# **RESOURCE SAVING OF DETAILS OF MOBILE ROLLING STOCK BY PROTECTIVE METALLIC COATING**

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**Summary**. In the article it is shown that mechanic-chemical treatment as resource-saving technology is an efficient method of the protection of responsible parts of rolling stock with high operational characteristics. An influence of amplitude and frequency of low frequency vibrations on speed of forming the metallic coating is ascertained at mechanic-chemical method of its application. An increase of microhardness in 1.1 time as well as the strength of the produced coating in 1.5 time is experimentally determined in comparison with the zinc galvanic coating.

Key words: mechanic-chemical method, forming the coating, low frequency vibrations, protective metallic coating, thickness of coating.

# **INTRODUCTION**

At creation of new mobile rolling stock there are new operating requirements, providing for reliability and longevity of its work. Copper plating, nickel plating, galvanizing are applied in practice of repair of mobile rolling stock for protection of details. These processes are energy-consuming, require very expensive materials, labour-consuming and complex in their realization. As a result, the cost price of these processes is very high.

There are known methods of application of protective coatings which improve physical and chemical properties of metals and alloys [Pat. 3328197, 1965; A.C. 1092204, 1985; Ankudimov 1983, Babichev 1994]. Among them the most perspective is a method of the mechanic-chemical application of coatings. The method is characterized by simplicity of technological realization, and also by possibility of the directed change of structure of superficial layers. Forming of coating is possible both at application of one metal [Starchevskiy, Kukonesku, Goldman 1978] and different metals [Babichev 1984].

The first works on the study of the combined processes of mechanic-chemical treatment of products and application of coatings were executed in 60th in the USA, and the works in 80th in Russia had shown the perspective of this direction. However, narrow range of frequencies to 2.5 Hz and amplitudes to 2.5 mm and absence of data on

influence of the different modes of treatment, composition and choice of working medium depending on used materials, require more deep investigations of the combined mechanic-chemical action on the processed parts of rolling stock.

# **RESEARCH OBJECT**

The research object is process of mechanic-chemical production of protective coating at action of low frequency vibrations with the purpose of the directed change of structure of superficial layers of the processed material and applied metallic powder.

Mechanic-chemical preparation of surface of detail in the conditions of oscillation treatment was carried out at the expense of the components of working medium (glass balls by a diameter 10 and 5 mm, solution of ZnCl<sub>2</sub>, zinc powder).

The experimental investigations were conducted on the vibration machine-tool of UVI-25 with the volume of chamber of 25 l.

Mechanic-chemical treatment was carried out on the specimens from steels of grade 20 and 45, with mass of 72 g, which together with metallic powder (70 g) and activators were placed in a plastic container from a polyethylene. The diameter of container -53 cm, a height is 27 cm, thickness of walls -1 mm. Glass balls by diameter of 5-10 mm served as workings bodies. 200 ml of ethylene glycol are filled in the container, and the treatment was carried out at applying of vibrations with frequency of 42- 67 Hz and by amplitude of 1.2-3.5 mm. Time of treatment of the specimens at the chosen mode made 30 minutes.

The microhardness of zinc mechanic-chemical coating was determined on the device PNT-3. The thickness of zinc coating was measured by the metallographic method. The strength of adhesion of zinc coating with a base was determined by the method of application of scratches net.

# **RESULTS OF EXPERIMENTAL RESEARCHES**

Steel of grade 20 and 45 for the experimental specimens are selected from the condition that a great amount of responsible parts of locomotives, diesel-locomotives and other kinds of rolling stock are manufactured from these structural steels.



Fig. 1. Picture of microstructure of particles size of metal powder: 1a - zinc powder, 1b - nickel powder, 1c - copper powder

Fraction composition of metal powder is given on microstructures in fig. 1. From the figure 1 we can see that in the composition of zinc powder (1a) the particle size makes 20-40  $\mu$ m, but in the composition of nickel powder (1b) particle size – 8-15  $\mu$ m, and in copper powder (1c) size is 15-20  $\mu$ m.

Fraction mass composition of applied metal powders depending on their grain size is shown in fig. 2.



Fig. 2. Fraction mass composition of metal powders depending on their fraction size

The results of determination of speed forming of zinc coating at different modes of vibration treatment are given in fig. 3.



Fig. 3. Changing of speed of hammering in of zinc powder by the glass balls of 5mm diameter into the surface of steel 45 depending on the treatment duration at different modes: 1 – amplitude of vibrations of reservoir – 3,5 mm, frequency – 63 Hz in 1% working solution of ZnCl<sub>2</sub> + Zn (powder); 2 – amplitude of vibrations of reservoir – 1mm, frequency – 42 Hz in 1% working solution of OH-CH<sub>2</sub>-CH<sub>2</sub>-OH + Zn (powder)

Changing of zinc grain shape takes place with the growth of deformation. The grains are stretching perpendicularly to load at their compression. The photos of the surface of zinc powder are given in fig.4. Here we can see changing of character of distributing zinc powder between the imprints of glass balls (with  $R_a = 0.2 - 0.16 \mu m$  (x140)) depending on duration of vibration treatment of the surface of steel grade 45.



Fig. 4. Changing of character of distributing of zinc powder depending on duration of vibration treatment of the surface of 45 steel at the following modes: amplitude of vibration of reservoir -3,5 mm; frequency -63 Hz, 1% solution of ZnCl<sub>2</sub>+Zn (powder); R<sub>a</sub> -0,2-0,16 µm between imprints of glass balls (x140); a -20 min; b -30 min; c -40 min; d -60 min

In figures 5 there are given the results of changing of thickness of zinc coating at different modes of processing and at different time of treatment.



Fig. 5. Dependence of the thickness of zinc coating on duration of vibration processing of 45 steel surface: 1 – amplitude of vibration of reservoir – 3,5 mm; frequency – 63 Hz in 1% solution of ZnCI<sub>2</sub>+Zn (powder); 2 – amplitude of vibration of reservoir – 1mm; frequency – 42 Hz in 1% solution of OH-CH<sub>2</sub>-CH<sub>2</sub>-OH+Zn (powder)

Fig. 6 shows the results of changing of the thickness of zinc coating on the surface of steel of different state (hardened and annealed state).



Fig. 6. Changing of the thickness of zinc coating depending on the time of vibration treatment (amplitude of vibration of reservoir - 1mm; frequency 42 Hz; in 1% solution of 1% OH-CH<sub>2</sub>-CH<sub>2</sub>-OH+Zn (powder); 45 steel grade: 1 – hardened (quenched) steel; 2 – annealed steel at 750<sup>o</sup>C

Zinc coating, produced at shock interaction of workings bodies with force of 15-30 N differs from zinc galvanic coating by increased adhesion strength in 1.5 time and by a greater microhardness in 1.1 time. Some new physical effects in the superficial layers of coating and basic metal are one of reasons of increase of strength of coating. These effects are related to the change an orientation and shape of grains from action of deformation. Grains are subject to compressive stresses, accepts an oval shape. An increase of diameter of imprint in 1.2 time takes place at expense of multiple action of workings bodies, and its depth is increased in 1.6 time, that provides forming of coating with high strength.

At forming of vibration mechanic-chemical coating due to deformation there is a removal of fragile columnar structure of grains, characteristic for zinc galvanic coating. The coatings are applied by several layers at expense of multiple shock action of shock working bodies. The layers recover each other, forming zinc coating without pores.

### CONCLUSIONS

1. The proposed mechanic-chemical treatment provides reliable protection of responsible details of units of rolling stock with higher operational properties.

2. Increase of amplitude of vibrations of reservoir from 1 to 3.5 mm and frequency of vibrations from 42 to 63 Hz, and also the use of activator of process  $ZnCl_2$  results in an increase of speed of hammering in of zinc powder into the surface of steel.

3. The offered method of producing zinc coating at shock action of workings bodies with force 15-30 N provides the increase of microhardness and strength of vibrating mechanic-chemical zinc coating relatively in 1.1 and in 1.5 time as compared to galvanic one.

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### РЕСУРСОСБЕРЕЖЕНИЕ ДЕТАЛЕЙ ПОДВИЖНОГО СОСТАВА ЗАЩИТНЫМ МЕТАЛЛИЧЕСКИМ ПОКРЫТИЕМ

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Аннотация. В статье показано, что механохимическая обработка как ресурсосберегающая технология является эффективным способом защиты ответственных деталей подвижного состава с высокими эксплуатационными характеристиками. Установлено влияние амплитуды и частоты низкочастотных колебаний на скорость формирования металлического покрытия при механохимическом способе его нанесения. Экспериментально определено увеличение в 1,1 раза микротвердости и в 1,5 раза прочности полученного покрытия по сравнению с цинковым гальваническим покрытием.

Ключевые слова: механохимический способ формирования покрытия при низкочастотных колебаниях, защитное металлическое покрытие, толщина покрытия.