ISPITIVANJE OMOTAČA AUTOKLAVA ZA PROIZVODNJU VODENOG STAKLA METODOM MAGNETNE MEMORIJE METALA

TESTING AUTOCLAVE SHELL FOR PRODUCTION OF WATER GLASS USING METAL MAGNETIC MEMORY METHOD

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Sažetak:

Poznato je da se tradicionalnim (NDT metode bez razaranja) metodama mogu detektovati samo greške koje su već nastale u toku izrade ili eksploatacije određene konstrukcije. Method MMM (Metal Magnetic Memory Method), nam omogućava da se na brz i jednostavan način detektuju kako već postojeće greške, tako i zone koncentracije napona (ZKN), koje su osnovni izvor budućih oštećenja. Na taj način moguće je predupirediti buduće, tehnogene havarije i povećati sigurnost u radu raznih postrojenja.

U radu je prikazan dio kontrole koja je obavljena na omotaču autoklava za proizvodnju vodenog stakla u tvornici glinice "Birač" u Zvorniku.

Abstract:

It is known that the traditional (non-destructive testing - NDT) methods can only detect errors that have been already made in the course of the development or exploitation of a particular design. The Metal Magnetic Memory Method, allows us to quickly and easily find existing errors, and area stress concentration zones (SC zones) which present the main source of future damages. In this way it is possible to prevent future technogenic accidents and increase safety in the work of various equipments.

The paper describes the tests performed on the autoclave shell for the production of water glass in the "Birač" Alumina Factory in Zvornik.

1. INTRODUCTION

The MMM method is in principle a new method of NDT. It is based on the analysis of distribution of scattering own fields (OSMF) on the tested surface. Therefore, the actual state assessment of the tested piece is integral, because it also reflects the structural properties, the arrangement of the defects and residual stresses. For this purpose, instruments to measure stress concentration (series IKN) are designed. The instruments measure the intensity of magnetic field, its gradient, and distance made while scanning with the appropriate probe.

Stress-strain condition is reflected in the measured values of the magnetic field of the tested object and the corresponding gradient. The main parameters measured by the instrument are [1]:

Hp [A/m], normal component of scattering own fields,

$K_{in} = \frac{dH}{dx}$ [A/m/mm], magnetic field gradient dHp/dx on length x, the coefficient of intensity or rate of change, of scattering own fields, the level of residual stress and

$m = \frac{K_{in}}{K_{sr}} = \left[\frac{\sigma_m}{\sigma_{0,2}}\right]^2$, magnetic indication of strain capacity of the material or an indication of strain hardening of the material.

Measured magnetic field *Hp* and its gradient are integral features of the stress-strain state, which also include changes in the structure of metal in SC zones. Therefore, this presents an important practical advantage of the Metal Magnetic Memory Method over the known methods of stress and strain control (ultrasound, the Barkhausen effect, tensometer measuring, x-rays and other methods).

Measuring magnetic field strength on the surface of ferromagnetic materials, the disturbances of even magnetization can be spotted on places of defects, there is an increased intensity of the magnetic field in the form of magnetic knots. This phenomenon is not only a characteristic for the macro-defects but it has been occurring in the changes of structure and phase composition of steel as well as in the presence of the stress concentration zones (SC zones).

Experiments have proven that the magnetic anisotropy occurs due to the provided action of external forces on an object and direction of anisotropy coincides with the vector of maximum mechanical torque. This phenomenon is called MAGNETOMECHANICAL EFFECT and presents the basis of the Magnetic Powder Method (MPM). This phenomenon was firstly studied by proff. A. Dubov.

The Magnetic Powder Method is a quick method, it is not limited by dimensions (thickness OM), requires almost no preparation of the tested area - degreasing, paint removal, corrosion, isolation up to 5 mm of thickness, artificial magnetization.

Detailed analysis of recorded magnetograms are made by using a special program for MPM. The method was standardized by the International Institute of Welding (IIW - Commission V for NDT).

2. TESTED OBJECT

Tested object (Fig. 1) is an autoclave produced in the former USSR, it has been in use since 1980, with periodical interruptions. Geometric characteristics of the autoclave are: height *H*, the external diameter *D* and the inner diameter *Du*. For the production of the autoclave Russian-made structural steel ST20 was used. The interior of the autoclave is covered with the Č.4572 sheet with the thickness of 3 mm, to protect against direct influence of aggressive media on the outer mantle. Over time, during exploitation, the crack on the inner protective sheet appears, and the contents of the autoclave enter between the inner protective sheet and the outer mantle.

Figure 1. *Tested object – Autoclave [2]*

Structural steel ST20 is subjected to corrosion destruction in places with higher concentration of stress when in contact with sodium hydroxide. This combination causes a crack known as caustic fracture.

In the autoclave there is a mixture of sodium hydroxide NaOH concentration 540 g/l and quartz sand, Na_2O x SiO_2 x XH_2O, at a temperature of 220 °C and 32 bar pressure.

Testing was done on the critical area where the leak occurred (Fig. 2). At this location the external insulation with the area of cca 1,5 m^2 and 200 mm of thickness was removed.

Figure 2. *Controlled area of the autoclave with the scheme of the recording routes and the geometry position of cracks*

The Metal Magnetic Memory Method was applied, ultrasonic control and electromagnetic crack indicator control. The control was performed with the IKN 3M-12 device and 8-*channel probe* 1-8M. In the case there is an electronic block that simultaneously registers the distance traveled and the size of the magnetic field [3].

Figure 3. *Display of the measurement procedure*

Figure 4. *Stress concentration measuring device IKN-3M-12*

Figure 5. *Electromagnetic indicator of surface cracks EMIT 1*

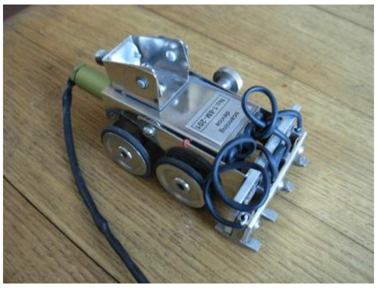


Figure 6. *Scanning device 1-8M, which is used with defectoscope IKN-3M-12*

To use the device IKN-3M-12, the operator must have a certificate from the manufacturer (Energodiagnostika Co.Ltd.) which was accepted by the International Institute of Welding (IIW).

Technical characteristics of the Russian-made IKN-3M-12 device are:

- Measurement range of *Hp* per channel,
- Number of channels measurements *Hp*,
- Basic *relative measurement error* for each channel *Hp*,
- Additional absolute error of measurement for each channel *Hp*,
- Min. scanning step,
- Max. scanning step,
- Basic absolute error of measurement of a transducer displacements,
- Additional relative error of measurement of a transducer displacements,
- Max. length of the memorized part in the step of 1 mm to 4 channels,
- Max. length of the memorized part in the step of 128 mm for 4 channels,
- Max. scanning speed at step of 1 mm,
- Operative memory capacity,
- Internal memory capacity,
- Range of working temperature,
- Range of relative humidity.

3. TESTING RESULTS

The basic capabilities of the method will be demonstrated in an example of a crack. While observing the passage no. 7, (scanning of the basic materials), the magnetogram clearly shows the crossing point over the crack at a distance of 284 mm from the beginning of the scanning. All components, normal and tangential, across all channels, cut zero with a sharp change of the intensity of magnetic field *Hp*, followed by the corresponding gradients of K_{in} where K_{max} = 109 A/m/mm. The remaining part of the magnetogram remains in a good condition, there is no anisotropy on any channel of the magnetogram.

The length of the crack found in the outer part of the sheathe is 140 mm. The ends of the cracks were located using electromagnetic indicator of surface cracks, by using EMIT 1 device.

Passage no. 8 covers part of the crack and a part out of the crack. The width of scanning device with four ferrous transducers is 60 mm. The sharp jumps of the magnetic fields on all the channels are also observed, where the gradient K_{max} = 124 A/m/mm. It should be noted that the gradient is greater here than in the middle of the crack.

Ultrasound revealed that the crack extends to the inner side and its length is cca 280 mm.

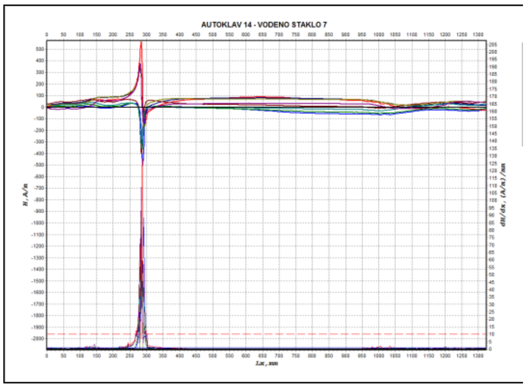
The passage number 9 comes out from the zone of the crack, the magnetic anisotropy is reflected only in one channel (normal and tangential component have sudden jumps). One channel of the normal component changes sign and passes through zero. The maximum gradient is K_{max} = 23 A/m/mm.

At the same magnetogram anomaly to the left of max. gradient becomes apparent. It draws attention to the surface damage of the mantle that has arisen during the autogenous cutting of the isolation carrier. The intensity of the gradient is K_{in} = 10,5 A/m/mm.

Horizontal passage no.11 along the crack.

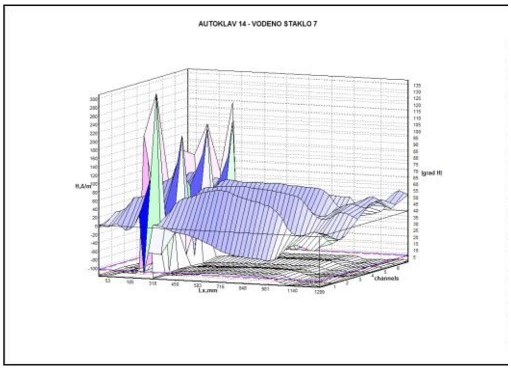
Based on the character of the magnetic field and the corresponding gradients, the length which should be overhauled *l* = 410 mm can be observed on the abscissa, which means that an existing crack has a developing character as its length is 280 mm.

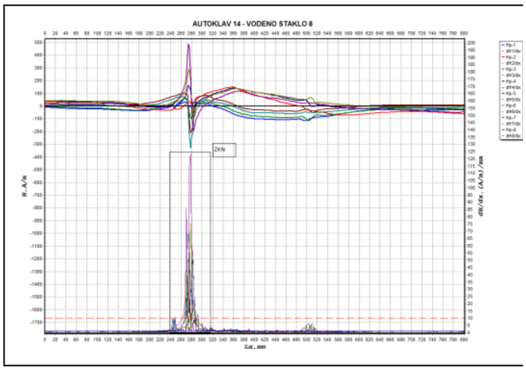
Display of the normal and tangential components with the corresponding gradients

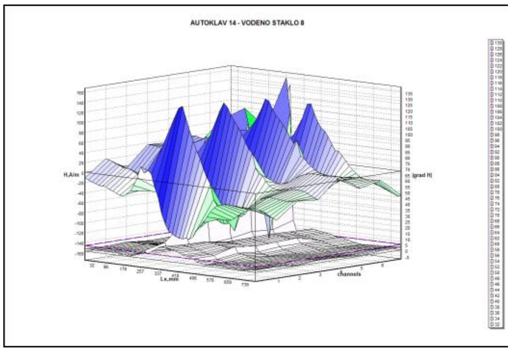


Autoclave 14 – Vater Glass 7

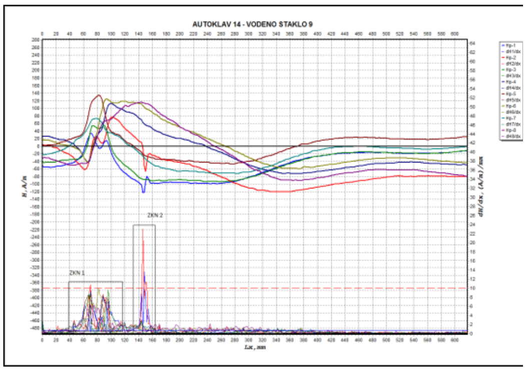
Spatial display of magnetogram

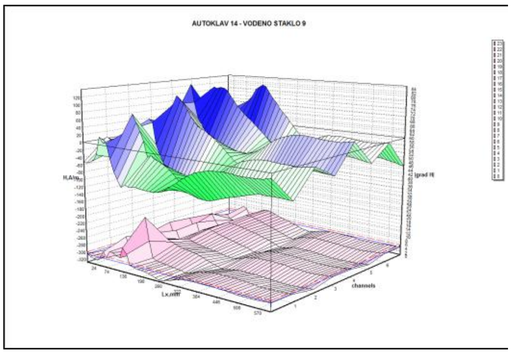




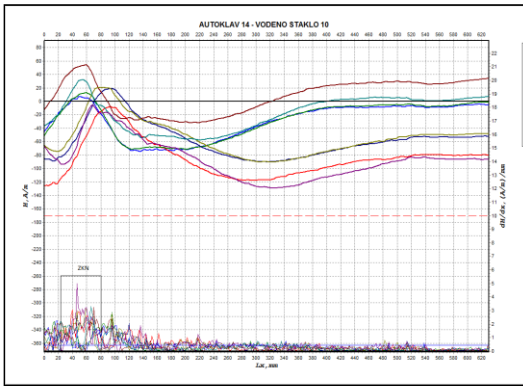


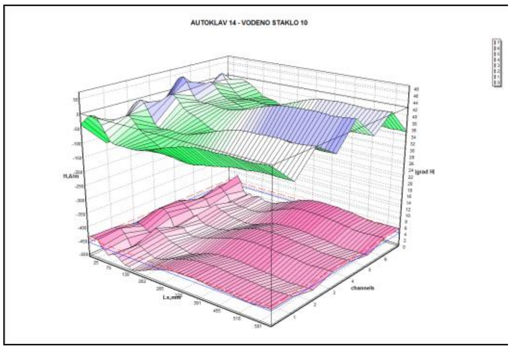
Autoclave 14 – Vater Glass 8



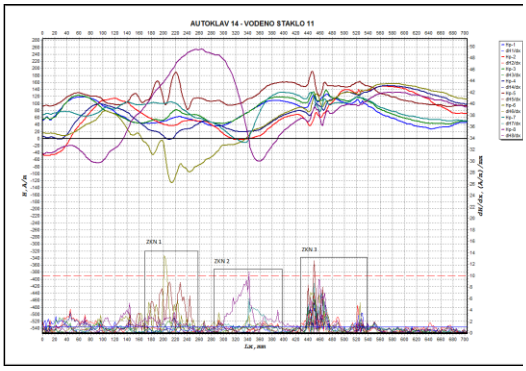


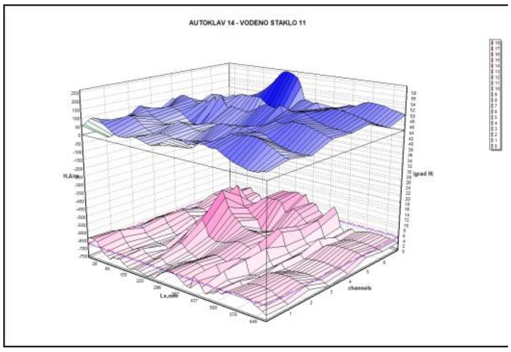
Autoclave 14 – Vater Glass 9





Autoclave 14 – Vater Glass 10





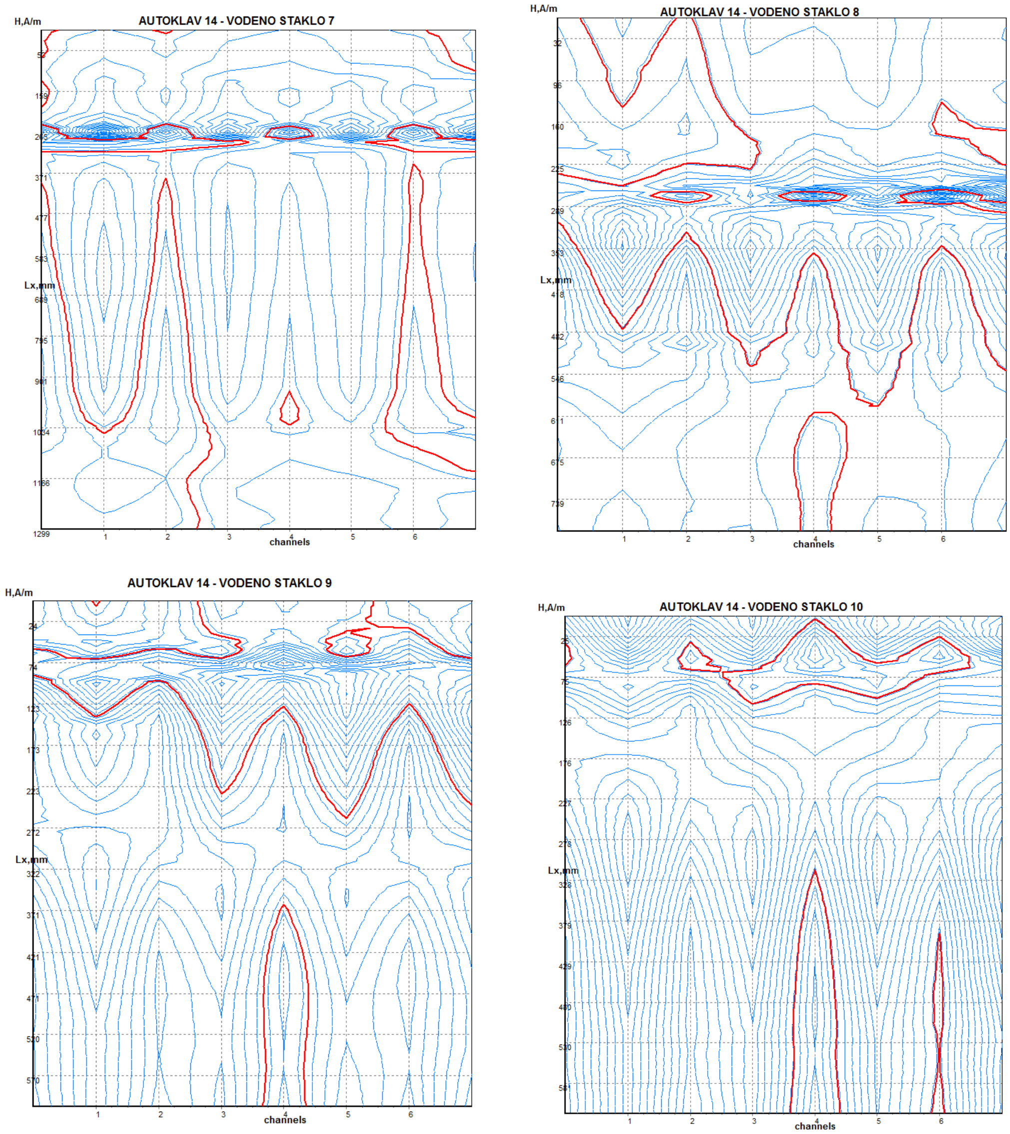
Autoclave 14 – Vater Glass 11

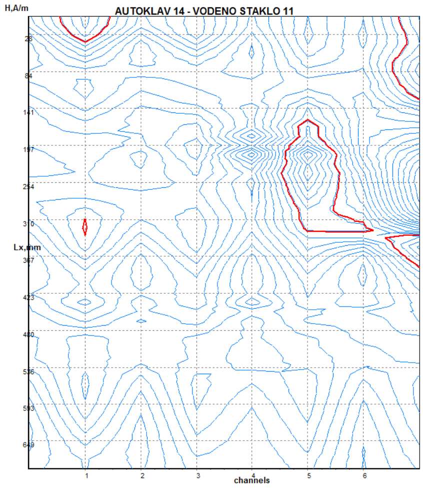
3.1. Distribution of isolines of the resulting magnetic field

When analyzing the scanning results of a given object, using the "MPM-system" the magnetograms of distribution of the resulting field and its gradient can be viewed on the computer screen. It is also possible to observe diagrams of isolines of the magnetic field *Hp* and its gradient K_{in}. Such interpretation can clearly present the distribution of residual strain where dense isolines indicate zones subjected to pressure, and the spread isolines indicate areas subjected to stretch. The red line indicates the zero line, ie, changing the character of magnetic field which points to the presence of area stress concentration zones [4].

During the testing two more horizontal cracks have been found. One is at the vertical weld (passage no. 4) 540 mm from the beginning of the scan with the length of 35 mm, and the other to the right of the weld at a distance of 610 mm from the beginning of the scan with the length of 30 mm (passage no. 1). Both cracks appear through the entire thickness of the mantle of 50 mm, confirmed by ultrasound control.

The distribution of the magnetic field isolines





4. CONCLUSION

Testing using MPM, did not require cleaning of the surface from corrosion and remaining paint. The surface of the mantle 850 x 850 was scanned in 100% of the area, when a new crack was found (two were visible by visual inspection). The report precisely defines the position and the length of the crack, which was confirmed by ultrasound control. The report describes if the crack has developing character or not (on the weld crack doesn't have developing character).

The recommendation is to examine the whole area again after overhauling, to determine not only whether there is some nonhomogeneity in the welds, but how the heat treatment of the residual stress relaxation was provided, or if there are places with increased SC zones.

Recommendation: The autoclave should be made with cladded sheet, where the connection of St. 20 and Č.4572 could be achieved by explosion energy.

5. REFERENCES

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