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# «MIP: Engineering-III 2021: Modernization, Innovations, Progress: Advanced Technologies in Material Science, Mechanical and Automation Engineering»

## «Catalytic system for surface treatment of steel products»

Ostaeva G. Yu., Morenko I.V., Isaeva I. Yu., Eliseeva E.A.

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# Problem statement

The creation of strong, durable and corrosion-resistant layers on the steel products surface is an effective and economical way to increase their performance and wear resistance. With this approach, there is no need to manufacture the entire volume of a product from highly alloyed (and expensive) materials. It is enough to form only a surface layer with the required properties. Many methods are used to create these surface layers: thermochemical treatment (nitriding, cementation, etc.), quenching, electroplating methods. Most of them have a number of disadvantages: high treatment temperatures, long processing times, high cost.

Catalytic phenomena play an important role in increasing the efficiency of thermochemical treatment of steel. Accelereation of the nitriding process is possible with the use of various catalysts.

In this work, the possibility of using an experimental catalytic system for intensification of nitriding and alloying processes is investigated.

# Solution methods

Catalytic systems based on the combination of copper-containing sol and alloying elements were investigated.

The copper-containing sol was obtained by reducing copper ions (copper sulfate) by tert-butylamine-borane in solutions of poly-N-vinylpyrrolidone.

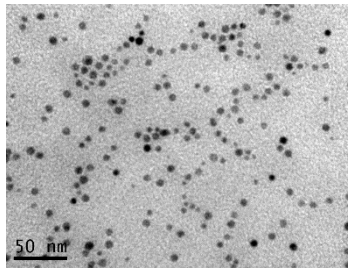
The combination of sol and the alloying element (W, Cr and Ni) was achieved by dispersing a wire containing the alloying element (chromel, tungsten wire) into the electrolyte by the method of electrodeless high-frequency discharge.

The obtained samples of sols and suspensions were studied by electron microscopy and electron spectroscopy.

Gas nitriding of steel products with applied suspension was carried out at a temperature of 580±5°C for 3 hours in an atmosphere of a mixture of carbon dioxide, water vapor and ammonia.

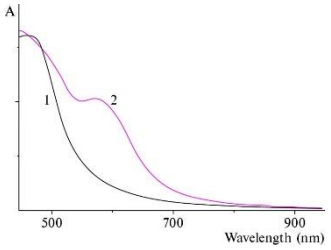
The treatment product was studied by metallographic research methods, microhardness was determined.

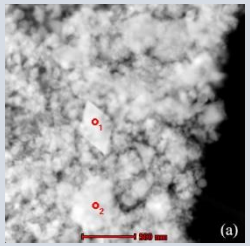
# Results

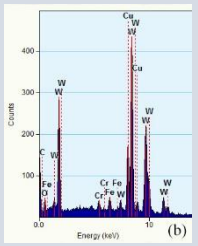


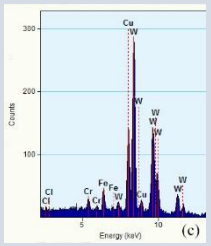

A copper-containing sol was formed by reduction by tert-butylamine-borane in the presence of poly-N-vinylpyrrolidone. The dispersed phase of a sol is actually a nanocomposite that includes nanoparticles (3-12 nm in diameter) and macromolecules.

Electron spectroscopy studies have shown that sols containing $Cu_2O$ particles (1) or Cu particles (2) are formed.

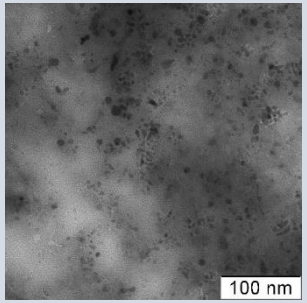



It was found that the combination of copper-containing sols with tungsten leads to the formation of a suspension containing particles of too large size. The process of rapid sedimentation of particles is observed.




The combination of sol and chromel wire dispersing products resulted in the formation of a suspension containing particles with high dispersion and stability.

The study of the microstructure of steel samples after thermochemical treatment showed that the thickness of the diffusion nitrided layer was 70 microns. The thickness was increased more than twice compared to the samples without suspension. At the same time, the hardness increased 1.5 times.

# Conclusions

The application of copper-containing particles in the composition of the catalytic coating to the surface of the treated steel product makes it possible to obtain an additional effect in the reaction of ammonia dissociation.

This process makes it possible to intensify the penetration of nitrogen and alloying elements into steel. As a result of the oxidation reaction of copper nanoparticles during subsequent heating in the nitriding process, an excess amount of energy is released, which is sufficient for the formation of local areas with an elevated temperature, which ensures a high rate of the diffusion process of metallization.

- A catalytic system for thermochemical treatment of steel products has been developed. The system included a copper-containing sol and oxides of alloying elements.
- It has been shown that poly-N-vinylpyrrolidone can be used as a polymer protector not only in the formation of nanoparticles in sols, but also when these sols are combined with alloying oxides. The polymer screen protected the particles from aggregation and oxidation.
- It was found that the use of a catalytic system leads to an increase in the microhardness and thickness of the diffusion layer.

# Contacts

Ostaeva G.Yu., Morenko I.V., Isaeva I.Yu, Eliseeva E.A.

Moscow Automobile and Road Construction State Technical University (MADI)

E-mail: galinaostaeva@mail.ru

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