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THE ASSESSING OF MECHANICAL CHARACTERISTICS OF THE STEEL SHEETS DESIGNED FOR DRAWING FOR A FIVE-MONTH-PERIOD AS AN EFFECT OF NATURAL AGEING

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ABSTRACT

In the paper it is presented a study run on a five-month-period regarding the changes in the mechanical characteristics due to natural ageing for a drawing steel, cold rolled, unalloyed with 0.04% C. The ageing tendency of the sheets designed for drawing is influenced by the chemical composition and the steel purity on the one hand, as well as by the structural state and on stress state. In order to determine the mechanical characteristics and the Erichsen parameter, specimens with the following dimensions were used: length l_0 = 240 mm; width b_0 = 20 mm; thickness h_0 = 1.5 mm.

The following mechanical properties were determined: the yield point Rp0.2[N/mm²], the breaking strength Rm[N/mm²], the breaking elongation [%], the Erichsen parameter IE [mm]. In order to characterize the material's quality with the objective of creating some marks it is useful to be studied besides the conventional set of trying, other parameters, as well, such as the drawing capacity with the help of the cold-hardening coefficient n.

KEYWORDS: drawing steel, natural ageing, mechanical resistance, elongation

1. Introduction

The cold rolled sheet can be used for deep drawing or in applications with multiple bendings, the requirements of resistance, rigidity and ductility being compulsory.

The main applications are in the car industry, in the domestic field, metal furniture, radiators and fans, the production of tubes and of small profiles.

The chemical composition of the steel is presented in Table 1.

Table 1

Steel	C	Mn	Si	P	S	Al	Cu	Cr	Ni	V	Mo	Ti
	[%]											
DC04-A	0.040	0.3000	0.025	0.015	0.010	0.068	0.020	0.010	0.020	0.004	0.003	0.005

In order to appreciate the cold deformation capacity of the thin sheets according to the regulations in force, the following mechanical characteristics were taken into consideration: *the yield point* (Rp $_{0,2}$), *the breaking strength* (R_m), *the breaking elongation* (A), *the Erichsen parameter* IE, *hardness* (HRB).

These experiments are part of the conventional set of trying for the products' reception, but they seem insufficient for the certification of the material's quality with the objective of making some marks. Hence, the usefulness of studying the resistance and plasticity parameters that should give enough information on the material's behaviour at the cold plastic deformation, like, as an example, the material's cold-hardening shown by the help of *cold-hardening coefficient* **n** or the anisotropy of the metallic material's properties shown by *the anisotropy coefficient* **r**. Through drawing, one can make a wide

range of marks, highly varied in shape and dimensions that are part of both the resistance structure andelements of car's body. This wide range of drawn marks, simple and complex, requires that the semiproducts are made to satisfy certain conditions of workability. The cold-hardening coefficient **n** and the anisotropy parameter **r** are values related to the internal properties of the processed material. In this way, the semiproducts of sheet for drawing car bodies, **n,** are in direct correlation to the yield point, the breaking strength, the relative elongation and the Erichsen parameter.

The parameter supporting the evaluation of the drawing capacity whose help one can appreciate the of a semi-product is dependent on the work piece's geometry as well as on the applied technology. For example, for the marks with large areas and that don't have a complex configuration like the sun-blind, the bonnet, the door boards, steels with high elongation are not needed, but, one must ensure as much uniform deformation repartization as possible and a hardening through deformation. In this case the drawing capacity is rated with the help of the cold hardening coefficient **n**. For the materials undertaking high deformation degrees, it is necessary for the yield point to be low, and the relative elongation and the breaking contraction to be high, as well as the ratio between the yield point and the breaking strength to be as low as possible.

2. Experimental results

In order to determine the mechanical characteristics and the Erichsen parameter the following samples with these dimensions were used: length l_0 =240 mm; width b_0=20 mm; thickness h_0=1.5 mm.

The following mechanical properties were determined: *the yield point* $Rp_{0.2}$[N/mm²], *the breaking strength* R_m[N/mm²], *the elongation strength* [%], *the Erichsen parameter* IE [mm], *the cold hardening coefficient* **n**.

In order to rate the deformation behaviour the following experiments were made every two weeks for the five-month-period:

- The stretching test, for determining the
- mechanical properties of the cold-hardening coefficient n and the anisotropy one r.
- The drawing test by the Erichsen method.

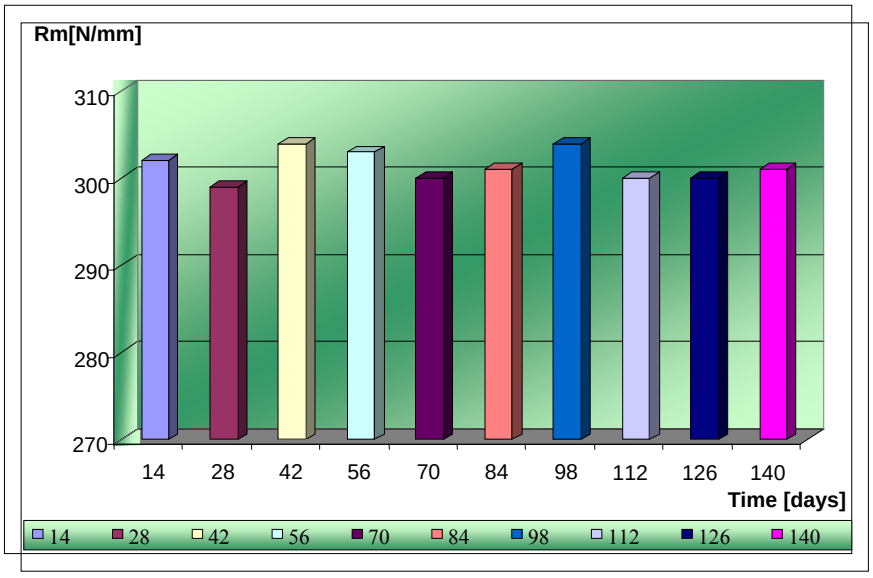

Fig. 1. *The influence of natural ageing on the mechanical resistance of the sheets indented for drawing for a period of 140 days.*

The values imposed by STAS SR EN10030 – for these steels are:

- the yield point $Rp_{0.2}$=max 210 N/mm^2
- the mechanical resistance R_m= 270-370 N/mm^2
- the elongation strength A_n=min 30 %
- the Erichsen parameter IE= min 8,90 mm
- the anisotropy coefficient r_{90} min =1.6
- the cold-hardening coefficient n min=0,18

The results of the determinations made during the study are presented in figures 1, 2, 3, 4, 5.

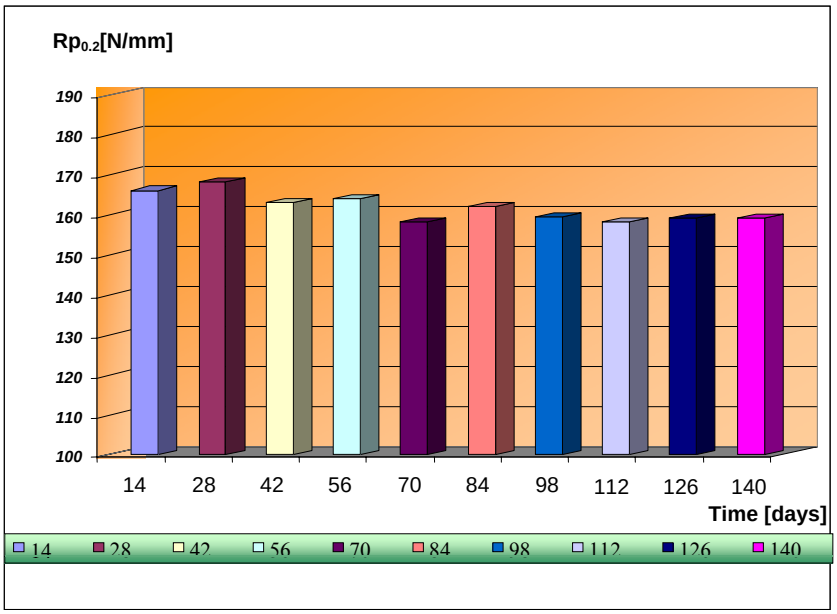

Fig.2. *The influence of natural ageing on the yield point of the sheets indented for drawing for a period of 140 days.*

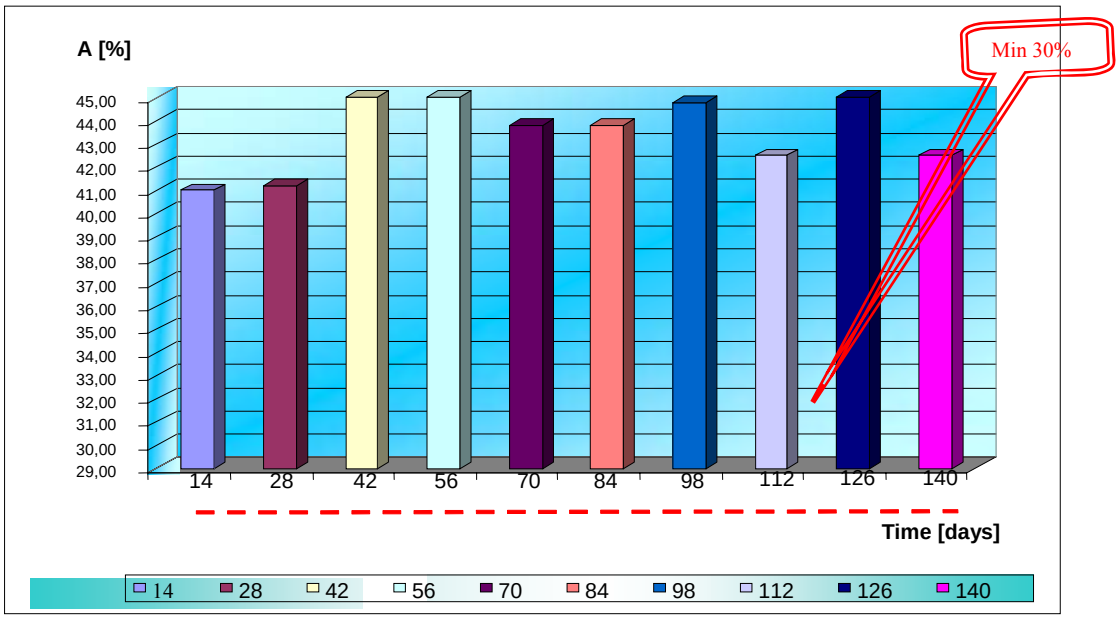

Fig.3. *The influence of natural ageing on the mechanical resistance of the sheets indented for drawing for a period of 140 days.*

The anisotropy parameter r characterizes the material's capacity to change its shape by lateral contraction during a linear forge drawing stress and it is determined with the help of a stretching test sample, at deformation values ranging between 0,15-0,2.

The **r** value gives indications regarding the property of a material to stand a higher or lower resistance at the flowing in the direction of its thickness. At high values of the anisotropy parameter, the semiproduct can deform itself, more from its width than from its thickness, improving the material's behaviour to deformation.

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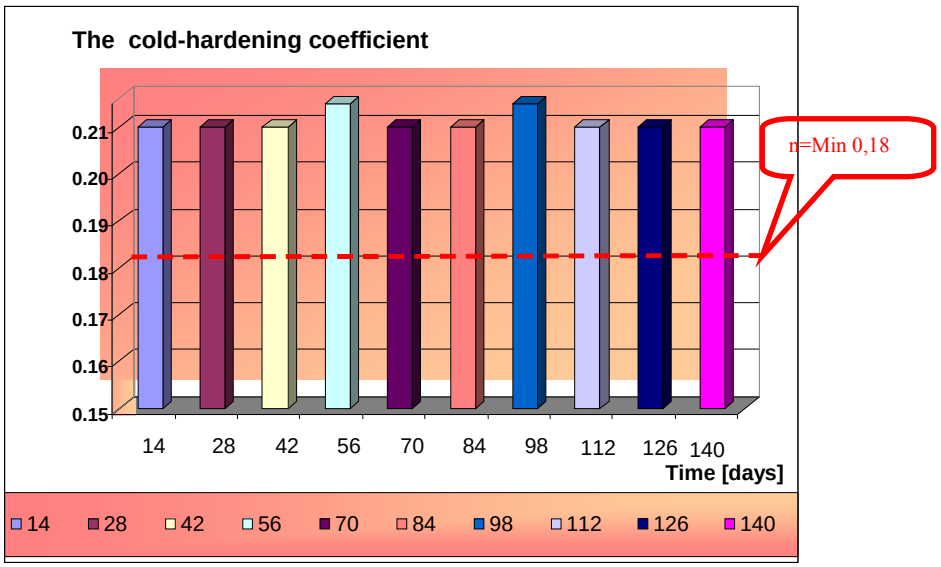


Fig. 4. *The influence of natural ageing on the cold-hardening coefficient of the sheets indented for drawing for a period of 140 days.*

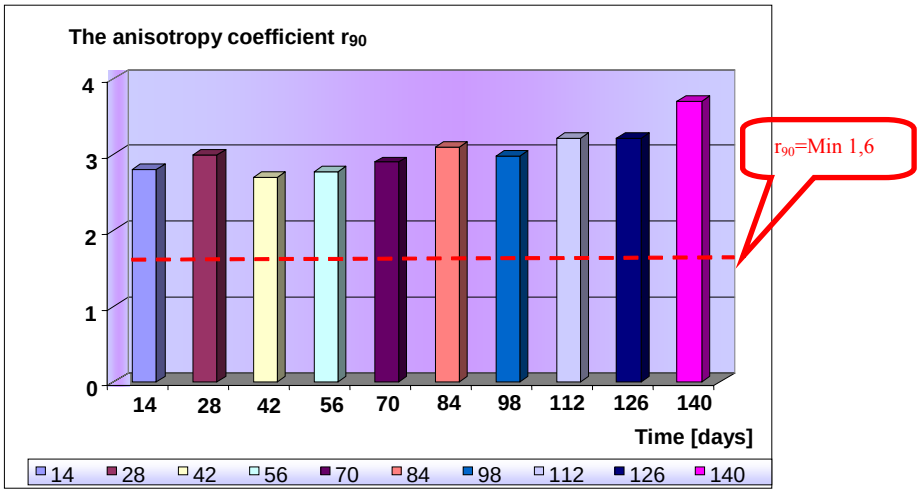


Fig.5. *The influence of natural ageing on the anisotropy coefficient of the sheets indented for drawing for a period of 140 days*

For a wide range of products the r value depends in a great measure on the processing direction of the sample against the rolling direction.

The high values of the anisotropy parameter show a good lateral behaviour and a high corrugation resistance, characteristics that lead to a good behaviour of the material at deep drawing.

The cold deforming behaviour of the steels can be weighed if it is known the cold-hardening coefficient **n**, parameter that presents a measure of the material capacity of evenly distributing the deformations. The higher the cold-hardening coefficient, the higher the value of the maximum uniform deformation of the material and the more uniformly distributed on the cold plastic deformed mark.

In fig. 6 it is presented the analysed steel microstructure in buttock and cross section.

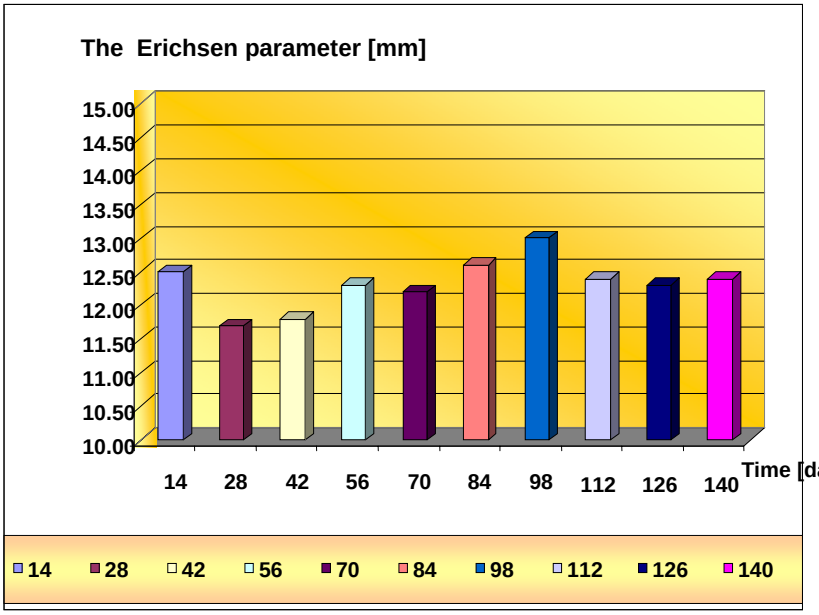
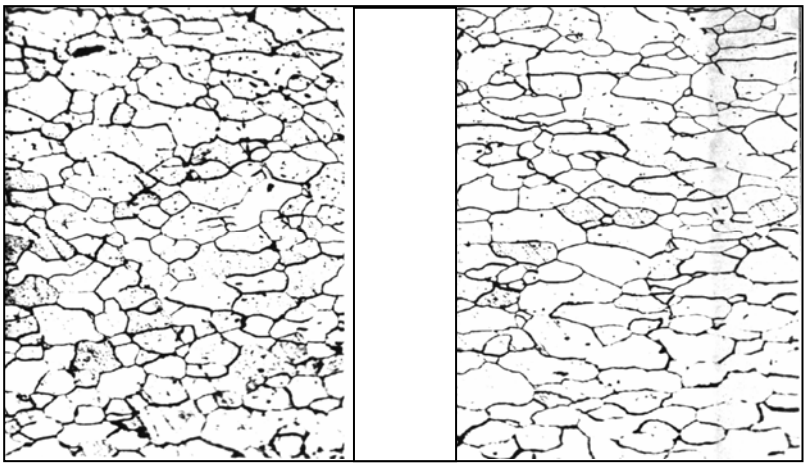


Fig. 6. *The influence of natural ageing on the mechanical resistance of the sheets indented for drawing for a period of 140 days*

In fig. 7 a and b it is presented the microstructure of the studied steel. One can notice a fine grain size (tally 8,5) made from ferrite grains with very little precipitate of $Fe3C_{III}$. After the analysed period of 140 days one can notice an increase in the number of precipitate at the limit of the ferrite grains, with globular aspect and uniformly dispersed in the ferrite matrix (natural steel ageing), fig.8.



a) b)

Fig.7. *The microstructure of the steel a) cross section; b) longitudinal section. (magnification 250x).*

The forming of these precipitates are owed in time to the carbon atoms diluted in excess that come out of the ferrite solution and to the forming of the secondary phase through precipitation.

These precipitates increase by coalescence and slightly modify the values of the mechanical characteristics (without strongly affecting the quality of the sheets).

Fig. 8. *The steel macrostructure after 140 days of natural ageing in longitudinal section (magnification 100x).*

4. Conclusions

- The sheet of drawing steel made for car bodies should have a high level of quality.
- According to the recommendations in the professional literature, confirmed also by the industrial activity, these steels should present a fine and even grain size and a high purity – characterized by a very low tally of non-metallic inclusions (the analysed steel in this study presented a tally of the non-metallic inclusions of 1: 0.5 oxides and 0.5 sulphurs).
- The free cementite precipitates at the grain limits' were not coarse.
- These steels should present mechanical characteristics according to the limits approved by standard, with the recommendation that the relative elongation to stretching should be as high as possible.
- In order to ensure a good behaviour to processing through drawing, it is recommended that the values of the cold-hardening coefficient's parameters n and of the anisotropy parameter r should be situated in the approvable limits.
- The high values of the anisotropy parameter indicate a good behaviour on cross section, characteristic that leads to a good material behaviour to deep drawing.
- The higher the cold-hardening coefficient, the higher the value of the maximum uniform deformation of the material and the more uniformly distributed on the cold plastic deformed mark.
- Along the analysed period all the analysed characteristics were situated in the required specifications.
- Ageing for the analysed period does not significantly diminish the drawing capacity of the sheets.

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