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USE OF 38X2MYA STEEL AFTER COMBINED PROCESSING WITH SIMULATION OF WEAR PROCESSES OF AUTOMOTIVE PARTS

ВИКОРИСТАННЯ СТАЛІ 38Х2МЮА ПІСЛЯ КОМБІНОВАНОЇ ОБРОБКИ З МОДЕЛЮВАННЯМ ПРОЦЕСІВ ЗНОСУ ДЕТАЛЕЙ АВТОМОБІЛІВ

The average age of trucks in Ukraine is almost 20 years. About 63 % of trucks are over 10 years old. For heavy trucks (with a gross vehicle weight of over 3.5 tons), the average age is 23.3 years. Tractor units on the domestic market have an average age of 16.5 years, while imported tractor units are about 10 years old. The average age of buses on the market: 16.4 years. Used imported buses: an average of 11.2 years. In some cases, buses with an average age of 30—50 years are operated. The aging of the truck and bus fleet in Ukraine is accompanied by limited renewal of transport and.

This may affect the safety, environmental friendliness and efficiency of transportation. To improve the situation, measures are needed to stimulate the renewal of the fleet, including support for the purchase of new and more environmentally friendly vehicles, the development of restoration technologies and the improvement of the repair base of motor transport enterprises. When choosing technological methods for repair and restoration, special attention is paid to materials and coatings used in the production of car parts. The indisputable conditions for restoration are the physical, mechanical and strength characteristics of the final result. The priority direction is the use of available materials and coatings that provide high quality, reliability, resource saving and operational characteristics.

Keywords*: restoration technologies, physical and mechanical characteristics, surface layer, strengthening technologies, wear, friction surface.*

Середній вік вантажних автомобілів в Україні складає майже 20 років. Близько 63 % вантажівок віком від 10 років. Для важких вантажівок (з повною масою понад 3,5 тонни) середній вік становить 23,3 роки. Сідельні тягачі на внутрішньому ринку мають середній вік 16,5 року, тоді як імпортовані тягачі — близько 10 років. Середній вік автобусів на ринку: 16,4 року. Вживані автобуси, що імпортуються: в середньому 11,2 року. В окремих випадках експлуатуються автобуси із середнім віком 30—50 років.

Старіння автопарку вантажних автомобілів та автобусів в Україні з умовлене обмеженим оновленням транспорту та. Це може впливати на безпеку, екологічність та ефективність перевезень. Для покращення ситуації необхідні заходи щодо стимулювання оновлення автопарку, включаючи підтримку придбання нових та більш екологічних транспортних засобів, розвиток відновлювальних технологій і вдосконалення ремонтної бази автотранспортних підприємств. При виборі технологічних методів ремонту та відновлення особливу увагу приділяють матеріалам та покриттям, які застосовують у виробництві деталей автомобілів. Безперечними умовами відновлення є фізико-механічні та міцні характеристики кінцевого результату.

Пріоритетним напрямом є використання доступних матеріалів та покриттів, що забезпечують високі показники якості, надійності, ресурсозбереження та експлуатаційні характеристики. Використання сталі 38Х2МЮА після комбінованої обробки, а саме азотування з наступною лазерною обробкою, дозволило суттєво зміцнити поверхневий шар та змоделювати процеси тертя з використанням мастильного матеріалу. Дослідження мікроструктури поверхневого шару деталей із сталі 38Х2МЮА, з урахуванням багатьох суттєвих чинників (наявність утворених фаз, розподіл та концентрація нітридів, карбонитрідів), дозволяє прогнозувати та змоделювати процеси зносу контактуючих пар деталей автомобілів.

Ключові слова*: технології відновлення, фізико-механічні характеристики, поверхневий шар, технології зміцнення, знос, поверхня тертя.*

Problem's Formulation

When choosing technological processes for strengthening the surface layer of a part, there is a choice of materials and coatings of tribo-bonded pairs, which determine the nature of the formation of wear-resistant structures. To solve the identified problems, an integrated approach is used, taking into account the influence of all constituent components. These factors take into account the entire set of technological components and the predicted results of structure formation when choosing the necessary materials and coatings.

Analysis of recent research and publications

Recently, the automotive industry has accumulated a rich spectrum of developments in the use of modern technologies for strengthening parts, selecting materials and coatings, developing modes and improving technological processes. The use of combined technologies for strengthening the surface layer of parts is a priority direction [1—3]. In the automotive industry, replacing the material of the components of automobiles with more durable and promising options is a common practice. Replacing the material of the part with more attractive analogues, which are common in terms of strength and physical and mechanical characteristics, provokes the use of the appropriate technology for strengthening the surface layer.

38Х2МЮА — high-quality nitrided steel, heat-resistant, relaxation-resistant. This is a reliable and load-resistant material that contains up to 2 % chromium, and the content of molybdenum and aluminum in it is no more than 1 %. Such steel is resistant to wear and fatigue, it is easy to cut (the surface is flawless), and it is practically not deformed during hardening.

The heat resistance of this steel is up to 450 degrees. This grade of steel has a wide range of applications, as it has good physical and chemical properties.

Nozzle needles, sprayers, plungers, production gears, bushings and shafts are made from 38Х2МЮА steel, measuring instruments. The steel is widely in demand in the rocket and aviation industries and has proven itself well as a material for pipeline parts and nitrided aircraft parts. Parts made of this type of structural steel have a long service life and are suitable for almost any production needs.

Formation of the study purpose

The structure of the original, restored and strengthened surface was studied by metallographic method using an optical microscope "Neophot-32" at different magnifications and scanning electron microscopy (Cambridge Stereoscan SU, Superprobe 733) and (REM 106I) (fig. 1).

Fig. 1. Scanning electron microscope (REM 106I)

A bar made of 38X2MЮA steel with a diameter of 22 mm after hardening of the surface layer using combined technology (nitriding with subsequent laser treatment) has a multilayer complex microstructure fig. 2 (×250), 3 (×1000). The surface has a dense layer up to 80 μm deep (zone 1) with accumulations of nitrides of the type Fe_2N and Fe_3N. Further, at a depth of (2) up to 400 μm, a layer of zones with tempered martensite, bainite, excess ferrite γ -Fe and residual austenite a-Fe is observed. Under the layer is located zone (3) with a ferrite-cementite microstructure Fe_3C (fig. 2, fig. 3).

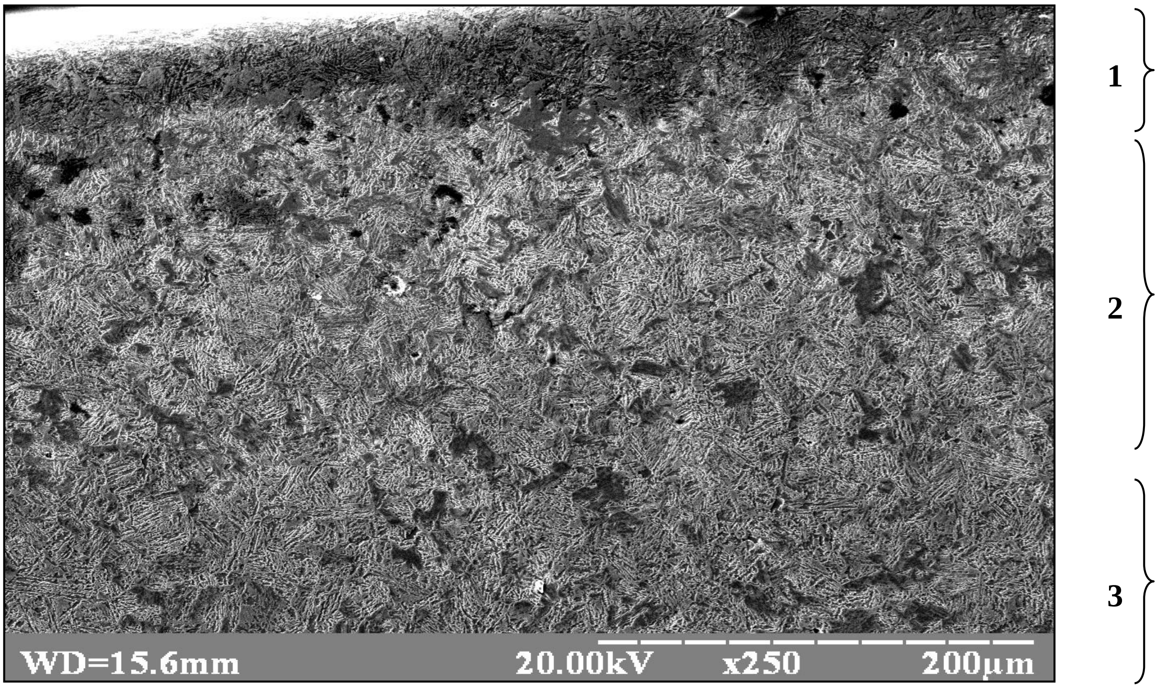

Fig. 2. A multilayer complex microstructure of 38X2MЮA steel (×250)

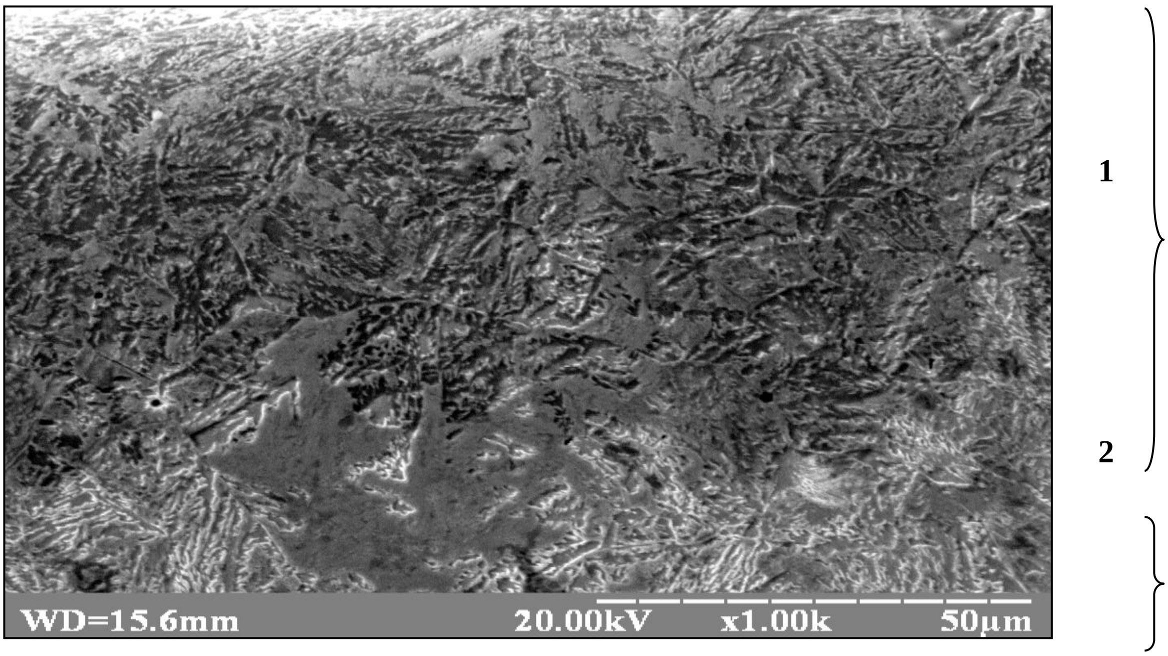

Fig. 3. A multilayer complex microstructure of 38X2MЮA steel (×1000)

X-ray phase analysis was performed (Fig. 4.) on a DRON-3 X-ray diffractometer in monochromatized Co-K λ radiation (α=1.7902A). Identification of compounds (phases) was performed by comparing interplanar distances (d, A) and relative intensities (I_{otn} — I/I_o) of the experimental curve with data from the PCPDFWIN electronic file. The shooting was carried out at angles of 10—90 degrees. Phase analysis step 0.1 degrees. Duration 5 s. Structural analysis step — 0.01 degrees. Duration — 5 s. Anode voltage — 30 kV Voltage current — 20 mA.

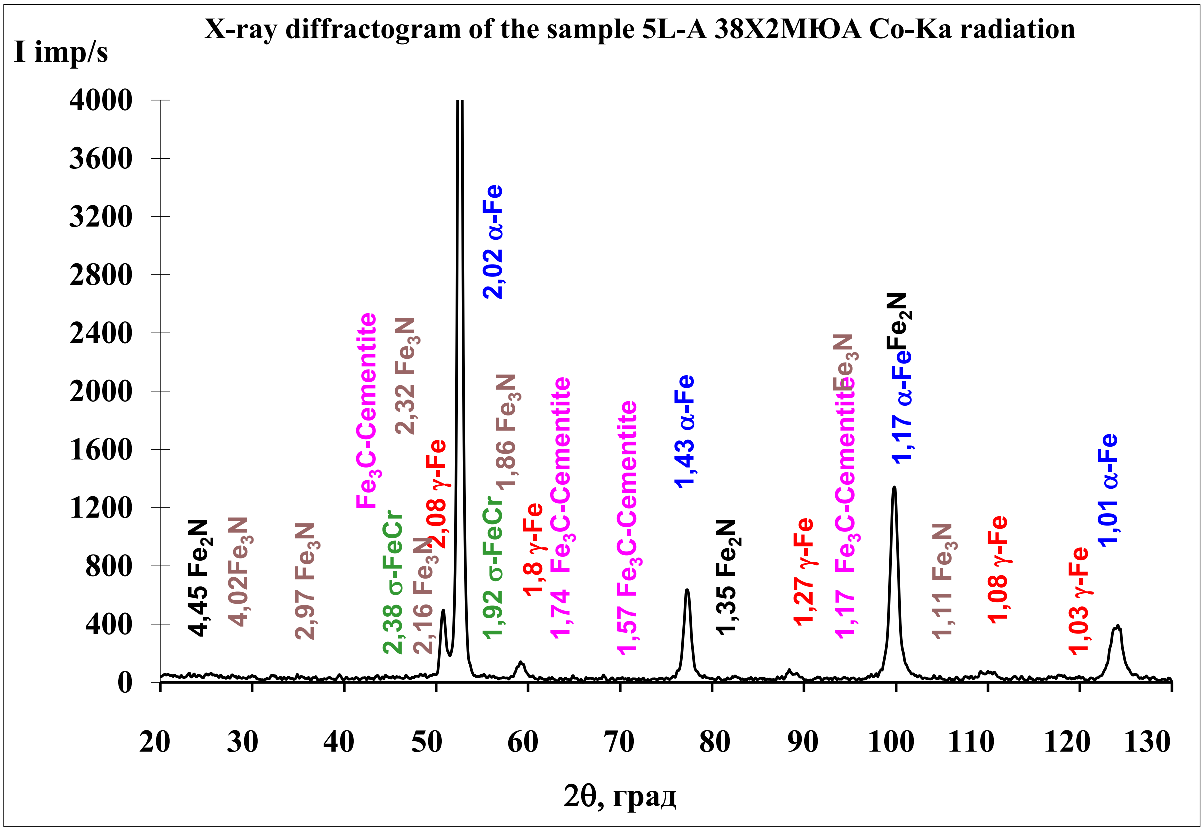

Fig. 4. X-ray diffractogram of the sample 5L-A 38X2МЮА Co-K *a* radiation

The analysis results consist of two files:

Quantitative analysis is not accurate, the error is approximately ±2 atomic percent;

– 1 file — table of interplanar distances (bazh1hkl, bazh2hkl, bazh3hkl, bazh4hkl);

– 2 file — diffractogram with designation of substances to which a particular peak belongs (identification);

– Explanation to tables of interplanar distances (files of type scor1hkl;

– 2Q — scanning angle, position of maximum in degrees;

– I_{abs} — absolute value of intensity at 2Q (imp/sec);

– I_{otn} — relative value of intensity at 2Q (Maximum 100 %);

– d,A — interplanar distance in A;

– In samples 1L-A, 2L-A, 3L-A, phases are observed in amounts less than 1 %.

Main phases:1.FeC, 2. Fe_3C — Cementite, 3. Fe_2N 4, Fe_3N γ-Fe (Ferrite) and α -F (austenite).

When friction in the boundary lubrication mode, the liquid film of the lubricant does not separate the friction surfaces, and the ability of the lubricating layer to reduce friction and wear is determined by its ability to form a strong boundary layer on the working surfaces. Friction during boundary lubrication is determined by the ability of the surface adhesion of the contacting pairs behind the peaks of individual micro-asperities, where the boundary layer of lubrication is destroyed. According to the Bowden friction model, the friction force is determined by the formula

$$F=[\tau_г\beta+\tau_м(1-\beta)]A_r, \quad (1)$$

where $\tau_г$ and $\tau_м$ are the shear strength of the boundary and soft layers, respectively; β is the fraction of the surface contact A_r that has a boundary layer.

Under conditions of boundary lubrication, the value of β is calculated according to the Langmuir equation:

$$\beta = bC /1 + bC, \quad (2)$$

where C is the concentration of the active element; b is the fraction of the distribution of the equilibrium constant of the process.

$$b=b'exp(-\Delta H^\circ / RT), \quad (3)$$

where b' — is the pre-exponential factor; ΔH° — is the total enthalpy of adsorption; R — is the universal gas constant; T — is the absolute temperature.

Conclusions

Studies of the microstructure of the surface layer of high-alloy steel 38Х2МЮА, obtained using the technology of combined processing on the base and subsequent laser processing on a GOOS1001 laser device with an accumulation energy of 15 kJ, a distance to the target of 290 mm, a laser spot diameter of 11 mm and an interval between shots of 3 minutes, are presented. Calculations of the formation of a lubricating film on friction surfaces and its effect on wear are presented.

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