THIN METAL MATERIAL TH 415 COMPOSITION TESTING

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Abstract: *This paper presents a method for testing material composition of TH 415sheet metal, 0.22* mm *thickness with the ARL – 3460 metal analyser used in combination with software ASPECT – 80. Construction and testing of a special specimen for thin-walled tinplate TH 415 material compositions are presented. Testing was conducted with metal analyzer ARL – 3460 that can be used for metals bases of aluminium and iron. An investigation of influential parameters of material composition process and principles of selected spectrometer procedure are discussed.*
Key words: *chemical composition, TH 415, sheet metal, tinplate*

1. INTRODUCTION

Metal forming processing requires a good insight in metal composition and mechanical properties for successful completion of forming process. Grain orientation (rolling direction) in tinplate must be taken into account for critical forming applications. The usual practice of manufacturers and suppliers of materials is to guarantee the chemical composition for steel supplied according to international norms. Specified production process often requires additional testing of a guaranteed chemical composition, this is due to more frequent use of cheap [1], raw materials that cause a decrease in quality of supplied materials. For this reason, regular testing of the consistency for some properties of the material quality TH 415 is conducted on the basis of norm EN10202:2001 that prescribe conditions for control and the supply of tin plate sheets. The paper investigates the testing done with mass. spectrometer, and principles which are used to quantitatively determine the concentrations of certain elements on the basis of their wavelengths and intensities. The absolute values of the properties were not significant, but their repeatability by segments of the sample was monitored and quality and accordance with standard for several series is monitored. Special specimen of thin walled TH 415 sheet plate was used for testing, it's creation is described in presented paper. The problem of thin sheet metal material testing is taken into account and an optimal size for burning was created for Metal analyzer 3460 and results compared with standard. Testing of tinplates can be regarded as a complex because of the electrochemical system and the discontinuities in layers of the tin coating when present. Problem of corrosion is a present problem of TH 415 material. This is usually displayed as the initial corrosion along the steel base on the interface of the tin coating and steel. Therefore testing for exact material proprieties of steel base is a standard test in tinplate processing industry. Galvanic corrosion is caused between tin coating as a cathode and base steel as an anode. The alloy layer plays an important part in the protection of steel base since it can widen the passive zone of the anodic polarization curve and decrease current density. To some extent, the alloy layer has a suffering effect between the free tin layer and steel base and improves the integrity of tin coating [2].

2. SPECTROMETRY AND CALIBRATION

Spectrometry is a part of instrumental methods and procedures which can obtain information on the chemical composition and structure of matter based on the detection and measurement of energy changes that occur in

atom. Metal analyzer 3460 (fig. 1) is used to quantitatively determine the concentration of chemical elements in metal samples [3]. The instrument uses analytical software that analyzes the types of samples for elements and concentration ranges specified by the user. The optimal chamber temperature at which the machine works is 23 ˚C, above 39 ˚C the spectrometer stops working. The electrical discharge is produced between two electrodes (the sample and the impact electrode), while the chamber is filled with argon gas. Metal analyzer 3460 calculates element concentration by using the light emitted by the discharge chamber concentration and reports its results as a percentage of concentration.

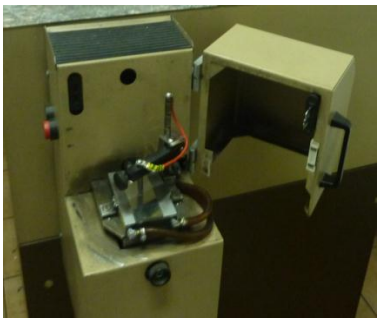


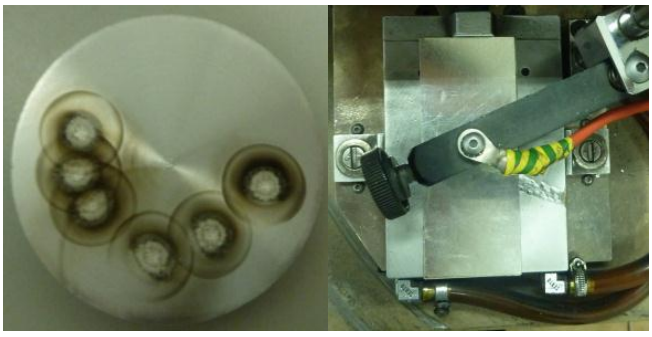
Fig.1. Chamber of metal analyzer ARL - 3460

When changing electron places from lower level to a higher level a photon of exact energetic state occurs (1).

$$E = h * v = E_v - E_n \qquad (1)$$

h - Planck constant - 6.634*10-34 Js,
E – energy of radiation,
v – frequency of electromagnetic radiation,
E_v, E_n – energy of higher or lower level.

The sample should be cleaned before testing and when setting up an analysis the sample center should be avoided as the outskirts contain greater homogeneity. The chamber analysis consists of three specific periods: prerelease of gas argon, preintegration and integration. The analysis of a sample includes the following steps: recalibration, pure state, profiling, argon cleaning filters, gap control, change the oil pumps and filters. Analytical operations include insertion of the sample and entering a few commands on the keyboard. The analysis takes 25 - 30 seconds. 3460 metal analyzer determines the concentration of elements from the measured intensity of the element. These intensities may be subject to long-term trends. Standardization or re-calibration is an operation aimed at correcting of currents by using a set of standards. The values are periodically re-measured and compared with nominal values and then performed the correction values. These values are used to correct all the intensity of the sample to the next standardization.



a) b)

Fig.2. Certified specimen a) and investigated specimen in chamber of analyzer ARL – 3460 b)

In fig. 2a testing of certified specimen is shown, the burn marks require minimum specimen diameter of 12 mm (diameter of 25 mm recommended). Figure 2b shows positioned special specimen before the material testing with 3460 metal analyzer. Thickness of the specimen is also important and this paper shows a method of testing TH 415 thin-walled sheets of thickness 0,22 mm.

3. SOFTWER ASPECT - 80

Program *ASPECT - 80* offers flexibility and overall capacity at the same time. Figure 3 shows interface of the software. The main features are: Routine analysis: measures of unknown samples up to 100 elements per program. The identity of the sample: 10 fields containing up to 12 characters can be configured. Systematic configuration: complete or selective standardization can be selected at any time. Quality: allows checking the above-defined lower and upper limits.

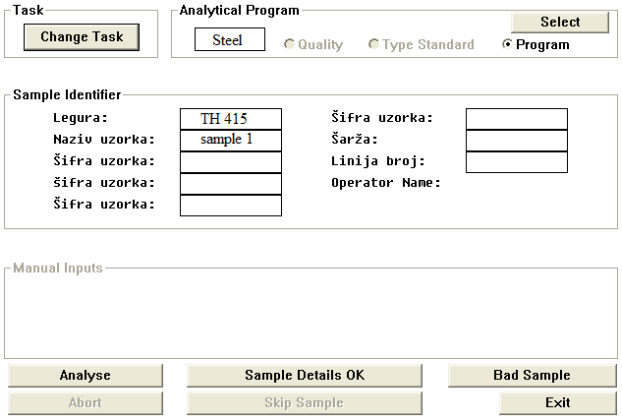


Fig.3. Interface of ASPECT - 80 software used program ALSICU-6

Division of Quality: Allows rapid distribution of elements on the basis of product specifications and flexible display of results. (Results are shown in nine different views). Manual entry of results: before recording the results of the possible entry of foreign analysis of optical data analysis. Storing the results, where the number of stored results is limited only by memory size. Results of statistical analysis are stored: the calculation of average, minimum, maximum, standard deviation. Multivariable regression: an integrated package of interactive graphics for model calibration, including corrections, such as further concentration, multiple intensity correction and correction of multiple concentrations. Monitoring the status of the system: for alerts and monitoring of parameters such as vacuum, power and temperature.

4. MATERIAL

Mild or soft steel sheet manufactured in sheets or strips, thickness from 0.125 to 0.49 mm is called the black plate (blackplate), which is almost on the border thickness of foil and it is still marginal value in regular production.. If the surface is covered with black metal primer on both sides with a thin layer of tin, minimum purity 99.85 %, which gives it a white colour, then it is called white or tin plate (tinplate). Final material thickness structure (fig. 4) is an assembly of different layers each added for specific purpose, and each influencing the final thickness of the product. For TH 415 standard material properties [4, 5] are shown in tab. 1.

Tab. 1. Mechanical properties of TH 415 according to the standard EN 10202:2001

Designation	Tensile properties [MPa]		Rockwell hardness HR30Tm		
	R_p	R_m	$0{,}21 < t \leq$ 0.28mm	$t \leq 0{,}21$ mm	$t > 0{,}28$ mm
TH 415	415 ±50	435 ±50	61 ±4	62 ±4	60 ±4
Steel 1.0377	365-465	385-485	58-66	57-65	56-64

The thickness tolerance standard [5] is – 4 % + 5 % measured with a calibrated micrometer (0,01 mm accuracy) at least 10 mm from the trimmed edge. Tinning is carried out by a continuous electrolytic process. Improved corrosion resistance, increased wear resistance, or a decorative finish can be achieved by plating of one or more metallic layers onto a substrate. The most common method of plating is by electro-deposition in which the plating occurs by the action of an electric current. A negative charge is applied to the object to be coated and it is immersed into a solution which contains a salt of the metal to be deposited. The positively charged metallic ions of the salt are attracted to the object and are reduced to their metallic form on the

surface, creating the plated metal layer. A number of metals such as Cu, Cr, Ni, Sn, can be applied by carefully controlled plating baths to yield layers of the desired thickness and properties. The specific features of tin plate are its mechanical properties that cover a wide range (from 230 to 620 MPa).
Alloy Fe-Sn layer is positioned between the tin and steel base, its purpose is a good grip on the tin. A continuous layer of free tin to protects the steel base from corrosion. Different layer, differential coating of tin on both sides have added to the label while the letter D while those with the same coating layers are marked with E. The minimum limit is 0,5 g/m^2 tin deposits (the lower layers of the reported problems with welding sheet metal). Increasing resistance to corrosion and improve the possibility of painting the purpose passivization layer [6], while damage in handling and to facilitate mutual separation of plates is the purpose of the oil film. Thanks to its mechanical properties, which cover a wide range, tin plate is suitable for use in many forming processes, in particular: deep drawing, expansion, embossing, beading, (expansion up to 30 %) bending, rolling.

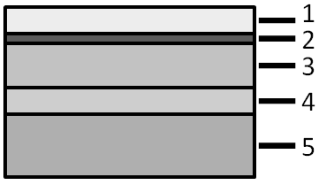


Fig.4. Structure of the TH 415 intersection with typical thicknesses of additives

Figure 4 shows final composition of TH 415 with added thickness of different layers: 1. Oil film = 0,005 μm, 2. Chromium oxide = 0,002 μm, chemical protection – chromatization (passivization film), 3. Tin free Sn = 0,26 μm, 4. Iron-tin alloy Fe-Sn 0,10 μm, 5. Base Steel 125-490 μm.
Surface finishes designation are therefore also regarded with great care, steel base surface roughness (μm): *bright finish*, *Ra* ≤ 0,25 μm, *fine stone*, *Ra* = 0,25–0,45 μm, *stone*, *Ra* = 0,35–0,60 μm, *silver finish*, *Ra* ≥ 0,90 μm, *matt finish*, *Ra* ≥ 0,80 μm.

5. RESULTS

5.1 Mechanical properties

Investigation of mechanical properties was conducted of the curve yield (fig. 5) and plasticity (fig. 6).
Yeld of 372 MPa is significantly lower than standard 415 MPa although within the tolerances it can cause modification in the flow conditions during tinplate shrinkage where drawing is used.

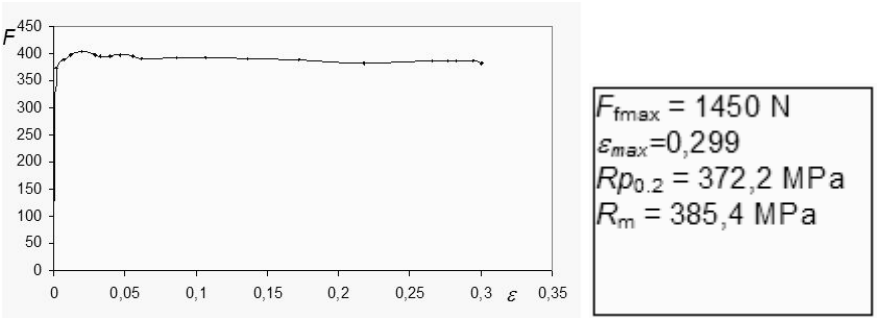


Fig.5.Yield curve of the TH 415

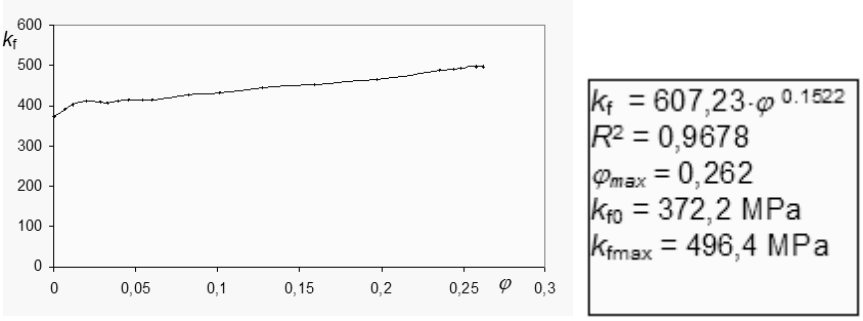


Fig.6. Strain stress curve of the TH 415

Therefore a test of earing in deep drawing is necessary for purpose of determining final anisotropy. Final anisotropy properties of double reduced tinplates significantly depend on the percentage reduction of tandem mill [7, 8]. F_{fmax} - maximum force, ε_{max} - the maximum relative deformation, R_{p02} - yield, R_m - tensile strength, k_f - the flow stress, φ_{max} - maximum logarithmic strain, k_{fo} - inital material flow.

5.2 Material composition

A special specimen for testing of chemical composition was created. In order to achieve the necessary material thickness 28 sheet plates of thickness 0,22 mm were combined (fig. 6.) into a unique specimen of total thickness of 6,16 mm.

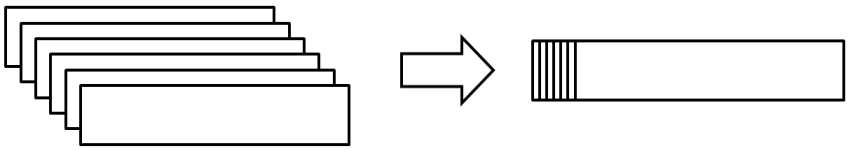


Fig.6. Special specimen for chemical composition test

Tab. 2. Chemical composition of tested TH 415, mas. %

	Calib. spec	*Sample no. 1*	*Sample no. 2*	*Sample no. 3*
C	0,03-0,06	0,0243	0,0098	0,0432
Si2	0,03	0,0098	0,0087	0,0212
Mn1	0,20-0,35	0,2486	0,1856	0,3632
S	0,02	0,0168	0,007	0,0152
P	0,02	0,0067	0,0098	0,0085
Ni2	0,08	0,0194	0,0103	0,0168
Sn2	0,02	0,0012	0,0028	0,0014
Cr1	0,08	0,0111	0,0147	0,0175
Mo	0,02	0,0019	0,0069	0,0018
Co	0,08	0,0008	0,0032	0,0031
Al2	0,020-0,070	0,0285	0,0412	0,0345

The Spectrometer ARL - 3460 [9] would otherwise burn to quickly trough a thin sheet of 0,22 mm and the amount of released elements would not be enough for quality measurements. The specimen was made on a hidraulic press KNUTH KP 100 where the high force combined the specimens into a single one with no air between them. The spectrometer creates a burn diameter of 12 mm therefore specimen of bigger diameter minimum of 25 mm is needed to secure and correctly conduct experiment of mass-spectrometry. Testing of material composition for several supplied batches of sheet plates was conducted (tab. 2).

Tab. 3. Chemical composition elements in traces of tested TH 415, mas. %

Elements in traces	*Sample no. 1*	*Sample no. 2*	*Sample no. 3*
Cu2	0,0202	0,0234	0,0104
Ti	0,0015	0,0012	0,0016
Pb	0,0013	0,0024	0,0015
V	0,002	0,0027	0,0016
W	0,0018	0,0005	0,0009
Nb	0,0003	0,0004	0,0002
B	0,0009	0,0009	0,0009

Samples were compared [4, 5] with calibration specifications in order to detect quality of tested steels (fig. 7). Additions of chromium, nitrogen and aluminium may be used to enhance the base metal properties. Several elements in traces (tab. 3) were also detected and further investigation will monitor their influence on their influence on TH 415 microstructure. The investigation of samples showed lover amount than specified for several elements in all samples. The material can be classified as a TH 415 of lower quality with minimum amounts of specified elements.

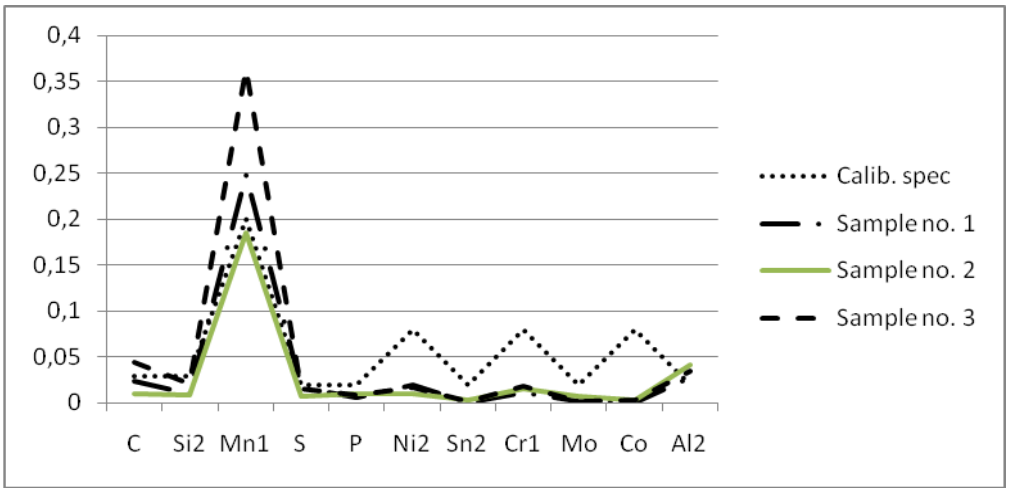


Fig.7. Comparison of material element percentage with max allowed of calibration specification.

6. CONCLUSION

A special specimen for testing of chemical composition on spectrometer ARL – 3460 needed for quality control was presented. Several tests to determine material properties were conducted. Specimen showed good behaviour during test and the testing results showed that chemical composition is within the tolerances for material TH 415. Analysis of mechanical proprieties were also conducted and showed that given material is within necessary tolerances. However continuous annealed tinplate is susceptible to ageing, or age hardening, which could increase the mechanical properties. To minimise this phenomenon it is recommended that the period between final processing at the mill and fabrication be kept as short as possible. Further research will be focused on numerical investigation and anisotropy behaviour of presented material in a deep drawing forming process.

7. REFERENCES

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