143 | 175 |
| 30.0 | 91 | 158 | 122 | 178 |
| 20.0 * | 81 | 167 | 146 | 178 |

Hardness distribution on the cross section is corresponding to the deformation degree applied.
Table 1 shows that the highest increases of average hardness are achieved with deformation degrees of up to 15 %, a continuation leading to relatively small increases, even to double compressions (*) along perpendicular directions.

Thus, an increase of the average hardness for a deformation degree of 15% is 30 – 39%, as to the initial state and the increase of deformations from 15 to 30 % has an influence of only 4% to 7% upon hardness.

In order to cover as many variants of interpretation as possible, with respect to the results obtained, we have established marked zones. The average hardness per zone (Table 2) had to the same conclusions that has been reached concerning the average hardness per sample, i.e. a deformation degree of up to 15 % is technologically most advantageous, a certain decrease of hardness being noticed in zones where the deformation degree was over 20%.

*Table 2. The ($HV_5$) hardnesses of test rods for shock break tests*

| Sample mark | % C | $HV_5$ hardness | | | | |
|---|---|---|---|---|---|---|
| | | Deforming force, x $10^4$ N | | | | |
| | | 0 | 30 | 50 | 60 | 70 |
| 1 | 0,10 | 144 | 155 | 151 | 162 | 152 |
| 2 | 0,13 | 146 | 152 | 167 | - | - |
| 3 | 0,17 | 150 | 158 | 167 | 180 | 174 |
| 4 | 0,20 | 144 | 150 | 165 | - | - |
| 5 | 0,25 | 152 | 140 | 160 | 178 | - |
| 6 | 0,33 | 156 | 158 | 168 | 168 | - |

Tables 1 and 2, lead to the conclusion that the extrasoft steel the maximum hardness in the central zone (the point hardness) has not exceeded 178 HV witch corresponds to a specific stress of 610 $N/mm^2$ according to the corresponding scales recommended by STAS R 883-81, or of 587 $N/mm^2$ according to relation

$$\sigma = 0{,}33.\ HV \qquad (1)$$

An over 20% increase of the deformation degree for the extrasoft steel leads to an increase of the number of tests having the maximum hardness of 175 – 178 HV along side with an extension of the contact zone representing 39 % of the maximum surface at a deformation degree of 5%, 51% at a deformation degree of 10%, 63 % at 15%, 69% at 20%, 82 % of the maximum surface at a deformation degree of 30%, the maximum area being determined by the maximum length and width of the sample after deformation.

Coming back to the value of maximum hardness established at 178 HV we notice that it comes near the theoretical value necessary for a complete plastic flow determined for the case of deformation by compression using a plane device having a surface by for inferior to that of the sample, by the relation:

## 3. CONCLUSIONS

- the break energy for quieted all-purpose construction steels decreases abruptly while cold plastic deforming, the decrease being more accented when the content in carbon is higher. Practically, the quieted steels grade OL 32, OL 34, OL 37 k can not guarantee the tenacity expressed by the break energy of 27J at environment temperature;
- with steels OL 37 kf, OL 42 kf and OLC 20, OLC 25, OLC 35, with a content in aluminum per product of at least 0.020% the break energy of at least 27J can be guaranteed even for deformation degrees of up to 20 %.

As a conclusion, we suggest as a method of increasing the resistance characteristics by about 30%, the cold plastic deformation by compressing (rolling) to a deformation degree of up to 15%, and if a minimum tenacity level is requested, the steels have to be quieted suplimentarily, by addition of aluminum, ensuring a minimum aluminium level per product of 0.020 %.

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