Abstract


1. Introduction
The branch of NDT of materials consists of defectoscopy and structuroscopy. Defectoscopy finds defects in material – defects of discontinuity type or their manifestation. The structuroscopy searches continuous mass characteristics. This contribution introduces to one of alternatives of magnetic structure diagnostics.

2. Structuroscopy
X-ray diffraction is standardized metod among currently used ones. Other methods in the frame of structuroscopy application are not subject of standards. These are mainly UT, ET and MT. Their practical application is based on creation of specific effective role by research, applied development of given problems.

3. Magnetic Methods
In the field of Czech research are developed methods of magnetic spot and MAT.

3.1. Magnetic Adaptive Testing Method
Shortly said Magnetic Adaptive Testing (MAT) is magnetic hysteresis NDT method exploiting large data file created by registration of voltage outlet induced in sensing coil wound on specimen in dependence of immediate value of magnetic field of specimen. The specimen is magnetized gradually by sequence of magnetic loops of variable magnetic field from minimum possible upto saturation amplitude. The MAT purpose is find in this data file the descriptors of monitored changes of used specimens which are just optimum against monitored changes of used material. Functional dependence, eventually dependencies of such descriptors on monitored changes of material can be designate as degradation functions. MAT results are typically more sensitive and the measurements is experimentally more friendly than conventional hysteresis tests [1].

3.2. Magnetic spot method
It is focused on local measurement of remanent magnetisms Hm with ballistic (impulse) magnetization method [2]. In the same manner magnetically oriented atoms in steel are concentrated in domains which are forming any subgrains inside of structure grains. By
polarization with external magnetic field the growth of domains occurs by shift of so-called Bloch zones and by polarization consistent with external magnetic field or jump change of polarization so-called Barkhausen jumps (the source of Barkhausen noise).

After expiry of external magnetic field Ho all domains do not return to original state. The remanent polarization $I_r$ is created. Magnetised place has its own magnetic field with intenzy $H_r$. The reversible changes are hindered by ferromagnetics atoms bound in molecules and atomic strength, lattice defects. For this reason structure constituents containing iron carbide, martensite, numerous dislocations and grain boundaries shows high value of remanent polarization $I_r$.

$$H_r = H_o - N \times I_r / \mu A/m$$ (1)

Demagnetizing factor $N$ characterizes both external and structural geometry circumstances of ferromagnetics boundary. The impulse magnetic field with intensity $H_o$ is acting onto as-tested site of product. Shape of current impulse conducted to attached power coil, eventually their exactly defined sequence defines flow of parasite eddy currents (they can be properly used to suppression of negative effects of $N$) and structure selective sensitivity of method. Methods used in Russia and Czech Republic differ essentially in magnetization characteristics and by it in aim of applications. $H_r$ sensor can be Hall or Försterova probe. The contribution $dH_{ri}$ of single ferromagnetics grains to resulting value $H_r$ depends on shielding effect $m$ and their distance from probe.

$$H_r = \sum m \times t \times dH_{ri}$$ (2)

With increasing penetrating depth of magnetizing field decreases effect of single grains on $H_r$; in practise uptu $t=12$ mm. So the pulse energy is concentrated to smaller volume of grains in the case of thinner walls. The $H_r$ value grows upto $L_{ki}$ after experimenetally determined model.

$$H_{li} = H_{l12} \times (81 \times L^{-3} + 1)$$ (3)

Iron alloys (steels and cast irons) creates the spectr of most widely used structural materials. Ferromagnetic properties can be allocated to their overwhelming majority. Knowledge of mechanic property values in critically loaded site of exposed parts dominates over need of integral information about choiced mechanical property. From this reason has the local magnetic structuroscopy significant position in the spectr of the rest methods. It found application spreading in the form of magnetic checking mainly in Russia and Czechia. It can be characterized by high productivity of checking with targeted satisfactory senzitivity to as-checked structure parameter. In the western Europe are used for this field of materials ET methods exclusively. Alternative eddy currents describe more surface regions of parts however. Local magnetic structuroscopy is more suitable for worked semiproducts and castings with unfinished surafaces.
3.2.1. Magnetic spot in practice – DOMENA B3
This method found its own application mostly in foundry of cast irons. The measurement shows satisfactory accuracy for unfinished casting surfaces as well. Matrix structure contains ferrite and pearlite only. Application development determines linear equations always (constants A, B) for mechanical properties calculation entered to memory of DOMENA B3 (Fig.1) before measurement. Optimum regime is set onto magnetizing M4 or M5. During operational applications was effort made for improvement of measurement reproducibility after repeated measurement and measurement at low and high temperatures (+-30°C). On basis of results of measurement stability the manufacturer of DOMEN B3 (ELKOSO s.r.o. Brno) made technical modifications to better operational stability. General formula:

\[ C = A \times M + B \]  \quad (4)

Where M=Hr in foundry shop SKS Krnov is used to: [3]

Hardness measurement of castings and disks from cast iron with flake graphite

\[ HB = 0,6 \times M + 100 \]  \quad (5)

Mechanical properties measurement on disks from cast iron with sferoidal graphite

<table>
<thead>
<tr>
<th>Property</th>
<th>Equation</th>
<th>K</th>
<th>K²</th>
<th>No.r.</th>
</tr>
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<tbody>
<tr>
<td>HB</td>
<td>0.8xM+128</td>
<td>10</td>
<td>0.958</td>
<td>0.918</td>
</tr>
<tr>
<td>F [%]</td>
<td>116 – 0.585xM</td>
<td>10</td>
<td>-0.932</td>
<td>0.868</td>
</tr>
<tr>
<td>Rm [Mpa]</td>
<td>2.69xM+383</td>
<td>26</td>
<td>0.955</td>
<td>0.912</td>
</tr>
<tr>
<td>Rp(0.2) [Mpa]</td>
<td>1.81xM+242</td>
<td>32</td>
<td>0.931</td>
<td>0.867</td>
</tr>
<tr>
<td>A [%]</td>
<td>22.4-0.09xM</td>
<td>2</td>
<td>-0.89</td>
<td>0.787</td>
</tr>
</tbody>
</table>

Validity condition for formulas is spheroidal shape of graphite formation of cast iron

3.2.2. Structure resolution of Fe alloys by repeated magnetizing.
Magnetic spot method for structure diagnostics of steels is not propagated. The steels own currently large scale of structures (martensite, bainite, sorbite, pearlite, ferrite) and their modifications. Hr values of some different types of structures are equal, with increasing strength, hardness the dependencies need not be monotonous. For magnetically “virgin” steel products the Hr value repeatedly measured on the same place all the time decreases. Mathematic model of decreasing or only difference between first and second measurement differs after type of structure [4]. High difference shows martensite, low mainly equilibrium states after annealing. See Tab.1.

<table>
<thead>
<tr>
<th>12 050</th>
<th>12 050</th>
<th>Tempoered 300°C</th>
<th>Tempered 500°C</th>
<th>Tempered 660°C</th>
<th>Annealed over A1</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₁₁ – H₁₂</td>
<td>52</td>
<td>41</td>
<td>35</td>
<td>31</td>
<td>10</td>
</tr>
<tr>
<td>H₁₂ A/m</td>
<td>248</td>
<td>218</td>
<td>265</td>
<td>274</td>
<td>191</td>
</tr>
</tbody>
</table>
4. Conclusions
Magnetic spot method is successfully optically applied on ferrous alloys with ferrite-pearlite structure (cast irons). One parametre measurement of Hr of steels does not contribute to unambiguous diagnostics of structural phases. Parameter enabling unambiguous structure diagnostics by magnetic spot method can be obtained by repeated measuring of Hr. Knowledges obtained on steel 12050 are now proved on other representants of steel sort in order to enable creation of general models.

Acknowledgement
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References