Summary of doctoral thesis

M. Eng. Agnieszka Maria Helminiak

"Kinetics of nitriding of nanocrystalline composite of iron in the carbon matrix"

The dissertation describes the preparations of materials which represent a combination of hard nanocrystalline iron nitrides and iron carbonitrides with elastic carbon fibers.

At the first step of carburization, iron is saturated with carbon, which leads to phase transition and formation of iron carbide. With an increase of the degree of carburization the nanocrystalline composite of carbon / iron carbide and / or carbon / iron carbide / iron is formed.

By researching the process of carburization of nanocrystalline iron and reduction of nanocrystalline iron carbide with the mixtures of methane – hydrogen, the minimum partial pressure of methane were specified - at which begins the process of iron carbide forming and also the minimum partial pressure of hydrogen - at which begins the process of reduction of iron carbide in a given process temperature. These dependences create a hysteresis, which can not be explained on the basis of equilibrium system by Schenck.

The initial rate of forming iron carbide process can be expressed by dependence in which the activation energy depends on the temperature of the process. For temperatures lower than 600°C the activation energy is 440 kJ / mol, and for temperatures higher than 600 °C - 78 kJ / mol.

The kinetics of the process of creating a carbon deposit on nanocrystalline iron carbide was also studied. With an increase of the degree of carburization - the rate of carbon deposit formation decreases, reaching a minimum of $n_C / n_{Fe} = 1.5$. Then it increases reaching a maximum at $n_C / n_{Fe} \approx 3$. At high levels of the degree of carburization the rate decreases monotonically reaching a constant value.

The correlation between the content of iron carbide (determined by XRD) and the reaction rate was found. It is noteworthy that the relative iron carbide content is proportional to the iron conversion α. Via extrapolation of this dependence to full conversion, one can obtain the rate of deposit formation running over the surface of iron carbide (about $6\times10^{-4}[(n_C /n_{Fe})/s]$).

There was also investigated the nitriding of: nanocrystalline iron carbide and nanocrystalline composites: carbon / iron carbide, carbon / ferrite and carbon / iron carbide / ferrite. In the nitriding process with ammonia on the nanocrystalline iron carbide, at a temperature lower than 450 °C, the iron carbonitride is formed with the crystallographic

system corresponding to ζ-Fe_2N and chemical composition close to the compound $Fe_2C_{0,5}N_{0,5}$. At 500 °C the iron carbonitride with the structure corresponding to the ε-$Fe_{2-3}C_{1-x}N$ is formed. There were also obtained nanocrystalline composites as carbon / iron carbide / iron / iron nitride and carbon / ζ-Fe2N containing carbon deposit with embedded nitrogen.

The obtained nanocrystalline composites were used as fillers to thermoplastic multiblock polyurethane elastomers. Abrasive wear resistance and density were analyzed.

Also adhesive and cohesive properties of acrylic PSA, containing iron carbide filler (nanocrystalline composite - carbon / iron carbide) were examined by using a special strength machine according to AFERA tests.

Agnieszka Hreniak