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STRUCTURAL ANALYSIS OF DR COVERED SHEET STEELS ON EARING EVALUATION

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ABSTRACT

The analysis of DR tinplate earing

The paper presents the influence of technological and material parameters in the deep drawing process to DR tinplate earing, methodic design for earing evaluation of tinplate and both structure evaluation of tinplate in various directions and methodic verification for various kinds of DR tinplate. The earing and comparison of tinplate structure owing to earing is in experimental.

Keywords: DR tinplate, deep drawing, anisotropy, earing, cup-drawing test.

INTRODUCTION

In recent years, the steel sheet is the basic material for the production of metal materials. Those are used in the form of tinning sheet. To decrease the price costs of tin as a protecting anticorrosive film, we use another film modification of sheet surface. The film is known as TFS (Tin Free Steel), and mostly present in the electrochemical coating of chromium and chromium oxide.

Tinned sheet has been holding a dominant level thanks to its mirror glossy surface accessory to the application of many-colored models, which are used in the packaging industry as version paints, lacquers and emulsions on packing food-stuff, beverage cans, biscuits, sweets, oils, lubricants, spirits and other products.

Based on the achieved results of mechanical and plastic properties the covered tin plates are divided into individual stages. (Bobenič, 2000; Kalpakjian, 1990; Spišák, 2000; and http://www.usske.sk/products)

Table 1 Mechanical properties of tinning sheet according to USS Košice.

Identification grade according to USS	$R_{p0,2}$ [MPa]	R_m [MPa]	$HR30T_m$	Stated by the norm standard
DR 520 CA	470-570	490-590		EN 10 202/2001 DR 520*.TH 520
DR 550 BA	500-600	525-625		EN 10 202/2001 DR 550*.TH 550
DR 550 CA	500-600	520-620		EN 10 202/2001 DR 550*.TH 550
	480-620		70-76	EN 10 203/91 DR 550 CA
DR 580 CA	530-630	540-640		EN 10 202/2001 DR 580*.TH 580
DR 620 CA	570-670	575-675		EN 10 202/2001 DR 620*.TH 620
	550-690		73-79	EN 10 203/91 DR 620 CA

Hardness HR30TM does not represent anisotropy of mechanical facilities of tinning tin-plate, which is typical for hardness. Anisotropy is better characterized by the index of normal anisotropy, but in case of tinning sheet, it is not possible to get a correct evaluation because of expressive Re. Through the development of technology production of deep drawing beverage cans, the problem has raised up to evaluation material for this process. The deep-drawing test was carried out on valuation of tinning sheet. The test appreciated the indicators of formability materials.

MATERIALS AND EXPERIMENTAL PROCEDURE

Deep-drawing test

Drawing is technological process, where from plane semi-product – sheet in one or more operation hollow entity is made. The scheme of deep drawing of round cuts is described in Figure 1. A round blank sheet metal is placed over a circular die opening, and is held in place with a blank-holder or hold-down ring. The punch travels downward and forces the blank into the die - 2 cavities, forming a cup. The important variables in deep drawing are the properties of the sheet metal, the ratio of blank diameter, he punch diameter, the clearance between punch and die, the blank-holder force, friction, and lubrication.

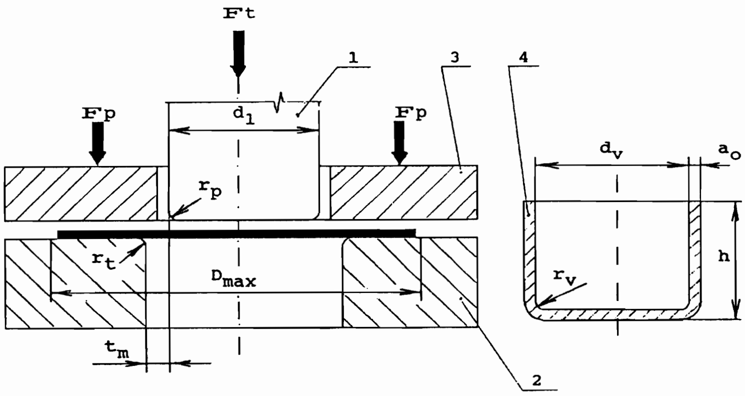

Figure 1 Scheme of deep drawing test.

One of the total indexes of formability is the state limit of drawing; it is stated by the deep-drawing exam. The compressibility of thin sheet is mostly characterized as state limit of drawing, which is for round cuts with plane bottom described by the relationship:

$$K_{max} = \frac{D_{max}}{d_v}$$

where, D_{max} - diameter of semi-product and d_v - diameter of cut

The process of drawing is not a reason for the rise of ears. Specific conditions have a large influence on drawing. Earing of cuts and direct orientation of ears is the consequence of specific deformation, respectively, recrystallization in texture tin-plate. In case of low-carbon metal sheets cold rolling the earing is coarsening by crystallographic texture.

After we have achieved cut without flange, the anisotropy of tinny cut displayed through different heights of cut in various side depends on the rolling of the sheet. We can evaluate anisotropy by several ways. Towards the evaluation anisotropy we have suggested the following technique:

- Ratio of earing Δh $\Delta h = \frac{h_0 - 2h_{45} + h_{90}}{2}$
- Index of earing z $z = \frac{H_{max} - H_{min}}{H_{min}} * 100$

Where: h_0 , h_{45}, h_{90} – height of cup in side of rolling sheet :0°, 45°, 90°
H_{max}, H_{min} – maximum, minimum height of cup

RESULTS AND DISCUSSION

From the measured and calculated values, we have determined:

Table 2 Values of earing DR thin sheets.

Type quality	Thickness [mm]	Diameter Δh [mm]	Diameter z [%]
T-57 BA	0,18	-0,273	2,527
DR 550	0,18	-0,42	4,661
DR 580	0,17	-0,369	4,948
DR 620	0,18	0,82	5,677

Microstructural analysis was performed in order to compare the structures of DR cover sheets before and after drawing of cups by the deep-drawing test. Figures 2 to 5 represented a structure of DR covered tin-plates. The sheets were fat free before observation. On the entire superficies tinning layer of cover tin-plate is visible. As it can be seen, the conspicuous lines structure of material appears in tendency of rolling, which is visible without any extension.

Microstructures of DR cover sheet steel: T-57 BA and DR 620:

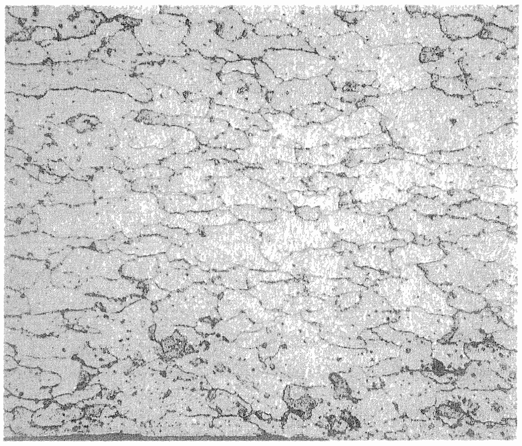

Figure 2 Microstructure T-57 BA, before drawing, 90°.

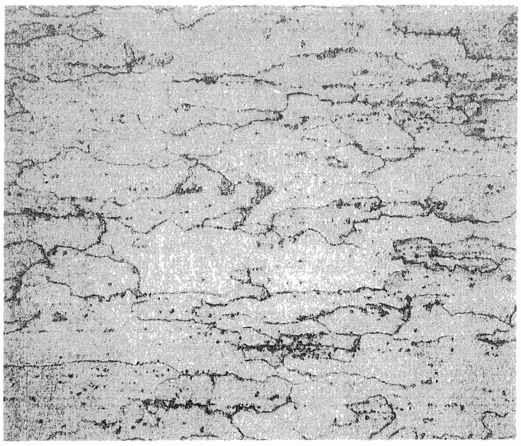

Figure 3 Microstructure T-57 BA, after drawing, 90°.

When looking at microstructure of cover sheet T - 57 BA (Figure 2 and Figure 3) we can see a textured grains of ferrite. Except ferrite, the structure of free cementite is visible. The cementite is segregated in a globular shape, which is equally distributed in basic ferritic component. This decomposition in lines of cementite has partially increased the flat anisotropy of mechanical facilities. In a small quantity, it is also occurring tertiary cementite distributed on grain boundaries. On their structure before and after drawing, an expressive flattened texture after drawing is visible. When drawing the cup the plastic deformation is occurring, which manipulates the orientation of the grain. The cover sheet T - 57 BA shows visual uniform size of grains in both directional observations (0°, 90°).

Cover sheet DR 620 (Figure 4 and Figure 5) has the smallest grain of all valuated cover sheets, according to normative; the grain size is 9, which can be designated as a less suitable size for compression. Sheet with fine grain can be more elastic, wavering and more stresses in the pressing tool. The difference of size of several grains is extensive too, this has a negative influence on anisotropy. This sheet has less structural free cementite in the basic ferritic element. It doesn't appear to be a big difference deformation of grain before and after drawn caused by the biggest strength characteristic of cover sheet. Corrosion aggression is well seen on microstructure DR 620 after drawn in the perpendicular on rolling direction (Figure 5). That aggression can be characteristic as intergranular aggression, which can develop the precipitate on boundaries of grains. That decreases corrosion resistance in the areas of grain contiguous to boundaries of grain. There are shaped cementite segregated around grain boundaries. The cause of this aggression is also increased internal stress, which is presented after drawing of a cup.

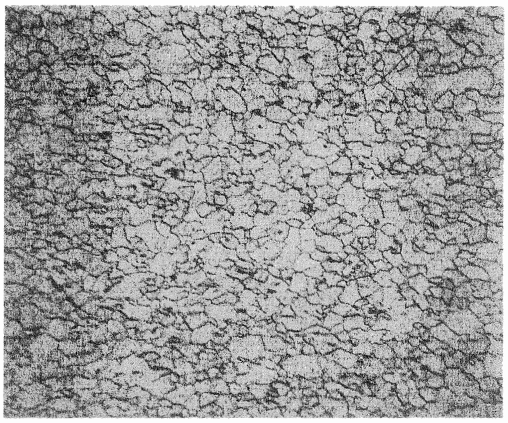

Figure 4 Microstructure DR 620, before drawing, 90°.

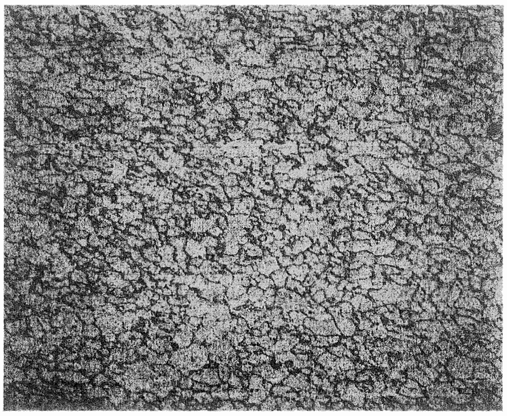

Figure 5 Microstructure DR 620, after drawing, 90°.

CONCLUSIONS

All the inscribed factors characterizing the microstructures correspond with measured values of earing.

When the values of earing z are compared, then the cover thin sheet T - 57 BA with the lowest value z =2,527 has the best properties. On the other hand, the remaining plates there with advancing grade of grain size resulted in higher values of earing factor z. It can be concluded that earing increases with decomposition of cementite in basic ferritic element too. However, the best fit is uniform segregation of cementite in a fine globular shape.An important factor of observation is uniformity of structure that decreases in advice T-57 YEA, DR 550, DR 580 and DR 620.

These three factors influence the values of anisotropy and earing DR cover sheets: uniformity structure DR cover sheet, grain size and style segregation of cementite. The best suitable structure is a uniform structure with grain size 6 - 8 according to STN 42 0462, but the optimal style cementite segregation is in a fine globular shape in ferritic element evenly. Unsuitable structure of DR cover sheet is line spacing segregation of cementite in rough shapes, particularly on grain boundaries.

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