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EXPERIMENTAL RESEARCH ON THE INFLUENCE OF COLD ROLLING PARAMETERS ON THE MECHANICAL PROPERTIES OF STEEL FOR DEEP DRAWING

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ABSTRACT

This paper presents an experimental research on the influence of cold rolling parameters on the mechanical properties of steel strips for deep drawing. The DC - 04 steel grade is a steel used for cold plastic deformation, with a maximum of 0.08 % C for deep drawing, used in the automotive industry for vehicle bodies. The results reveal that the mechanical properties, strain-hardening and anisotropy coeficcients are within limits.

KEYWORDS: cold rolling, strain-hardening and anisotropy coeficcients

1. INTRODUCTION

Rolling is a metalworking in which a metal is passing through a successive set of rolls to reduce its thickness.

Rolling is classified into cold and hot rolling. The difference between hot and cold rolling is related to the processing temperature. When the processing temperature of the metal is above its recrystallization temperature, the process is called hot rolling; when the processing temperature of the metal is below its recrystallization temperature, the process is called cold rolling.

Cold rolled steel is one of the widely used flat products in various industries, such as automobiles, home appliances, electrical appliances, steel drums [1], [2].

The cold rolled steel manufacturing process involves the steps presented in Figure 1. The recrystallization annealing treatment aims to remove a part or all of the hardening state of the material [3, 4], forming new nondeformed grains [5], [6] and getting the initial plasticity and toughness [7]. The annealing of the rolls is done in bell furnaces with protective gas whose concentration must be 4 ÷ 8 % H_2 and 92 ÷ 96 % N_2.

Training is the cold rolling done with single cuarto stand with small degrees of deformation, ε = 0.2 = 0.8 %. By training the following effects are obtained: very smooth surfaces, which is especially important for the strips that are subject to protective coatings, and also the elimination of the apparent flow plateau on Hooke's curve [8].

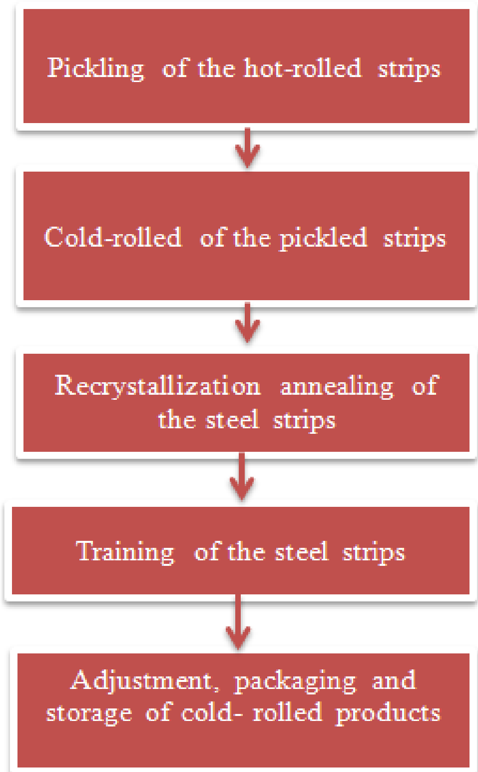

Fig. 1. *Cold rolled steel manufacturing process*

Figure 2 shows the dip pickling line, built from the following parts: 1. running hot rolled strip, 2. pre-milled scale off processor, 3. butt welding machine, 4. duo mechanical descaling stand, 5. battery band share – 6000, 6. battery band share – 3000, 7. chemical pickling tanks, 8. wash basins, 9. battery band share 0, 10. loop strip, 11. lateral side guide, 12. disc scissors for cutting the edges, 13. coilings of pickled strip.

Figure 3 shows the tandem mill, the mill in which the metal is rolled in successive stands and its principal parts are: 1. pickled roll strip, 2. working cylinder, 3. support cylinder, 4. bearing support cylinder, 5. screw pressure, 6. framework stand, 7. strip thickness in flux measuring machine, 8. final strip thickness measuring machine, 9. coil stress roll strip, 10. strip coil.

The deformation behavior of the flat products is estimated using the hardening and anisotropy coefficients.

It is considered that a high strain hardening coefficient ensures a uniform distribution of plastic deformation favorable in the deep drawing with reduction in thickness [9]. The anisotropy coefficient ensures good lateral contraction of the material and crimping strength (doubling) high, useful in deep-drawing processes of the stretch-contraction type [10].

In this paper the experimental research was done on a cold rolled strip delivered in the strain-hardened state without recrystallization annealing and it is aimed to study the influence of cold rolling parameters on deep-drawing.

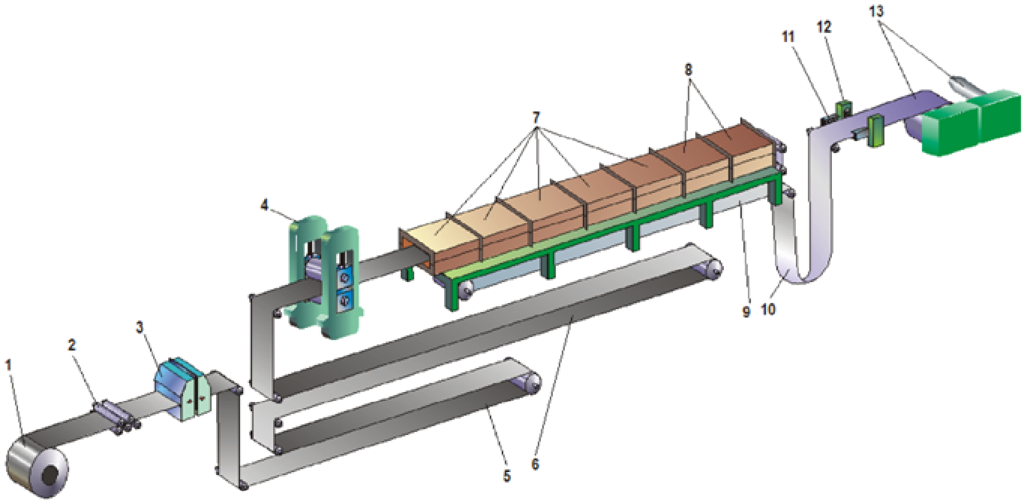

Fig. 2. *Dip pickling line*

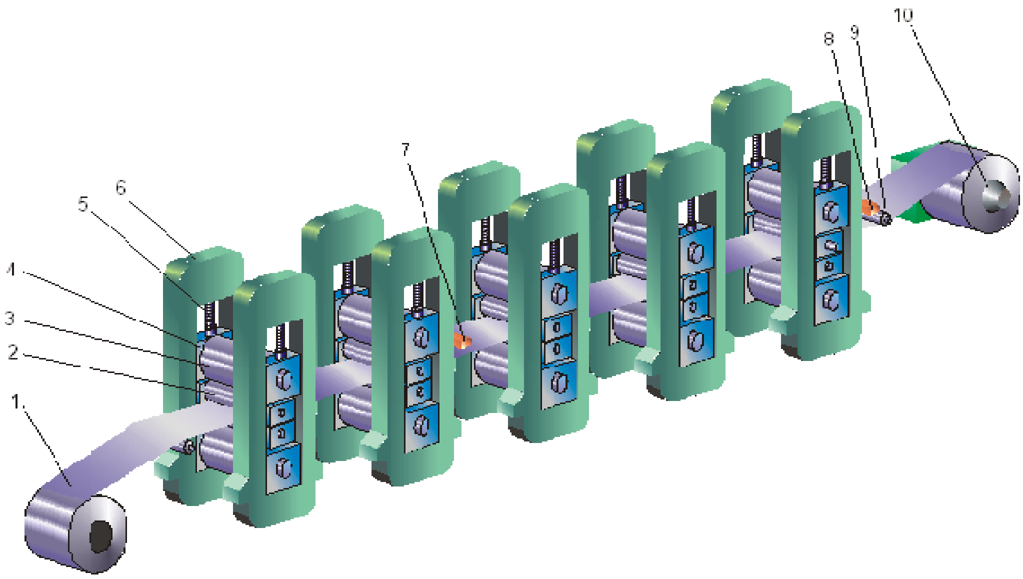

Fig. 3. *Tandem mill*

2. EXPERIMENTAL PROCEDURE

The started material is represented by DC-04 steel. The DC -04 steel grade is a steel used for cold plastic deformation, with a maximum of 0.08 % C. The DC - 04 steel grade for deep drawing is used in the automotive industry for vehicle bodies and is standardized in our country by SR EN 10130/1996. The standard chemical composition of this steel is given in Table 1.

For this study were analyzed five DC -04 rolled batches quality for deep drawing used for car bodies. Table 2 presents the chemical composition of liquid steel from each melt. The standard mechanical properties are presented in Table 3. The initial slabs were rolled into Hot Strip Mill, with the following process parameters: the started rolling temperature is 1200°C-1250°C (target – 1225°C), the temperature at which starts rolling on the finishing-mill stand is 1000°C-1050°C (target – 1025°C), the rolling end temperature is 820°C-880°C (target – 850°C), the coiling temperature is 570°C-630°C (target – 600°C). The thickness of the hot rolled strip is 2.25 mm, currently used in Arcellor Mittal Galati for the production of cold rolled strips of 0.5/0.6 mm thickness. The pickled rolls were cold rolled at thicknesses between 0.72 and 2 mm. The process of drawing up had the required level of schooling (0.6 %) for processing all thickness, the schooling level ranged between 0.5 % and 0.7 % .

Table 1. *Standard chemical composition of analyzed steel*

Quality type steel	Standard	Chemical composition [%]								
		C max	Mn max	Si max	P max	Cr max	Ni max	Cu max	S max	Al
DC-04	SR EN 10030/1996	0,08	0,04	0,01	0,025	0,03	0,1	0,1	0,03	0,015÷ 0,080

Table 2. *Chemical composition of liquid steel from each melt*

Melt no.	Chemical composition of liquid steel					
	C%	Mn%	Si%	P%	S%	Al%
P1	0.04	0.26	0.02	0.016	0.014	0.035
P2	0.03	0.23	0.03	0.017	0.014	0.033
P3	0.05	0.25	0.03	0.014	0.012	0.036
P4	0.05	0.28	0.03	0.012	0.015	0.037
P5	0.08	0.29	0.03	0.012	0.011	0.037

Table 3. *Standard mechanical properties of analyzed steel*

Steel type	R_m [Mpa]	R_c [MPa]	A_{80} [%]	"r"	"n"
DC 04	270-370	max. 220	min. 36	1.6	0.22

3. RESULTS AND DISCUSSIONS

Figure 4 presents the specific microstructure for deep drawing steels DC 04 with ferritic grains with diagonals in the ratio > 2.7 to 3. Grain size is about 8.5. The resulted values for the mechanical properties and strain-hardening "n" and the normal anisotropy "r" coefficient are presented in Table 4: mechanical properties, strain-hardening and anisotropy coeficcients are within limits .

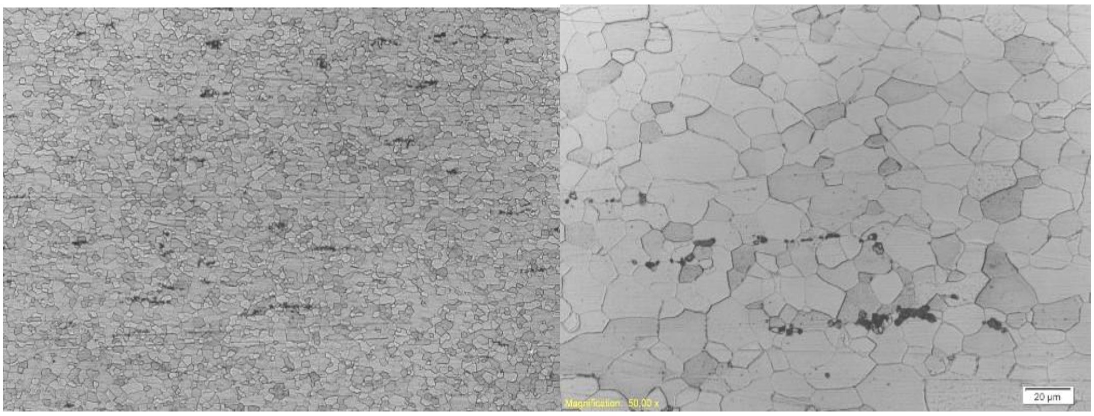

Fig. 4. *Optical micrographs of analyzed steel (a- 100x, b- 500x magnification)*

Table 4. *Mechanical properties of analyzed steel*

Melt no.	R_m [Mpa]	R_c [MPa]	A_{80} [%]	"r"	"n"
P_1	290	184	41	2.23	0.201
P_2	291	190	39	2.43	0.223
P_3	298	184	43	2.12	0.229
P_4	295	185	44	2.12	0.233
P_5	292	187	43	2.14	0.232

4. CONCLUSIONS

1. The hardening coefficient value increases with the increase of the deformability value that a material can withstand.
2. Thin sheets undergo to deep drawing should make from steel with uniformly and grains fine without coarse free cementite and nonmetallic inclusions.
3. In preparing and casting a high purity of the steel must be ensured as nonmetallic inclusions during plastic deformation become sources of microcracks.

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