THE METAL MAGNETIC MEMORY (MMM) AND PRACTICAL APPLICATION

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Abstract: *The method was appeared as result of constant client's demands to make a testing in very short time, making a tested object useful so soon to reduce the stoppage time and costs. Using the measuring of own magnetism and physical phenomenon of magnetostriction on very fast and precise way the areas of stress concentration will be uncovered, which in second phase become the object of other NDT methods application.*
In work paper was shown a testing application of: vessel - dimensions Ø 5000 x 6 mm, welds of gas line and central (axial) hole of midle pressure (MP) and high pressure (HP) turbine rotor. The testing was done by measurer of sress concentation IKN-3M-12.

Key words: *metal magnetic memory (MMM), stress concentration, magnetostriction;*

1. ABOUT METHOD

The metal magnetic memory method (MMM) was appeared as the result of constant client's demands to make a testing in very short time without previous preparation, giving an instant indication of critical places reducing the stoppage time and costs. An evaluation of the stress state of feromagnetic material is the essence of method which represents the way for diagnostic of energy and life time for critical parts of material structure and components. [1]

The feromagnetic domain behavior (dimensions from 10-9 up to 10-5 nm) in materials caused by phenomenons like magnetostriction (changing of energy state in domain will change a domain dimension) and mechanostriction (changing of domain dimension caused by stress state will change domain magnetic field) is necessary for use of the method. [2] [3]   The method was standardized and approved by International Institute of Welding (IIW – commission V for NDT). Its preliminary creator was Prof. Doubov from Russia which has applied the knowledge of electromagnetism. The used testing device in listed exsamples was a stress concentration gauge IKN-3M-12, Russian product („Energodiagnostika" firm) with folowing caracteristics:

- *measuring range of Hp value per each channel.........................± 2000 A/m,*
- *channel number for Hp measiring...12,*
- *basic relative error of Hp measuring per each channel ....± 5%,*
- *additional absolute error of Hp measuring per each channel............± 2 A/m,*
- *minimal scanning step..1 mm,*
- *maximal scanning step..128 mm,*
- *basic absolute error of sensor move measuring.....................................± 1 step,*
- *additional relative error of sensor move measuring....................................± 5%,*
- *maximal length of memorised part for step 1 mm per 4 channels.............110 m,*
- *maximal length of memorised part for step 128 mm per 4 channels.......14080 m,*
- *maximal scanning speed for step of 1 mm..0,5 m/s,*
- *capacity of operational memory...1 Mb,*
- *capacity of internal memory...32 Mb,*

A device for scanning is 1-8M with two component sensors, 8 – channels.

2. PRACTICAL APPLICATION – EXAMPLES

2.1 An axis hole testing of rotor of middle pressure turbine (section A1, Power station „Nikola Tesla A")

The testings were done by standard method for axis holes using 4 passes and mutual angle of 90^o (watching from forehead and analog to clockhends positions: 3, 6, 9 and 12 o'clock).   The measuring path from input edge of hole was moved for scanning device length (about 70 mm) and was not included by measuring. Initial measuring point was moved for noted lenght into hole, what should be taken for determine of coordinates of stress concentration zone.

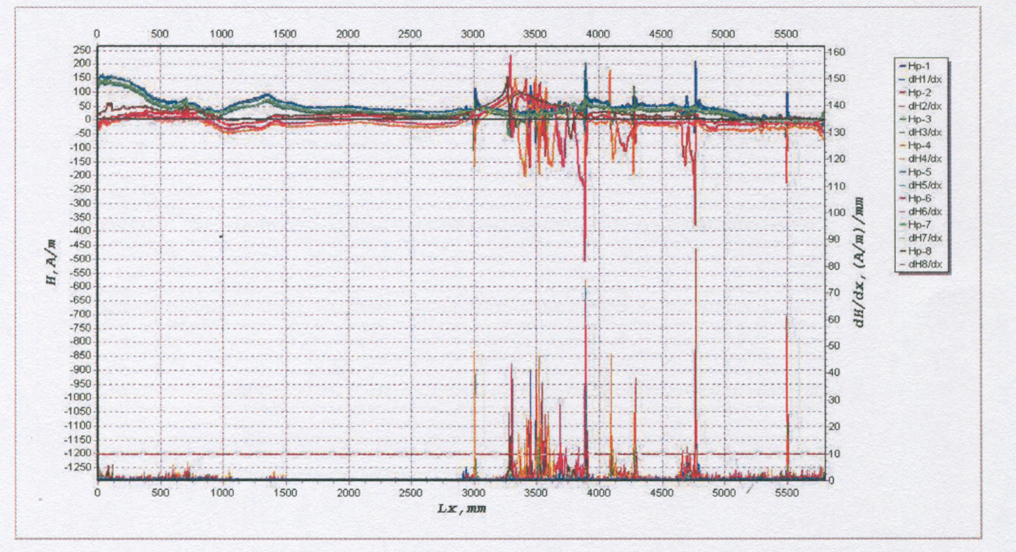
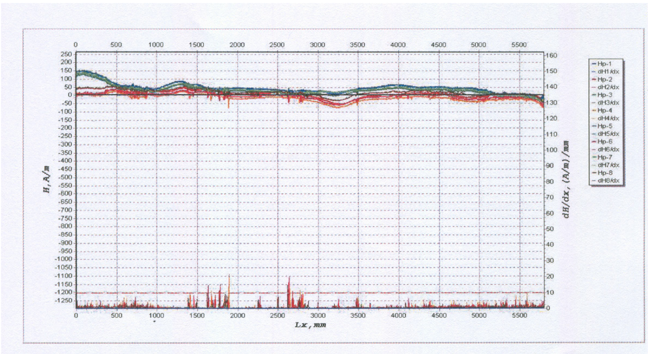


Figure 1. – Graph on scanning line No.1 of all 8 channels (4 normal and 4 tangential components of self magnetic field). Scanning line length is 5798 mm. Visible stress concentration zones are from x = 3000 mm to x = 5500 mm, and gradient dH/dx is maximal 86,56 A/m/mm (on channel No. 2).



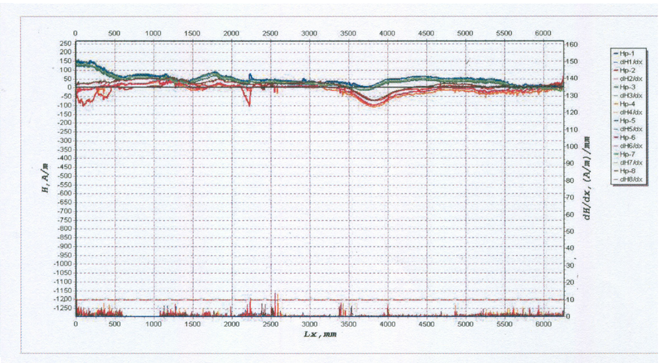


Figure 2 *Figure 3*

Figure 2. – Graph on scanning line No.2 of all 8 channels (4 normal and 4 tangential components of self magnetic field). Scanning line length is 5798 mm. Visible stress concentration zones are from x = 1620 mm to x = 1910 mm, and around of coordinate x = 2625 mm, and gradient dH/dx is maximal 21,31 A/m/mm (on channel No. 4).
Figure 3. – Graph on scanning line No.3 of all 8 channels (4 normal and 4 tangential components of self magnetic field). Scanning line length is 6258 mm. Visible insignificant stress concentration zones are from x = 2200 mm to x = 2600 mm, and gradient dH/dx is maximal 13,93 A/m/mm (on channel No. 6).

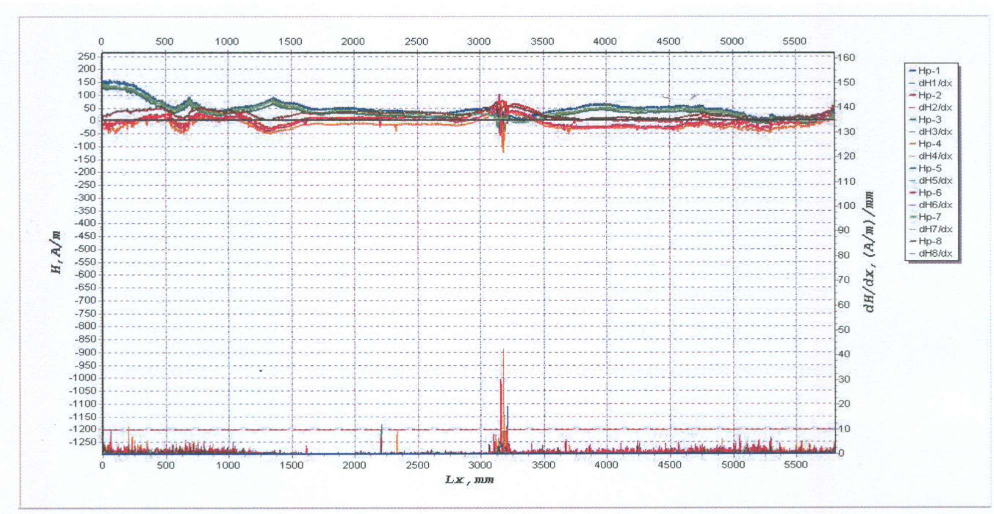


Figure 4. – Graph on scanning line No.4 of all 8 channels (4 normal and 4 tangential components of self magnetic field). Scanning line length is 5806 mm. Visible stress concentration zones around one coordinate x = 3178 mm, and gradient dH/dx is maximal 42,68 A/m/mm (on channel No. 4).

According to significant gradient values into stress concentration zones on scanning lines No.1 and No.4, it is necessary the aditional testing of the part of axes hole surface on the lines 1 and 4 and between them, especially on coordinates with higher stress concentration values.

2.2 Testing of axial hole of high pressure turbine's rotor – Power station „Nikola Tesla“

Before the starting of testing on the part of turbine shaft, precisely on the bearing place a pitting corrosion was detected. The shaft part was scanned around whole volume to check sensitivity of stress concentration gauge and scanning device. A pitting zone is very clear exspressed on the graphs. On the channel 4 (normal component of the own magnetic field on the second sensor) maximal gradient is dH/dx max = 78,18 A/m/mm in the pitting zone.

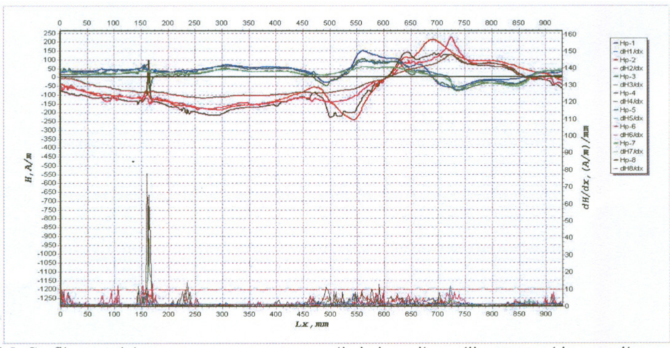
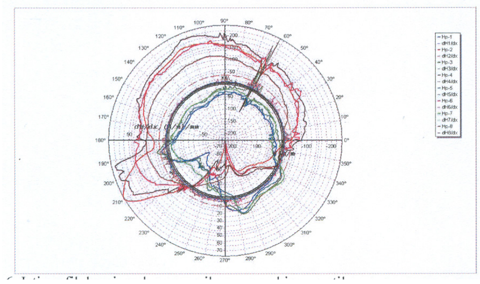
	

Figure 5 – Graph of self magnetic field distribution and its gradients per shaft volume with pitting zone (linear review of scaning channels)	*Figure 6 – graph per shaft volume Watching from a forehead the own magnetic field distribution per volume and its gradients*

2.3 Testing of factory made weld 23P in „BMR“ –Sabac City (gas pipelines „Banatski Dvor“)

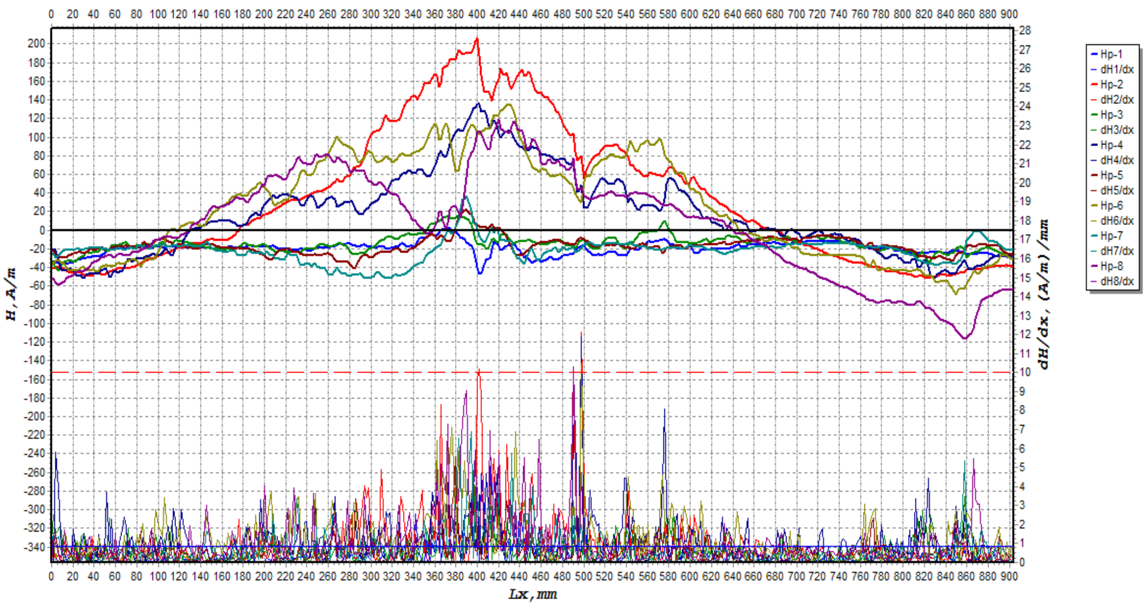


Figure 7 - Graph on scanning line of all 8 channels (4 normal and 4 tangential components of self magnetic field). Scanning line length is 900 mm. Visible stress concentration zone is at x = 500 mm, and gradient dH/dx is maximal 12 A/m/mm.

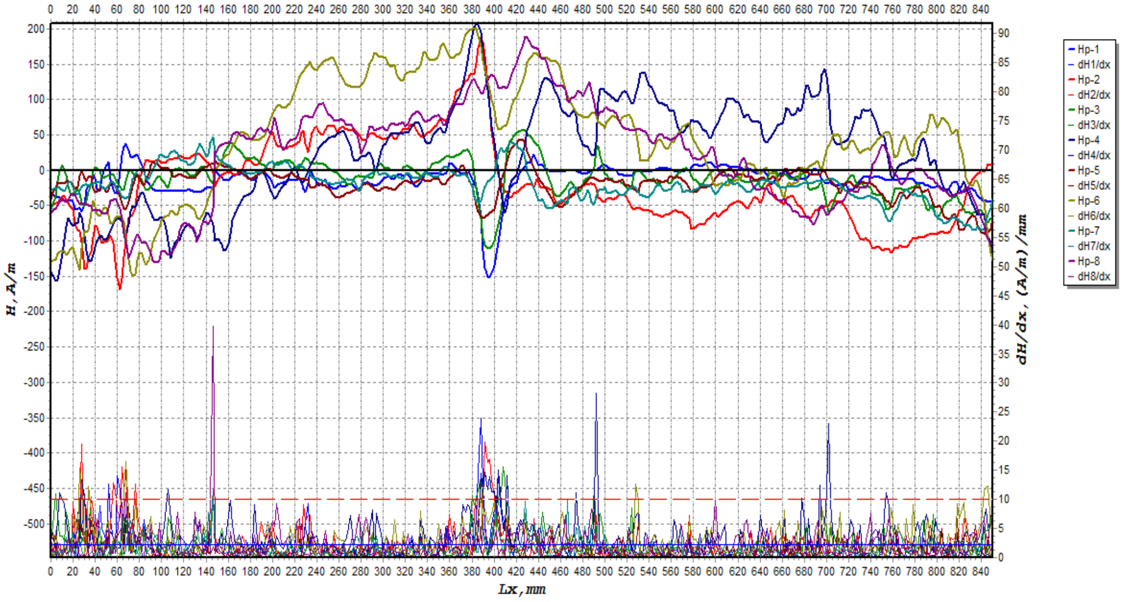


Figure 8 – Graph on scanning line of all 8 channels (4 normal and 4 tangential components of self magnetic field). Scanning line length is 850 mm. Visible stress concentration zones: x = 140 mm and dH/dx max = 40 A/m/mm; x = 390 mm and dH/dx max = 25 A/m/mm;
x = 490 mm and dH/dx max = 28 A/m/mm; x = 700 mm and dH/dx max = 24 A/m/mm.

On the places with higher concentration zones, using ultrasonic testing the material paste was uncovered.

2.4 Weld testing of vessel in firm „Milanovic Inzenjering“ – Kragujevac city

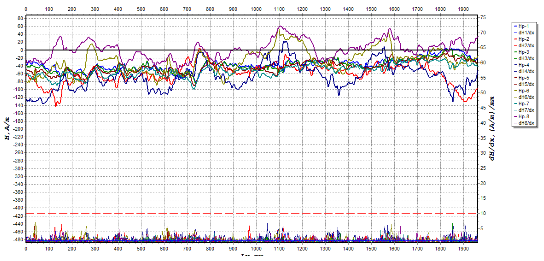


Figure 9

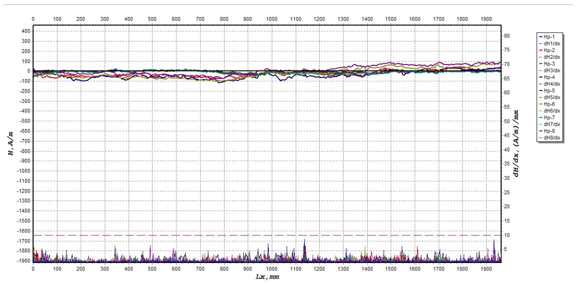


Figure 10

Figure 9 - Graph on scanning line G2 of all 8 channels (4 normal and 4 tangential components of self magnetic field). Scanning line length is 2000 mm. Visible insignificant stress concentration zone was not detected.
Figure 10 - Graph on scanning line G4 of all 8 channels (4 normal and 4 tangential components of self magnetic field). Scanning line length is 2000 mm. Visible insignificant stress concentration zone was not detected.

3. CONCLUSION

The use of method is possible on the welds of different sizes and configurations: pipelines, vessels, metal constructions, etc. The natural magnetisation created in material during welding process under Eart magnetic field will be used for measuring and analisys. The testing without previous surface preparation, great scanning speed and exceptional sensitivity are advantages of method. Note, the presence of external magnetic fields of several ferromagnetic materials and fluctuating currents into testing material may caused the wrong reading of magnetic field gradient.

4. LITERATURE

[1] Vlasov V.T., Dubov A.A. Physical bases of the metal magnetic memory method , Moskva [2] Popović V. , Osnove elektromagnetizma, ETF Beograd [3] Milatović B. , Osnove elektrotehnike ETF Sarajevo [4] ISO 24497 -1,2,3 NDT- Metal magnetic memory (1-Vocabulary, 2-General requirements, 3-Inspection of welded joints)