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INFLUENCE ON MACHINABILITY BY DRAWING THE INTRINSIC PARAMETERS OF MATERIAL

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Abstract: *In this paper have shown the relationship between intrinsic parameters and the technology resulting from a trial (σr, σc, A, IE). Has been defined notion of capacity utilization coefficient drawing and has been shown that for each group of pieces carried, the number of discards is directly related to the size* ($n_{med}\cdot r_{med}$).
Keywords:*drawing, Lankford coefficient, strain hardening exponent*

INTRODUCTION

Processing capacity by drawing can be appreciated using general methods (such as the mechanical tests, microstructure analysis, chemical analysis) and species (such as those that highlight the intrinsic parameters of the material, limit curves, deep drawing tests). Of these, the paper will tackle study of the influence of intrinsic parameters such as Lankford coefficient "r" and hardening exponent "n".

Determination of intrinsic material parameters. Their use in order to make the deep drawing processing while reducing the number of discards

After tensile test to determine the characteristic curve of the carbon steel sheet and low alloy carbon steel, from which it results the capacity of the material hardening during cold plastic deformation, which is expressed by the equation:

$$\sigma_{real} = C \cdot \varepsilon^n, \tag{1}$$

where: σ_{real}–the real tension; C - constant material; ε - the real deformation; n - hardening exponent.

The real deformation is determined by the relationship:

$$\varepsilon = \ln \frac{L_i}{L_0}, \tag{2}$$

where: L_0 - initial length of the fixed point, the undeformed specimen; L_i - length of the specimen between fixed points corresponding deforming force F_i.

The real tensionis determined by the relation:

$$\sigma_{real} = \frac{F_i}{A_i}, \tag{3}$$

where A_i is the correspondingsectionspecimen for the time action deforming force F_i.

The hardening exponent values to are obtained by logarithmation of the equation (1) is the slope of the straight line of fig. 1 [1].

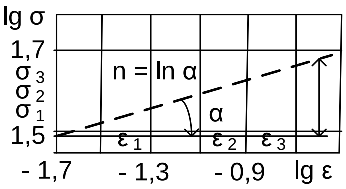


Figure 1. The diagram necessary determination of hardening coefficient "n"

In the fig. 2 to represent the elongation of the material deformed by dividing the network parameter for different values of material strain hardening exponent. It is noted that for large values of the exponent, the resulting deformation will be smaller and more uniformly distributed in the piece, which will decrease the danger of breakage.

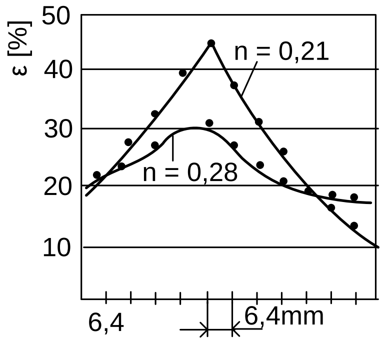


Figure 2. Variation of elongation of the material during deformation, for different values of strain hardening exponent

The Lankford coefficient is related to the circumferential compression deformation.It provides information as to the yield strength of the material in the direction of thickness which can be less or greater than [2]. The coefficient of anisotropy is determined by the relation:

$$r = \frac{\ln \frac{b_0}{b}}{\ln \frac{g_0}{g}} = \frac{\ln \frac{b_0}{b}}{\ln \frac{b \cdot L}{b_0 \cdot L_0}}, \tag{4}$$

where: g_0, b_0, L_0 is the thickness, width, respectively undeformed specimen length between fixed points on the sheet; g, b, L - are the same size, but for the specimen deformed by stretching.

Following the tensile test specific strains recorded falls in the range (0,15; 0,2).Tests shall be made on the universal machine tried and test specimens used are taken at 0 °, 45 ° and 90 ° to the rolling direction.

Corresponding high values of "r", the material is deformed more in width than in thickness, that presents a favorable deformation behavior.

The values of the intrinsic parameters of the sheet metal is determined by means of diagrams, [3], followed by calculation of mean values (normal) with the below relationships:

$$\bar{n} = n_{med} = \frac{n_0 + 2 \cdot n_{45} + n_{90}}{4}, \tag{5}$$

$$\bar{r} = r_{med} = \frac{r_0 + 2 \cdot r_{45} + r_{90}}{4}. \tag{6}$$

Normal anisotropy gives indications of resistance to thinning drawing sheet metal and the depth of it.

At the cold rolled sheets was observed variations in the plane of the sheet metal Lankford coefficient to the direction of rolling, so that planar anisotropy calculated by the relation:

$$\Delta r = \frac{r_0 - 2 \cdot r_{45} + r_{90}}{2}. \qquad (7)$$

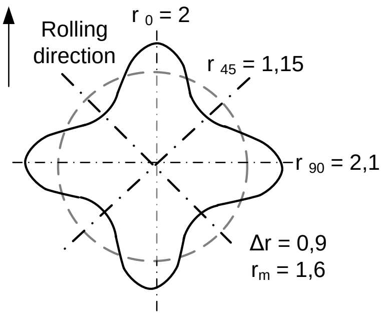


Figure 3. Variation Lankford's coefficient to the rollingdirection

The plane anisotropy favors the appearance of wrinkles (bend) the surrounding walls drawing parts [4].In the fig. 3 shows that the festoons are formed in directions that are 0 ° and 90 ° to the rolling direction, that is in the same direction that the average Lankford coefficient is at a maximum.Therefore, knowing the value of the normal distribution of the coefficient of anisotropy in different directions, the directions characterized by peaks can be selected with the aim as they can be carried deep drawing of the material.

This conclusion is corroborated by metallographic researches [5], which shows that the same directions, the crystalline grains have a favorable orientation processing by drawing orientation, that resulted from rolling.After processing by rolling is an increase in the size of crystalline grains, resulting in minimal resistance to deformation during of subsequent processing.

The metallographic texture determination was made by means of inverse pole figures.The conclusion that the result by this method was that the texture P (111) is the most favorable processing by drawing, while texture P (100) is the worst.Also, between structure and Lankford coefficient relationship has been established:

$$\bar{r} = 1{,}184 + 0{,}257 \ln\frac{P(111)}{P(100)}. \qquad (8)$$

This led to the conclusion that improving deformability during processing by drawing sheet metal can register by directing the formation of crystallographic texture.

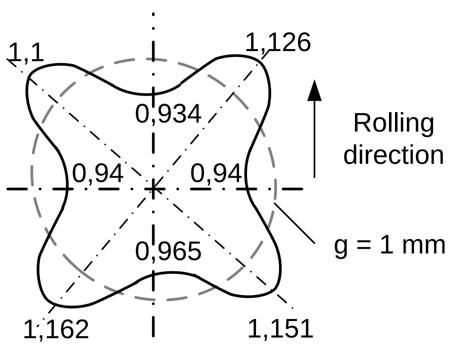
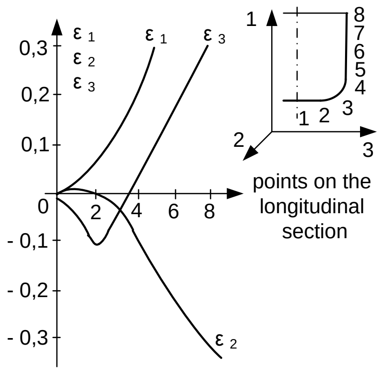


Figure 4. Variation of the wall thickness of the drawing piece to the direction of rolling

At the same time, the measurements of the cylindrical wall thickness were made on the darwing piece without thinning, starting from a blank in the form of a disc having a thickness of 1 mm. It is noted that for the directions which are 45 ° to the rolling direction has been increased wall thickness, while the directions of 0 ° and 90 °, the thickness decreased (fig. 4).Comparing figures 3 and 4 leads to the conclusion that the material thinning is produced corresponding to festoons.

Study material behavior during processing by drawing included principal strains ε_1, ε_2,$\varepsilon_3$recording variation, for different points in a longitudinal section, observing that (fig. 5):

a) sheet is deformed slightly based on the cylindrical part;
b) the most pronounced thinning is produced corresponding of the



transition of the flat bottom with the walls;
c) strain increase with height walls.

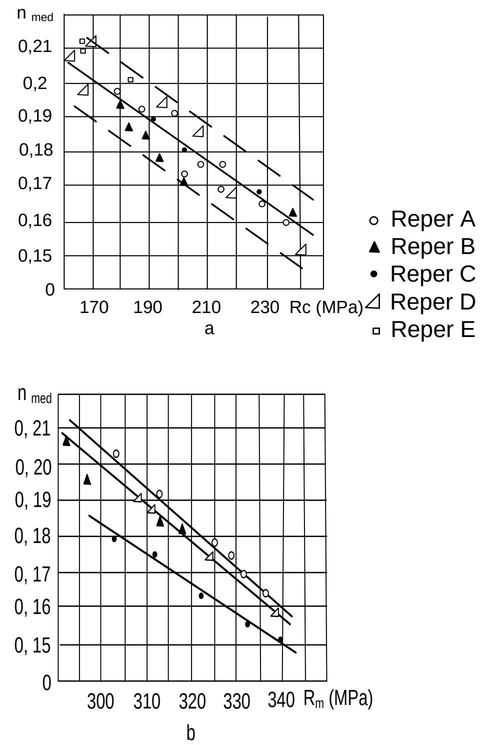
Figure 5. Variation of real principal strains ε_1, ε_2, ε_3 in the longitudinal section of a cylindrical piece

Between sheet features resulted from the tensile test or a technological test for determining Erichsen index and the sheet intrinsic parameters were determined following relations:

$$n_{med} = 0{,}3 - 0{,}00056 \cdot R_c, \qquad (9)$$
$$n_{med} = 0{,}49 - 0{,}00097 \cdot R_m, \qquad (10)$$
$$IE = 83{,}8 + 115{,}05 \cdot \bar{n}, \qquad (11)$$
$$D_{cr} = 53{,}322 + 3{,}752 \cdot \bar{n} + 29{,}8 \cdot \bar{r}, \qquad (12)$$
$$A = 22{,}96 + 74{,}464 \cdot \bar{n}, \qquad (13)$$
$$\frac{R_m}{R_c} = 1{,}243 + 2{,}56 \cdot \bar{n}. \qquad (14)$$

it has been noted: R_c - conventional yield strength [MPa]; R_m - mechanical strength [MPa]; IE - Erichsen index [mm]; D_{cr} - Engelhardt critical diameter [mm]; A - the elongation ratio [%].

The above relationships resulting from the the experimental data shown in figures 6a - 6d. From equation (11) means that a large value of strain hardening exponent corresponds to a deformation good stretching - compression.



Equation (12) shows that a normal value high Lankford's coefficient corresponds to a good deformation biaxial stretch.

Between hardening exponent and crystallographic texture could not establish any relationship. In contrast, in this module hardening and carbon content was determined a relationship of the form:

$$\bar{n} = 0,1003 \cdot (\%C)^{-0,2322}. \quad (15)$$

This demonstrates that the recommendation is mild steel sheet,in other words present a low carbon content, in the case of the deformation stretching - compressive, where the mean value hardening exponent must be high value.

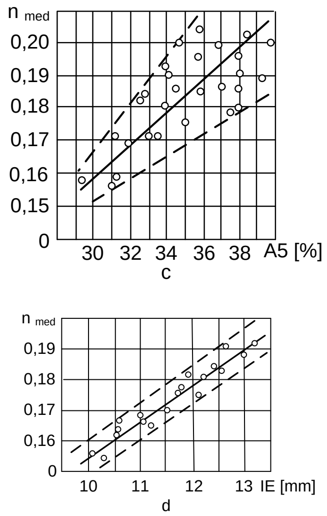


Figure 6. Variation parameter n_{med} depending on the characteristics R_c, R_m, A_5, IE

It was also highlighted that the hardening modulus depends on the crystalline grain size by a relationship of the form:

$$n = \frac{a}{b+\sqrt{d}}, \quad (16)$$

where a, b - constant of the material; d - diameter of the crystalline grain. It is noted that as the structure is becoming finer, the strain hardening exponent increases.

Has been studied relationship between intrinsic parameters and coefficient sheet drawing capacity utilization [6]. It is determined by the relationship:

$$\eta = \frac{\varepsilon_{ech}}{\varepsilon_{cr}} \cdot 100 \ [\%], \quad (17)$$

where: ε_{ech}- equivalent strain; ε_{cr}- critical strain corresponding to breakage initiation time sheet metal.

Equivalent strain is calculated using:

$$\varepsilon_{ech} = \frac{2}{\sqrt{3}} \cdot \sqrt{\varepsilon_1^2 + \varepsilon_2^2 + \varepsilon_1 \cdot \varepsilon_2}, \quad (18)$$

wherein the main deformations of the sheet metal plane, namely in the direction of thickness are $\varepsilon_1 = \ln\frac{l_1}{d}$, $\varepsilon_2 = \ln\frac{l_2}{d}$, $\varepsilon_3 = \ln\frac{g}{g_0}$;d – diameter circular motif; l_1 și l_2 –axis of the ellipse high and low, resulting from the circledistortion; g_0 și g – sheet thickness before and after deformation.

The critical strain is calculated with:

$$\varepsilon_{cr} = \frac{2}{2-k} \cdot n \cdot \sqrt{1+k+k^2}, \quad (19)$$

It is noted: $k = \frac{\sigma_2}{\sigma_1} = \frac{\varepsilon_1 + 2 \cdot \varepsilon_2}{2 \cdot \varepsilon_1 + \varepsilon_2}$. (20)

Taking into account of the equations (17-19) is obtained:

$$\eta = \frac{2-k}{\sqrt{3}} \cdot \frac{1}{n} \cdot \sqrt{\frac{\varepsilon_1^2 + \varepsilon_2^2 + \varepsilon_1 \cdot \varepsilon_2}{1+k+k^2}} \cdot 100 [\%]. \quad (21)$$

In the specialty literatureit is recommended that η <80-90%, because the rate of capacity utilization of drawingis lower, the number discards is less, for a particular material entered for processing.

It was observed that the growth anisotropy index recorded increases of critical strains (Fig. 7). From equation (19) it is seen that the critical deformations increase with increasing strain hardening exponent.Therefore, the rate of capacity utilization of drawing, and the number of discards will be even smaller as the intrinsic parameters of the material will be higher, and Δr will be lower.

The product (n_{med} · r_{med}) has great practical importance, so has been studiedthe possibility of determination of values n_{med} and $r_{med}$for different groupsdrawn pieces, depending on the nature of the material processed and complexity.Consequently, were considered different types of car body parts, which depending on their complexity were divided into groups denoted by A, B, C, D. It took into account the value of the product (n_{med} · r_{med}), which was linked to the number of parts discarded, so that the resulting fig. 8.

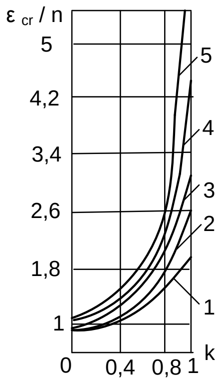


Figure 7. Variation ratioε_{cr}/ ndepending on the parameter k; curve 1: r = 1; curve 2: r_{90} = 1,5; curve 3: r_{90} = 2; curve 4: r_{90} = 3; curve 5: r_{90} = 4

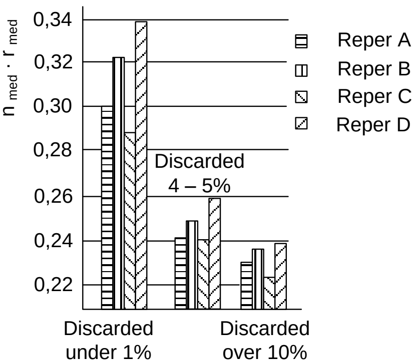


Figure. 8.Connection between the product (n_{med} · r_{med}) and the number of discarded pieces

Having regard to the experimental data medium shown in fig. 8 and noting with $P_{n\,r}$ = (n_{med} · r_{med}) and R - the percentage of discarded, resulting relationship:

$$R = 384{,}9686 - 2705{,}2059 \cdot P_{n\,r} + 4724{,}4871 \cdot P_{n\,r}^2 \text{ [\%]}. \qquad (22)$$

The important conclusion the resulting from this is that to get the pieces pieces obtained by drawing with a minimum consumption of material (by decreasing the number discarded) and energyis not necessary to obtain preforms with high levels of intrinsic parameters for any type of play, but must as strips or sheet to be characterized by optimal values of these parameters, the types of parts.

CONCLUSIONS

Knowing the intrinsic parameters of materials determines the rate of capacity utilization of drawing η that can characterize the machinability by drawing strips and sheets and allow reduction of discarded**.**

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