Influence of the Heat Treatment and the Ultrasonic Waves Attenuation at the 34MoCrNi14 Steel

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Abstract: - The paper present studies on the 34 MoCrNi14 steel. The steel suffer a heat treatment and it is measurement the effect of the treatment. It is analyzed the hardness, the strength ultrasonic attenuation versus heat treatment temperature. Using mathematical apparatus it is determine for the steel 34 MoCrNi14 the equation for a surface dependence between ultrasonic wave attenuation, heat treatment temperature and hardness.

Key-Words: - Heat treatment temperature, ultrasonic wave’s attenuation, hardness, nondestructive testing

1 Introduction
Nondestructive testing gives the possibility to determine materials defects in a piece, without other damage or alteration their capabilities and it is possible to identify some physical and mechanical properties. Nondestructive techniques can be made not only with ultrasonic waves, can be made with electromagnetic methods, with penetration radiation but the bought are difficult and with penetration radiation there is danger but there is a very good resolution for defect. Because, the issue is to determine not only the defect of the materials but also information about physical and mechanical properties of the materials but also information about physical and mechanical properties of the materials the used methods is with US waves. The inspection starts with a visual inspection to determine if the surface of the material is degraded because in this case the NDT examination is really influenced. The heat treatments are applied to the products in order to obtain mechanical characteristics and practical application, superior to initial state of metallic material. Using heat treatment it is possible to control the structural constituents that there are obtained in the material and so to obtain a better physical and mechanical characteristic. After temper hardening all kinds of steel have important fluctuation of physic – mechanical properties. Apparition of the flinty and mild structural constituents with shapes dimensions and changed crystal structures products important modification. The paper shows the mathematical model of the ultrasonic transparency of the metal.

2 Theoretical Consideration
In oscillations theory, alternative sonic pressure has a maxim value, named sonic pressure amplitude “p” which has a reference value and from that we make the reference p₀. The relation gives the relation between p and p₀:

\[ p = p₀ \cdot e^{-(\alpha_a + \alpha_d)x} \]  \hspace{1cm} (1)

- \( \alpha_a \) - attenuation coefficient given by absorption
- \( \alpha_d \) - attenuation coefficient given by diffuse

Both coefficients characterize the sonic attenuation, which is characteristic for each material. They are adequate to two principal phenomena’s which are born when an ultrasonic wave crossing the material. (Absorption and diffusion in material structure)
The reference of grains size and length way, has an important influence to the diffusion, so, the ultrasonic attenuation depend in principal by frequency. Other important characteristic dimension for sonic propagation in a material is the specific acoustic impedance Z, which is given by the product of sonic speed “\( v_s \)” and material density “\( p \)”.
\[ Z = \rho \cdot v_s \]  
\[ I = P^2 / 2Z \quad (\text{mW/cm}^2) \]  
Ultrasonic wave transport too energy therefore we can establish the quality of energy who cross an area in unit time.

Ultrasonic propagation it is possible in homogenous materials and the most usually ultrasonic methods used longitudinal or transversal waves in through transmission and echopuls method. Longitudinal ultrasound wave’s speed is:

\[ C_L = \sqrt{\frac{E}{\rho}} \cdot \frac{1 - \mu}{(1 + \mu)(1 - 2\mu)}. \]  

ultrasonic pressure:

\[ dP = -\alpha Pdx \]  
where \( \alpha \) is linear attenuation coefficient
ultrasonic wave intensity:

\[ I = I_0 \cdot e^{-2\alpha x} \]  

attenuation coefficient:

\[ \alpha = \frac{1}{x} \cdot \ln \frac{P}{P_0} \quad (N_p/cm) \]  
\[ \alpha = \frac{1}{x} \cdot 20 \log \frac{P}{P_0} \quad (dB/cm) \]  
\[ \alpha (dB/cm) = 8,7\alpha (Np/cm) \]  
\[ \alpha = \alpha_a + \alpha_d \]  

where:

\( \alpha_a \) is absorption attenuation coefficient
\( \alpha_d \) is diffusion attenuation coefficient.

3 Experimental Procedure

At the 34MocrNi16 material the beneficiary put the condition to have a hardness of 350 Vickers units. To obtain this hardness, I made a bettering heat treatment, and the temper operation is achieved in three version, temper at 500\(^\circ\)C, 580\(^\circ\)C, 620\(^\circ\)C. The three heat treatments applied to the sample are:

1. Tempering at 850\(^\circ\)C oil cooling, and a temper at 500\(^\circ\)C.
2. Tempering at 850\(^\circ\)C oil cooling, and a temper at 580\(^\circ\)C.
3. Tempering at 850\(^\circ\)C oil cooling, and a temper at 620\(^\circ\)C.

<table>
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<tr>
<th>Table 1: Experimental results</th>
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<tbody>
<tr>
<td>attenuation</td>
</tr>
<tr>
<td>9,927</td>
</tr>
<tr>
<td>13,194</td>
</tr>
<tr>
<td>13,914</td>
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<tr>
<th>Table 2: Chemical composition</th>
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<tr>
<td>%elementes</td>
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<tr>
<td>34MoCrNi16</td>
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The sample obtain after three-heat treatment are cleaning and rectify because we need polished plane parallel surface.
Sonics 13 plus is the ultrasonic device used to determine the attenuation of the longitudinal ultrasonic wave characteristic. Because the aped in metallic materials is different, it is used a device (ECHONOMETER 1070D-56Wuppertat 1Karl Deutsh) to determined the speed in the 34 MoCrNi14 steel sample.
All the results are collected from the display the device, and it is used Microsoft excel program to made the graphics hardness versus heat treatment temperature, figure1, attenuation ultrasonic wave coefficient versus hardness, figure 2, and attenuation ultrasonic wave coefficient versus heat treatment temperature, figure 3. Using mathematics apparatus and MAPLE programs gives the possibility to establish and see the variation surface given by three-dimensional function, figure 4.
4 Conclusion
Nondestructive tests with ultrasonic waves can be easy used on metallic materials without stop the device or made important preparation for measurement.

In the paper are established temper temperature hardness, tensile strength and chemical composition for 34 MoCrNi14.

For each steel, the ultrasonic device must be calibrated. (to determine the right speed in the steel). Ultrasonic attenuation is given as a function by heat treatment temperature and hardness. The mathematical equation and graphic shows that there it is possible to find an optimum when you know the parameter that we want.

References:


