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THE TEMPERATURE ACTIVATION OF CARBON SATURATION STEEL PROCESS

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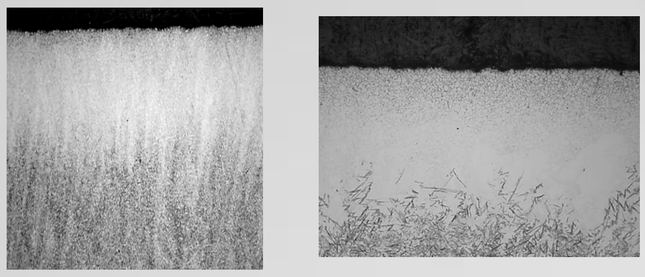
Abstract

The study presents the application of a mathematical description of a thermo-chemical process which consists in diffusion saturation of steel with carbon atoms. The mathematical description assumes temperature-based activation of the process of carburizing and estimates the effect of diffusion flow, which has a direct effect on the thickness of the obtained carburized layers, on the process temperature. The assumed model can be universal for all thermo-chemical processes of diffusion saturation of metallic materials

Carburizing process

The most popular technique today is carburizing using the gas phase, ion carburizing and liquid carburizing. All the above types of carburizing are diffusion-based processes. The thickness of the carburized layer is determined chiefly by carburizing time and temperature of the carburized material. The results of this process are also determined by carbon potential and the flow of medium gases termed the diffusion stream, which is formed by the particles of a solid maintained in a suspension by a hot saturating gas flowing through a bed from the bottom upwards. After carbonizing processes usually are obtain surface layers characterized by distribution of different physical and mechanical properties as the same properties of the materials root.



The sumples of Microstructure of surface layer steel after carburizing, T-1173 K, etched in nital, magn. 50x, a) □-3 h, b)) □-12 h [10]

Mathematical formulas

The diffusional saturation process is usually the tempe-rature activate, by oscillation and move of atoms in the lattice of the metal. A quantitative description of this phenomenon is complex and likely using many simplifying assumptions. The carbon saturation process is dependent on temperature, time and a concentration of the atoms gradients. These factors have big influence on material properties such as thickness and structure of the surface layer, which is obtained by carrying out the carburizing process.

The diffusion processes are described by Fick's laws, because in this process, the stream of atoms diffusion is variable at the time, in this case is suitable using Fick's second law.

$$\frac{\partial \phi}{\partial t} = D\frac{\partial^2 \phi}{\partial x^2} \quad (1)$$

Where: Φ – concentration, x - distance from the source to the diffusing substance, t – time, D - is a proportionality coefficient (diffusion constant, this coefficient is connected with the probability of atom jumping in a crystal lattice)

$$D = D_0 e^{-\frac{E_A}{kT}}$$

Where : E_A - activation energy, k - gas constantdistance from the source to the diffusing substance, T – temperature

Considering the bulk diffusion, which requires the highest activation energy should be considered directional anisotropy present in the crystallographic structure of solid state [10,11].This implies that, in practice, diffusion is not a one-direction, mass flow should be considered in three perpendicular directions, then the equation (1) takes the form

$$\frac{\partial \phi}{dt} = \frac{\partial}{\partial x}\left(D_x \frac{\partial \phi}{\partial x}\right) + \frac{\partial}{\partial y}\left(D_y \frac{\partial \phi}{\partial y}\right) + \frac{\partial}{\partial z}\left(D_z \frac{\partial \phi}{\partial z}\right)$$

Where: D_x ,D_y ,D_z- directional diffusion coefficients

Conclusion

The analysis presented in the paper represents an introduction to further research into development of a universal mathematical model that describes diffusion of atoms of saturating elements into metallic materials. The measurable effect of the further research expected by the authors will be the development of computer software which will offer real-time support for engineering decisions and be dedicated to the people dealing with design and supervision of thermal and chemical processes.