TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 63, Issue III, September, 2020

ASPECTS REGARDING THE MACHINABILITY OF STEEL PLATES BY COLD COMPRESSING

Radu – Nicolae CORCHEȘ, Cristian – Ioan INOAN, Gheorghe ACHIMAȘ

Abstract: The authors present a study on the machinability of sheets by cold compressing. Knowing the workability of metal sheets is important for metallic sheet manufacturers, as well as for their users. From the producer's point of view, the problem arises in knowing the characteristics of the plates that are in correlation with their processing capacity and determining the parameters of the process of elaborating the plates that influence these characteristics in order to produce some semi-manufactured products with the desired properties. From the user's point of view, the problem arises in choosing, in order to obtain the finished piece of well-defined shape and dimensions, that block which, on the one hand, allows the production of the piece and, on the other, is the cheapest.

By machinability, in general, it must be understood, both the capacity of a material to be machined by a certain machining process, and the way it behaves during processing. Usually, this regards the supplier of materials and semi-finished goods, while the one who carries on the processing must know also, the second aspect, related to the behavior manner.

For the assessment of the processing capacity of the plates, over time, several methods have been developed: one part based on simulated tests of the pressing process, another part based on the mechanical tests of the blank. In the last years, a more realistic and general method has been introduced for this purpose, namely that of the limit deformation curves (CLD).

***Key words*:** sheet workability, cut-out, boring, drawing, mechanical tests.

1. INTRODUCTION

Sustainable development - is a development model in which the satisfaction of present generations is foreshadowed without prejudice to the possibilities of future generations to meet their own requirements. [11].

The concept of sustainable development is based on the conclusions drawn from the analysis of the results of two currents:

- The current of strictly economic approach o the development;
- Approaching of the development only on ecological criteria.

These two currents raise the issue of the ecological dimension of development and the relationship between rationalization (in production-consumption activities) and development.

The metallic materials, depending on the deformation behavior, are classified into: elastic, fragile, plastic, viscous, differing in each other by the way the technological factors (degree of deformation, deformation rate, and hydrostatic pressure at deformation) influence the resistance to deformation of the material.

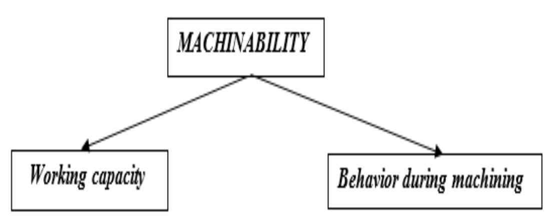

Fig. 1. Definition of the concept of workability

The main factors of dependence of the machinability of the sheets by stamping – die forging are presented in figure 2:

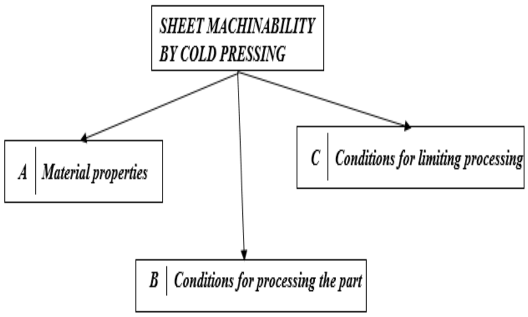

Fig. 2. The factors of dependence of the machinability of the sheets by cold pressing

A. The conditions imposed on the material of the semi-finished material, from the material properties point of view (fig. 2), are: mechanical, metallurgical and chemical properties.

B. The separation / deformation conditions of the part include (Fig. 2): the state of tensions, the working speed, the shape of the part, the lubricant (lubricant), the thickness of the half-product, the type of the pressing machine.

C. The conditions for limiting the workability of the sheets by cold pressing (Fig. 2) are: the surface roughness of the sheet, the undulation, the value of the clearance between the punch and the active plate of the tool, the pressing procedure, the quality of the material of the half-product.

The quality, accuracy and cost of the parts obtained, depend on the way of solving the workability of the sheets by cold pressing.

2. MATERIALS USED FOR COLD PRESS PROCESSING

When machining by cold pressing different parts of the machine building, both metallic and non-metallic materials are used.

The metallic materials (steel, copper and their alloys, aluminum and his alloys etc.) are the most used in the shape of sheet, strip, bars, wire, pipe, and sections. Some material used for the cold pressing process are delivered with different grade of cold hardening, i.e. mild (annealed), a quarter hard, half hard and hard, and for some non-ferrous alloys: hardened and natural or artificial ageing.

For the proper establishment of the materials and semi-finished products used for processing by cold pressing, it is necessary to take into account the constructive – functional, technological and economic conditions that they must fulfill.

For the material to correspond from the constructive – functional point of view it is necessary to consider: the chemical composition, mechanical resistance, wear hardness, resistance to corrosion, thermal conductibility, high-temperature resistance or very low temperature resistance or magnetic resistance etc.

For the material to correspond from technological point of view, the material will have to be subject to the analysis of chemical composition, microstructure analysis, physical-mechanical properties, technological properties, dimensional accuracy, surface quality, etc.

For the economic analysis, the weight of the piece and the material consumption, its cost, as well as whether it is deficient or imported is taken into account. Also, it will have to be determined whether the obtaining of the respective material implies a high energy consumption, favoring in all cases those materials that are obtained with the lowest energy consumption..

Of the ferrous alloys, the steels can be processed by cold pressing. Generally with the increase of carbon content in steels, the mechanical strength characteristics increase and the plasticity ones are reduced. Also, the cold-hardening curves (σreal - ε or σreal - φ) are located the higher (at higher values for σreal) the higher the carbon content is.

Non-metallic inclusions are harmful to steels, contributing to the formation of micro-cracks and cracks. The content of Si, S, P, N and O must be kept within very tight limits, as they have a negative influence on the plasticity of the steel. The material must be homogeneous, otherwise the deformations are non-uniform. For a good deformation behavior, it is recommended that the processed material has a uniform ferritic or ferrite-pearlite structure.

A wide range of non-ferrous alloys can be processed by cold pressing, taking into account, as in the case of steels, their chemical composition and microstructure.

Among the metallic materials used for cold plastic deformation, special conditions of workability are required for the sheets that are drawn, as well as for the semi-finished products used for volumetric deformation.

For precision stamping it is recommended to use materials that meet the following conditions: uniform thickness and properties, flow limit and breaking resistance of low values, relatively long elongation. In the case of steels, it is recommended that the microstructure of the cementite be globular and finely distributed. Also, it is advisable to use killed steels, without segregations and with low ageing susceptibility.

Non-ferrous metals, such as: copper, aluminum and their alloys, do not represent more than 10%, although the tendency of their use is increasing.

3. DETERMINATION OF THE TENSION – DEFORMATION CURVE OF THE MATERIAL OF SEMI-FINISHED MATERIAL BY TENSILE TEST

The knowledge of the mechanical properties of the semi-finished product subject to cold compressing is necessary both for the correct assessment of the semi-finished product behavior during the practical experiments and for a more accurate modeling of the material behavior during the numerical simulation of the pressing process.

The tensile test method, including specimen shapes and sizes, test conditions, flow limit determination, etc., is regulated by SR EN 10002-1 and SR EN 10002-2 standards. In Figure 3 and Table 1 are shown the main elements of the material curve in tension – elongation percentage coordinates, according to the standard SR EN 10002-1.

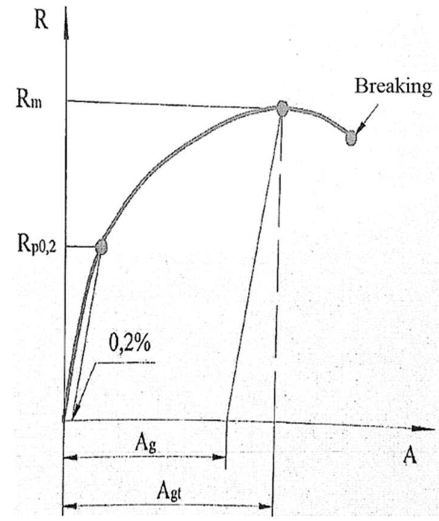

Fig. 3. Curve in tension-elongation percentage in the tensile test method

Symbol	Name	Unit of measure
R	Tensile	[Mpa]
$R_{p0.2}$	Conventional flow limit	[Mpa]
R_m	Traction breaking resistance	[Mpa]
A	Percentage elongation	[%]
A_g	Non-proportional elongation under maximum force	[%]
A_{gt}	Total percentage elongation below maximum force	[%]

It is considered that the tensile test is the basic test of a material. This is supplemented, in some situations, by specific tests to other requests such as: bending, twisting, shearing, compound requests, etc.

The tensile test is performed by applying an increasing axial force to a specimen and recording the corresponding variations in specimen length. The test is done until the specimen is broken, the symbols used in this part are according to ISO 6892-1: 2000.

The standard SR EN10002-1 provides that the specimen for the tensile test, is taken from a section of sheet, either from a longitudinal strip or from a strip at an angle of 45 degrees (Fig. 4).

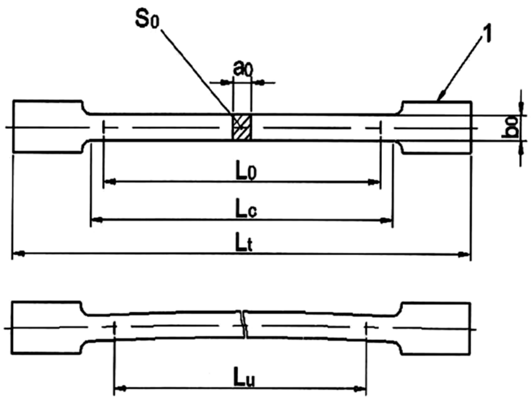

Fig. 4. Machined sample with cross rectangle section according to SR EN ISO 6892-1:2010

The determination of the conventional flow limits Rp01 and Rp02 is regulated by the standard SR EN 1002-1: 1995. The value of the flow limit at the uniaxial stress, is determined from the tension – deformation logarithmic curve obtained by the uniaxial tensile test.

There are several ways to define the flow limit, namely (Fig. 5):

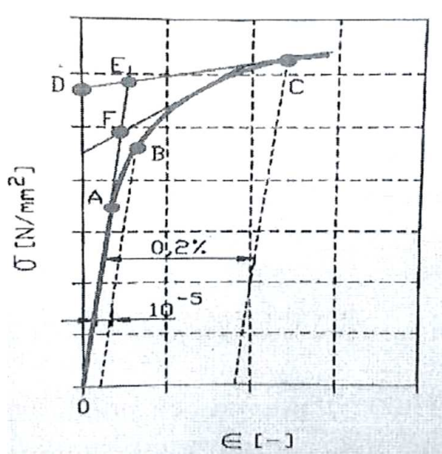

Fig. 5. Defining the flow limit on the stress – logarithmic deformation curve

- for point A, the proportionality limit;
- for point B, the yield limit;
- for point C, the conventional yield point (the tension that causes an irreversible deformation imposed, for example 0.2%;
- for point D, extrapolation backwards till the intersection with the tensions axis;
- for point E, backwards extrapolation till the intersection with the prolongation of the linear section of the diagram;
- for point F, backwards extrapolation using a fixed fraction of the elastic module, until the intersection with the prolongation with the linear section of the diagram

The logarithmic deformation of the sample is calculated with the relation:

$$\varepsilon = \ln\frac{L}{L_0} = \ln\left(1 + \frac{A\%}{100}\right), \quad (1)$$

where:
- L_o is the initial length of the measurement base;
- L – is the current length of the measurement base;
- A% - the relative percentage elongation ($A\% = \frac{\Delta L}{L_0} * 100\%$);
- $\Delta L = L - L_o$ is the elongation of the measurement base.

Cauchy tension is calculated by the relation:

$$\sigma = \frac{F}{S}, \quad (2)$$

where: - F is the axial force which is loading the specimen at the current moment;

- S – area of the cross section of the specimen at the current moment.

Law of constant volumes is written as follows:

$$S * L = S_o * L_o, \quad (3)$$

in which: S_o is the cross-sectional area of the non-deformed specimen;

L_o – the reference length of the specimen.

From the relation (3), it results:

$$S = S_0\frac{L_0}{L} = \frac{S_0}{1+\frac{A\%}{100}}. \quad (4)$$

According to the relation (4), the relation (2) becomes:

$$\sigma = \frac{F}{S_0}\left(1 + \frac{A\%}{100}\right). \quad (5)$$

Values of the Force F and percentage elongation A% are measured and registered automatically by the date purchasing system of the testing machine.

4. TESTS TO DETERMINE THE HARDNESS

Hardness is defined in the technique, as the material resistance of an action of mechanical penetration of a hard body from the outside.

The methods for determining the hardness of the materials are classified according to the force acting on the penetrator in:

- Static methods (action speed limited to under 1 mm/s);
- Dynamic methods (great action speed).

The method of determining the hardness of materials with a square-base pyramid-shaped diamond penetrator was called Vickers. Noting with “F” the test force, and with “s” the area of the lateral surface of the pyramid with diagonal “d”, is obtained for the hardness Vickers the expression:

$$HV = \frac{F}{S}, \quad (6)$$

Expressing “s” according to the diagonal “d”, we obtain the relation:

$$HV = 1.8544\frac{F}{d^2}. \quad (7)$$

Depending on the size of the test load, the hardness obtained by the Vickers method, the standards STAS 492-78 and STAS 7057-78 have prescribed certain tasks, namely:
-hardness tests with usual loads (100 – 5 daN);
-hardness tests with small loads (5 – 0,5 daN);
-hardness tests with micro-loads (under 0,5 daN), known as “micro-hardness Vickers”.

In order to determine the hardness of the materials by the Vickers method, at least three impressions are executed, the surface being prepared by processing to a roughness to ensure a good measurement of the impressions, which must have a clear and undisturbed contour of the traces of the processing.

The cold hardening state of the semi-finished product can be assessed by variation of the micro-hardness.

5. EXPERIMENTAL RESEARCH

The value of theoretical research increases when they can be applied in industrial practice, becoming working tools for researchers and specialists working in the field of cold pressing parts processing.

The tests were performed on a Zwick-Roel type uniaxial tensile testing machine in the CERCETA laboratory, in the Machine – Building Faculty. The speed of movement of the mobile beam of the machine was 0.001 mm / min.

In order to obtain the material properties of the M50 steel plate (s = 2.5 mm), the uniaxial tensile test was used, on tensile samples taken along the lamination line, because the bent pieces are cut after the lamination line in order to have a better resistance.

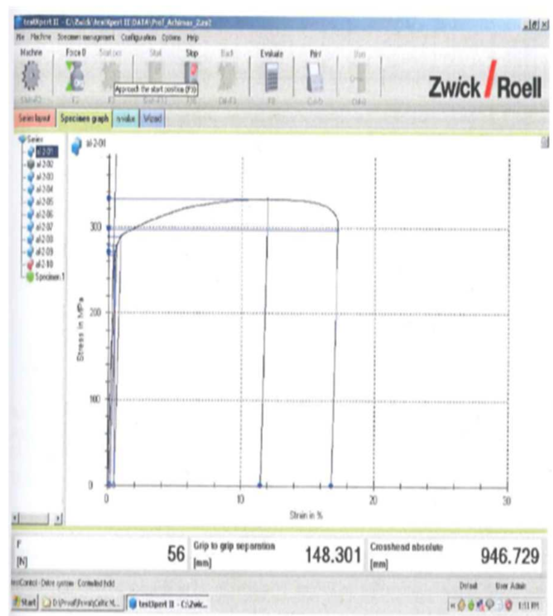

Figure. 6 Interface of the program

The data obtained during the tensile tests were processed in the TestXpert program, which automatically generated the test diagrams (Fig. 6). The number of samples was 7.

The plasticity characteristics were determined after the following the tensile tests:

- Anisotropy factor "*r*" (Table 2);
- Tensile yield stress "$Rp_{0,2}$" (Table 2);
- Ultimate stress "R_m" (Table 2);
- Cold-hardening index from the Swift Law "n" (Table 2);
- The cold hardening module "k" (Table 2).

These characteristics of the material were determined on samples at "0°"to the lamination direction (DL).

Table 2 Experimental results obtained on sample taken from steel plate Grade M50 (s=2.5 mm):

Test report

Customer :
Job no. :
Test standard : DIN EN 10002-1 / ISO 10113 / ISO 10275
Type and designation :
Material :
Specimen removal :
Specimen type :
Pre-treatment :
Tester :
Remarks :
Machine data :

Pre-load : 2 MPa
E-Modulus speed : 60 MPa/s
Speed Yield point : 60 MPa/s
Speed in the yield range : 0.0025 1/s
Test speed : 0.001 1/s

Test results:

Nr	Specimen no.	Specimen identifier	Date/Time	E GPa	$R_{p0.1}$ MPa	$R_{p0.2}$ MPa	$R_{p0.5}$ MPa	$R_{t0.5}$ MPa	$R_{p0.2}/R_m$ %
121	1	Test-1	11/21/2015 12:43:43 AM	235	391	391	381	386	70.77
122	2	Test-2	11/21/2015 12:55:31 AM	250	391	398	392	395	71.22
123	3	Test-3	11/21/2015 1:07:02 AM	196	402	405	406	407	73.15
124	4	Test-4	11/21/2015 1:14:39 AM	223	386	389	393	391	70.05
125	5	Test-5	11/21/2015 1:22:03 AM	230	362	374	377	375	67.17
126	6	Test-6	11/21/2015 1:29:36 AM	212	389	393	397	397	70.71
127	7	Test-7	11/21/2015 1:37:00 AM	209	383	383	387	385	68.69

Nr	R_{eH} MPa	R_{eH}/R_m %	R_{eL} MPa	A_e %	R_m MPa	F_m kN	$A_{gt\ (corr.)}$ %	A_g %	R_B MPa	BP	$A_{t\ (corr.)}$ %
121	397	71.95	378	1.5	552	16.12	15.5	15.0	456	Switching to the crosshead	20.0
122	395	70.57	388	1.5	559	16.78	16.0	16.0	451	Switching to the crosshead	25.0
123	-	-	-	-	554	16.62	16.0	15.5	455	Switching to the crosshead	22.5
124	392	70.68	385	1.5	555	16.03	16.5	16.5	442	Switching to the crosshead	24.0
125	376	67.62	374	0.5	556	15.88	17.5	17.5	454	Switching to the crosshead	27.5
126	399	71.88	389	1.5	556	16.67	16.5	16.5	450	Switching to the crosshead	26.0
127	-	-	-	-	558	16.73	16.0	15.5	459	Switching to the crosshead	23.5

Nr	$A_{5,65}$ %	$A_{11,3}$ %	A_{80} %	$n_{4-6/Ag}$	$k_{4-6/Ag}$ MPa	$n_{10-15/Ag}$	$k_{10-15/Ag}$ MPa	$n_{2-20/Ag}$	$k_{2-20/Ag}$ MPa	$n_{10-20/Ag}$	$k_{10-20/Ag}$ MPa	$n_{x1-x2/Ag}$	$k_{x1-x2/Ag}$ MPa
121	27.0	21.0	20.0	0.219	1018	0.161	873	0.205	969	0.160	873	0.205	969
122	39.0	27.5	25.0	0.209	1010	0.155	874	0.196	961	0.154	873	0.196	961
123	33.0	24.5	22.5	0.204	990	0.153	863	0.191	944	0.152	862	0.191	944
124	35.5	26.0	23.5	0.218	1020	0.162	879	0.203	967	0.161	876	0.203	967
125	43.5	30.5	27.0	0.215	1013	0.165	887	0.200	959	0.164	883	0.200	959
126	41.0	28.5	26.0	0.206	995	0.155	869	0.193	949	0.154	868	0.193	949
127	35.0	25.5	23.0	0.204	996	0.152	867	0.189	944	0.152	866	0.189	944

In Table 3 are presented the mechanical properties of the material subject to uniaxial traction.

Lately, research has focused on developing models of material capable of describing the behavior of the material as accurately as possible.

Mechanical parameters of the plate M50 (s = 2,5 mm) Table 3

Lamination direction	$Rp_{0,2}$ [MPa]	R_m [MPa]	r [-]	n [-]	K [MPa]	Ag [%]
0°	390	556	1.281	0.197	871	15.0

The coefficient of plastic anisotropy "*r*", is the ratio between the natural specific deformation in the direction of the specimen width and the natural specific deformation in the direction of the thickness of the specimen (Table 2), in the case of a specimen subject to a mono-axial tensile stress, the following is obtained:

$$r = \frac{\varepsilon_b}{\varepsilon_a}\ , \qquad (8)$$

where: ε_a is the natural specific deformation along the thickness of the plate; ε_a is the natural specific deformation along the width of the specimen. The size of "*r*" is between 0.9 and 2.4 [10] for steel plates and is not influenced by the working speed. For steel plate grade M50, was determined r = 1.281, so it is within the recommended limits.

The cold-hardening coefficient "*n*" is defined as an exponent of the natural deformation in the mathematical equation that expresses the real stress / natural deformation relation, which is expressed by the relation [10]:

$$\sigma = K * \mathcal{E}^n\ , \qquad (9)$$

in which: K is a constant of the material;

- ε – the natural deformation;
- n – cold-hardening coefficient.

The values range of the cold-hardening coefficient "*n*" for steel plates is between 0.180 and 0.250 [10]. By the uniaxial tensile test of the steel plate Grade M50, it was obtained for n = 0.197 (Table 2), so it is within the recommended limits. Measurement of the Vickers Hardness with micro-loads was performed with an apparatus Type Wilson – Harness Tukon 2500. Measurement results on a steel plate Grade M50 are: 107HV10 – 112HV10, results a good cold-hardening. To validate the simulation model of the processing of aluminum alloy plates by cold pressing, a 1050 Type plate was used, the chemical composition of which is presente in table 4.

Table 4 – Chemical composition of aluminum alloy

Type of alloy	Si	Fe	Cu	Mn	Mg	Ti	Zn	Cr
1050	0.13	0.23	0.00	0.00	0.02	0.24	0.01	0.01

The uniaxial traction test was carried out on a ZWICK - ROELL Z150 machine, the measurement of the extensions until the test pieces were broken, was performed using extensometers with which the machine is equipped.

Table 5 – The experimental results obtained at tensile test on specimen from aluminum plate Grade 1050 (s = 3 mm).

Test report

Customer :
Job no :
Test standard : DIN EN 10002-1 / ISO 10113 / ISO 10275
Type and designation :
Material :
Specimen removal :
Specimen type :
Pre-treatment :
Tester :
Remarks :
Machine data :

Pre-load	2	MPa	Speed in the yield range	0.0025	1/s
E-Modulus speed	60	MPa/s	Test speed	0.004	1/s
Speed Yield point	60	MPa/s			

Test results:

Nr	Specimen no	Date/Time	E GPa	$R_{p0.1}$ MPa	$R_{p0.2}$ MPa	$R_{p0.5}$ MPa	$R_{t0.5}$ MPa	$R_{p0.2}/R_m$ %	R_{eH} MPa	R_{eH}/R_m %	R_{eL} MPa
1	1	6/21/2008 1:53:07 PM	72	267	277	287	270	83.35	-	-	-
Φ2	2	6/21/2008 1:58:19 PM	209	803	832	865	809	83.74	-	-	-
3	3	6/21/2008 2:03:51 PM	71	266	275	286	269	83.73	-	-	-
4	4	6/21/2008 2:06:58 PM	71	266	277	288	270	83.40	-	-	-
5	5	6/21/2008 2:12:16 PM	70	267	277	288	270	83.65	-	-	-
6	6	6/21/2008 2:16:40 PM	70	269	278	288	271	83.36	-	-	-
7	7	6/21/2008 2:20:12 PM	71	266	276	287	269	83.18	-	-	-
8	8	6/21/2008 2:23:21 PM	71	268	277	288	271	83.37	-	-	-
9	9	6/21/2008 2:32:56 PM	73	270	280	291	274	84.49	-	-	-
10	10	6/21/2008 2:37:38 PM	71	267	277	287	270	83.58	-	-	-

Nr	A_e %	R_m MPa	F_m kN	$A_{gt\,(corr.)}$ %	A_g %	R_B MPa	BP	$A_{t\,(corr.)}$ %	$A_{5.65}$ %	$A_{11.3}$ %	A_{80} %	$n_{4-6/Ag}$
1	-	332	19.91	12.0	11.5	297	Switching to the crosshead	17.0	21.0	16.5	17.0	0.119
Φ2	-	994	19.88	10.0	9.5	987	Switching to the crosshead	10.5	10.5	10.0	10.0	0.119
3	-	329	19.73	12.0	11.5	302	Switching to the crosshead	17.0	21.0	16.5	16.5	0.117
4	-	332	19.90	12.0	11.5	292	Switching to the crosshead	16.5	19.5	15.5	16.0	0.119
5	-	331	19.89	12.0	11.5	312	Switching to the crosshead	16.5	19.5	15.5	16.0	0.118
6	-	333	19.99	12.5	12.0	325	Switching to the crosshead	14.0	15.0	13.5	13.5	0.121
7	-	332	19.92	12.0	11.5	310	Switching to the crosshead	17.0	20.5	16.0	16.5	0.120
8	-	333	19.95	12.0	12.0	295	Switching to the crosshead	16.5	20.0	16.0	16.0	0.120
9	-	332	19.90	11.5	11.0	314	Switching to the crosshead	14.5	16.5	13.5	14.0	0.113
10	-	331	19.87	12.0	11.5	320	Switching to the crosshead	15.0	17.0	14.0	14.5	0.119

Nr	$k_{4-6/Ag}$ MPa	$n_{10-15/Ag}$	$k_{10-15/Ag}$ MPa	$n_{2-20/Ag}$	$k_{2-20/Ag}$ MPa	$n_{10-20/Ag}$	$k_{16-20/Ag}$ MPa	$n_{x1-x2/Ag}$	$k_{x1-x2/Ag}$ MPa	r_{x1}	r_{x2}	r_{x3}	r_{x4}	r_{x5}
1	484	0.112	476	0.113	476	0.112	476	0.113	476	0.150	0.287	0.311	0.388	0.000
2	1450	-	-	0.110	1419	-	-	0.110	1419	0.000	0.004	0.038	0.080	0.136
3	477	0.112	472	0.113	472	0.112	472	0.113	472	0.301	0.351	0.396	0.394	0.416
4	482	0.112	476	0.114	477	0.112	476	0.114	477	0.130	0.228	0.286	0.344	0.358
5	480	0.114	478	0.114	476	0.114	478	0.114	476	0.472	0.397	0.781	10.353	5.036
6	486	0.118	485	0.117	482	0.118	485	0.117	482	0.312	0.300	0.269	0.278	0.303
7	484	0.114	479	0.115	479	0.114	479	0.115	479	0.615	0.662	0.644	0.583	0.000
8	485	0.115	481	0.116	480	0.115	481	0.116	480	0.253	0.220	0.280	0.423	0.449
9	476	0.108	472	0.109	471	0.108	472	0.109	471	0.423	0.534	0.501	0.446	0.436
10	481	0.113	476	0.114	476	0.113	476	0.114	476	0.275	0.396	0.397	0.418	0.469

Nr	r_{x6}	$r_{4-6/Ag}$	$r_{8-12/Ag}$	$r_{10-15/Ag}$	$r_{2-20/Ag}$	$r_{x1-x2/Ag}$	L_e mm	L_e 2 mm	L_0 mm	L_t mm	a_0 mm	b_0 mm	S_0 mm²
1	0.000	-1.585	-1.723	-1.798	-1.726	-1.726	80.00	80.00	80.00	126.00	3	20	60.00
2	0.168	0.133	0.249	-	0.176	0.176	80.00	80.00	80.00	126.00	3	20	20.00
3	0.476	0.427	0.762	1.205	0.610	0.610	80.00	80.00	80.00	126.00	3	20	60.00
4	0.314	0.344	0.384	0.418	0.358	0.358	80.00	80.00	80.00	126.00	3	20	60.00
5	3.470	4.861	2.544	2.840	2.772	2.772	80.00	80.00	80.00	126.00	3	20	60.00
6	0.317	0.299	0.321	0.312	0.319	0.319	80.00	80.00	80.00	126.00	3	20	60.00
7	0.000	-1.490	-1.434	-1.472	-1.432	-1.432	80.00	80.00	80.00	126.00	3	20	60.00
8	0.465	0.449	0.489	0.487	0.468	0.468	80.00	80.00	80.00	126.00	3	20	60.00
9	0.473	0.442	0.516	0.516	0.498	0.498	80.00	80.00	80.00	126.00	3	20	60.00
10	0.536	0.480	0.536	0.538	0.515	0.515	80.00	80.00	80.00	126.00	3	20	60.00

Series graph:

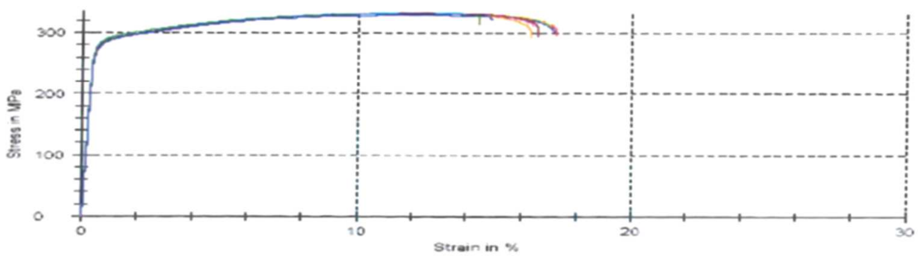

Figure 7 – Force – Elongation curves obtained at tensile test on aluminum specimen

Table 5 presents the experimental results obtained on aluminum Grade 1050 (AL99.5) samples taken at 0 degrees from the direction of rolling, when testing uniaxial traction. Figure 7 shows the force-elongation curves, obtained by the tensile test of the samples taken at 0º in relation to the direction of lamination, aluminum plate material Grade 1050, with thickness s = 3 mm, the number of tests 9 samples.

Values of the yield strength at uniaxial traction load is determined from the curve stress – logarithmic deformation according to Figure 5.

The experimental method used in the Laboratory of the Technical University from Cluj-Napoca allows us to obtain some cold-hardening curves at uniaxial traction.

6. CONCLUSIONS

In order to evaluate the workability of the material of steel plate Grade M50 semi-finished product having s = 2.5 mm, on samples taken in the rolling direction (CDL) and aluminum plate Grade 1050 (Al99.5) thickness s = 3 mm, on specimen taken at 0º relative to the rolling direction (DL), uniaxial tensile tests were performed on the ZWICK-ROELL Z150 machine and determination of the hardness of the boards using the Vickers method.

The data obtained during the tensile tests were processed in the Program TestXpert, program that automatically generated the test diagrams.

The plasticity characteristics which were determined following the uniaxial tensile tests are as follows:

- Conventional yield strength, $Rp_{0,2}$ in [MPa];
- Ultimate stress R_m in [MPa];
- Percentage elongation Ag, in [%];
- Cold-hardening index "*n*", [-];
- Anisotropy factor "*r*" , [-];
- Maximum Force F_m, in [N];
- Cold hardening module, in [MPa].

For the analysis of micro-hardness, metallographic samples made especially for this type of analysis were used. The micro-hardness analysis revealed a close connection between this parameter, on the one hand, and the level of cold-hardening, respectively the limit values of the deformations, on the other hand.

8. REFERENCES

[1] Banabic, D. and Dörr, I.R – Deformability of thin metallic plates. OIDICM Publishing House, Bucharest, 1992.

[2] Banabic, D. and Dörr, I.R – Plastic deformation of modelling processes of plates. TRANSILVANIA PRESS Publishing House, Cluj-Napoca, 1995.

[3] Bâlc, N. ş.a. Competitive production design. Alma Mater Publishing House, Cluj-Napoca, 2006.

[4] Cândea, C.V., ș.a. Ferrous and non-ferrous alloys classification and symbolization, UTPRESS Publishing House, Cluj-Napoca, 2010.

[5] Cândea, C.V., ș.a., Metallographic Structures Atlas, U.T.PRESS Publishing House, Cluj-Napoca, 2012.

[6] Comșa, D.S., Finite elements method. U.T.PRESS Publishing House, Cluj-Napoca, 2007.

[7] Lăzărescu, L., ș.a., Design of technologies and molds for metal plates processing. Publishing House of Science Book, Cluj-Napoca, 2017.

[8] Roș, O.B. and Frățilă, D., Design for environment. Publishing House of Science Book, Cluj-Napoca, 2000.

[9] Teodorescu, Al. M., ș.a. – Processing by cold plastic deformation, Vol. I, Technical Publishing House, Bucharest, 1987.

[10] Teodorescu, Al. M., ș.a. – Processing by cold plastic deformation, Vol. II, Technical Publishing House, Bucharest, 1988.

[11] Tureac, I., ș.a., Ecological design and sustainability development of applications in machine building industry. Publishing House – of Transylvania University from Brașov, Brașov, 2003.

[12] *** DIN 50125, Testing of metallic materials – Tensile Test pieces.

ASPECTE PRIVIND PRELUCRABILITATEA TABLELOR PRIN PRESARE LA RECE

Rezumat: Cunoaşterea prelucrabilităţii tablelor metalice prin presare la rece, este importantă atât pentru producătorii de table cât şi pentru utilizatorii acestora. Din punctul de vedere al producătorului problema se pune de a cunoaşte caracteristicile tablei care sunt în corelaţie cu capacitatea de prelucrabilitate a acestora şi de a determina parametrii procesului de elaborare a tablei care influenţează aceste caracteristici în scopul producerii unor semifabricate cu proprietăţi diferite.

Din punctul de vedere al utilizatorului problema se pune de a alege, pentru obţinerea piesei finite de forma şi dimensiuni bine definite, acel semifabricat care, pe de o parte, permite realizarea piesei iar, pe de altă parte, este cel mai ieftin.

Caracteristicile de plasticitate care au fost determinate în urma încercărilor la tracţiune uniaxială, au fost următoarele:

- Limita de curgere convenţională, $R_{p0.2}$;
- Rezistenţa la rupere, R_m ;
- Alungirea uniformă, A_g ;
- Indicele de ecruisare „n” ;
- Coeficientul de anizotropie „r” ;

- Forţa maximă, F_m ;
- Modulul de ecruisare, K.

Analiza microdurităţii a evidenţiat o strânsă legătură între acest parametru, pe de o parte, şi nivelul ecruisării materialului, respectiv valorile limită ale deformaţiilor, pe de altă parte.

Radu-Nicolae **CORCHEȘ,** PhD Student, Eng.: Technical University of Cluj – Napoca, Department of Manufacturing Engineering, 103 – 105 Muncii Blvd. 400641 Cluj – Napoca, E-mail: radu.corches@delgaz-grid.ro, Phone: 0040-744 644 515.
Cristian-Ioan **INOAN,** PhD Student, Eng.: Technical University of Cluj – Napoca, Department of Manufacturing Engineering, 103 – 105 Muncii Blvd. 400641 Cluj – Napoca, E-mail: cristi.inoan@gmail.com, Phone: 0040-745 128 412.
Gheorghe **ACHIMAȘ**, Prof. PhD, Eng.: Technical University of Cluj – Napoca, Department of Manufacturing Engineering, 103 – 105 Muncii Blvd. 400641 Cluj – Napoca, E-mail: Gheorghe.Achimaş@tcm.utcluj.ro, Phone: 0040-264 401 731.