ANNOTATION

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on specialty: 6D071000 - Materials science and technology of new materials
by

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DEVELOPMENT OF VIBRODAMPING ALLOYS ON THE BASIS OF IRON, ALLOYED WITH NICKEL, VANADIUM AND BORON

The proposed dissertation is devoted to the research and creation of damping metallic materials based on iron, alloyed with nickel, vanadium and boron, which can be used as items of industrial equipment, operating in the mode of collisions.

Relevance of the research. One of the major problems of industrial production is reducing the production of noise and vibration. It is connected with the use of high-speed machines and mechanisms. Among the varieties of noise there stands out mechanical noise. Its levels reach 120-130 db. Variety of mechanical noise - pulse and impact, characterized as the most harmful.

Noise of collisions is typical for industries: metalworking, metallurgy, mechanical engineering, energetic, etc. Noise of collisions is very harmful, and its method of reduction is extremely difficult. Traditional methods of noise reduction (sound insulation, sound absorption, PPE, organizational, etc.) are not effective enough due to blockage of working areas (sound insulation, sound absorption), masking of warning signals (the use of PPE for hearing), ineffectiveness, fire hazard, more dust on the workplace (absorption).

Reduction of noise at its source - the replacement of impact processes on nonimpact, replacement of gears on V-belts, the use of non-metallic materials instead of metal, etc., are effective ways to reduce the production of noise. However, according to the technological criteria these methods are often irrational.

In order to reduce the noise at the source it is more effective to use metallic materials with high dissipative properties. But nowadays, designers and engineers have insufficient information about the dissipative characteristics of used steels and alloys. Known steel 20ХНР alloyed with nickel, chromium and boron, after a certain heat treatment has not only different physical and mechanical properties, but also modified acoustic and damping characteristics. This fact in the designing of machines and mechanisms is not often taken into account.

Analysis of the literature showed that scientists from different countries (USA, Japan, Hungary, Russia , Kazakhstan, etc.) are searching for the information to create new damping metallic materials (Takahara H., N. Hideo, M. Panda, Pisarenko G., Zaborov V., Favstov J., Golovin S., Suleev D., etc.), but their studies do not contain the analysis for the establishment of the damping high strength steels, alloyed with nickel, vanadium and boron used for critical machine parts (parts of steel 20ХНР, 30ХН2МФА and 38ХН3МФА).

Damping investigation, acoustic, physical and mechanical properties of widely used steels and alloys and creation of new steels with the high damping properties is an urgent problem in modern materials science.

The aim of this work is to develop vibrodamping alloys based on iron alloyed with nickel, vanadium and boron for the producing of machine parts operating in a collision mode and the collision damping properties.

The objectives of the work include:

- Analysis of the current state of noise control in industrial plants;
- Study of acoustic, damping, physical and mechanical properties of the known steel alloys;
- Development of new steels alloyed with nickel, vanadium and boron, with improved damping characteristics, sound radiation and mechanical properties (heat treatment, application of nanostructure coatings) for replacing the well-known types of steels;
- Application of the method of mathematical experiment planning in order to find the optimal values of the chemical composition of vibrodamping alloys;
- Production testing and implementation of its new alloys with high vibrodamping properties.

The subject of the research is metal materials used for machine parts and mechanisms that operate in the mode of collisions.

The object of the study is industries (metalworking, metallurgy, energetic, etc.) which use iron-based metal materials for the parts operating in the mode of collisions.

The method of investigation. The dissertation is based on the research methodology including analytical review of the literature, patent search, summarizing the results of the experience of scientists from Kazakhstan, Russia, United States and others in creating damping alloys in engineering of noise control, physical modeling, experimental investigation, application of mathematical experiment planning (MEP) methods.

Basic scientific principles and results for the defense:

- there was developed the steel 3M, alloyed with nickel (3.5%), vanadium (0.25 %) and boron (0.005 %) with the carbon content (0.4 %) having the higher damping characteristics (δ=0,0146; ψ = 0,0291; Q^{-1}= 0,0458), the reduced sound radiation during the collision (L_A=54 db) and a sufficient physic mechanical properties ($\sigma_B \geq 990 mP$; $\sigma_T \geq 825 mP$; $\delta_5 \geq 13\%$; $\psi \geq 45\%$; $KCU \geq 55$ j/sm^2, $HB \geq 270 mP$; J/ sm^2), thermal treatment of the steel 3M (hardened at 890°C with cooling in a oil and high-temperature tempering at 650°C) creates a structure that provides optimal strength properties and increased dissipation (internal friction increase with $4{,}58\times10^{-2}$ to $8{,}64\times10^{-2}$);
- layering a nanostructured coating (Ti-Al-N) by the vacuum-arc of 30 nm on the surface of steel 3M (total coating thickness - $3{,}32\times10^{-6}$ м) to provide a further noise reduction of the mechanical origin by 2-3 db during the sufficient strength of the coating;
- application of the method of mathematical planning of experiments (Box-Wilson method) allowed to reduce the amount of experimental work and to build a logical diagram of the experiment of damping alloys smelting, as well as to get the regression equation, using the coefficients estimating seven variables (carbon content, nickel, boron, vanadium, cerium, the value of the nanostructured coating,

heat treatment type) affecting the level of the sound at impact: $y=62,30X_0-2,02X_1-0,841X_2+0,755X_3+0,451X_4+0,321X_5+0,888X_6+1,112X_7$. In this case, the maximum effect on the sound level has a carbon content (-2,02), the type of heat treatment (1,112), nanostructured coating (0,888), the nickel content (-0,841);

- conducting the research and industrial inspection for enterprises "KVOiT" and "KazTorgPromCompany" LLP of the steel 3M (0,4% C, 3,5% Ni, 0,25% V, 0,005% B, the rest of iron). There were made good plate for straightening in fitter welding plant and the sleeve in a guide tube of the lathe. Noise reduction was 4-12 db compared with the steel 40. Expected annual savings amounted to 2237000 tenge.

On the topic of the dissertation there were published 17 articles, 6 articles were published in journals recommended by the Committee on the Control of Education and Science of Republic of Kazakhstan, in four editions of various names, one article was published in the edition included in the Scopus database, 10 articles published in international scientific collections of technical and scientific conferences (Kazakhstan, Russia, Ukraine and the United States).