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EFFECT OF LASER TREATMENT ON THE STRUCTURE AND PROPERTIES OF PISTON RINGS [18]

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Abstract. *The study is devoted to the urgent problem of increasing the durability of armored vehicle engines by applying advanced laser processing technology. The object of study is piston rings that are subjected to laser processing in order to form special structures on the surface that provide increased wear resistance. The obtained results made it possible to establish the regularities of formation of the structure and properties of the surface layers of piston rings depending on the parameters of laser processing. The optimal modes of laser processing were determined, which ensure the maximum increase in wear resistance and durability of piston rings.The results of the study can be used to develop new technologies to improve the reliability and durability of armored vehicle engines.*
Key words: *laser processing, piston rings, wear resistance, durability.*

ВПЛИВ ЛАЗЕРНОІ ОБРОБКИ НА СТРУКТУРУ ТА ВЛАСТИВОСТІ ПОРШНЕВИХ КІЛЕЦЬ

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Анотація. *Дослідження присвячено актуальній проблемі підвищення довговічності двигунів броньованої техніки шляхом застосування перспективної технології лазерної обробки. Об'єктом дослідження є поршневі кільця, які піддаються лазерному обробленню з метою формування на поверхні спеціальних структур, що забезпечують підвищену зносостійкість. Отримані результати дозволили встановити закономірності формування структури та властивостей поверхневих шарів поршневих кілець в залежності від параметрів лазерної обробки. Було визначено оптимальні режими лазерної обробки, що забезпечують максимальне підвищення зносостійкості та довговічності поршневих кілець. Результати дослідження можуть бути використані для розробки нових технологій підвищення надійності та довговічності двигунів броньованої техніки.*
Ключові слова: *лазерна обробка, поршневі кільця, зносостійкість, довговічність.*

Introduction

The object of research is laser treatment of piston ring surfaces by melting and hardening, which forms special structures and properties to increase the durability of armored vehicle engines.

The aim of the work is to solve the scientific and technical problem of increasing the durability of piston rings of central compressor stations by forming special structural properties of the surface layer using laser treatment by melting and hardening.

The research methods include optical microscopy, electron microscopy, X-ray diffraction analysis, microhardness measurements, laboratory and in-service tests for piston ring wear resistance.

[18] Робота виконана під керівництвом асистента Байдали В. Ю.

Research results and discussion

In order to study the effect of laser treatment on the hardening of the treated surface of the liner, experiments were conducted in which the cast iron used was hardened in different modes to study the properties of the hardened layer. At an irradiation speed of 5.4 mm/s, the surface of the cast iron melted over the entire area of contact with the beam, and at irradiation speeds of 6.5 and 7.6 mm/s, it partially melted. At an irradiation rate of 11 mm/s, only the surface layer was hardened. The depth of the layer decreased with increasing irradiation rate according to a parabolic law (Fig. 1).

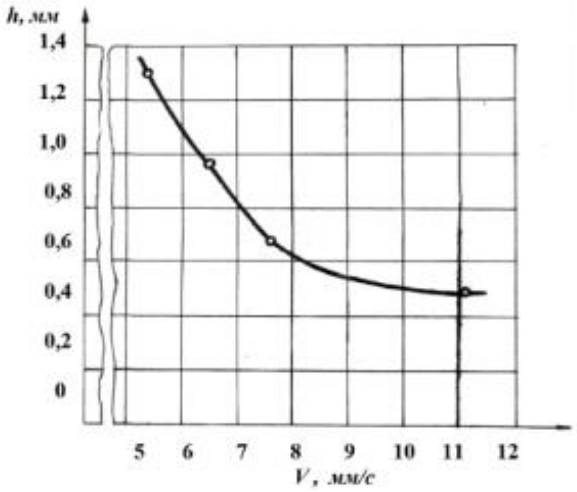

Figure 1 – Effect of laser irradiation speed on depth

At an irradiation speed of 11 mm/s, it is 0.5 mm, and at 5.4 mm/s – 1.3 mm.

The microstructure of the melt zone is heterogeneous over the irradiated area and usually consists of three structural elements: as the irradiation power decreases, the proportion of white cast iron microstructure with a pre-eutectic structure increases and the proportion of areas with a high-carbon steel structure with different carbon content decreases. The X-ray diffraction of the melt shows different amounts of austenite, martensite and cementite. The amount of austenite and cementite increases with decreasing irradiation rate. Laser treatment does not significantly change the purity or surface topography of the piston rings (Fig. 2).

The analysis of experimental data shows that laser treatment, which includes both surface melting and hardening, provides high wear resistance of the ring, which significantly exceeds the wear resistance of ordinary chrome-plated rings. Thus, the structure of cast iron obtained after laser irradiation is highly resistant to tempering, provides high hardness in the operating temperature range up to 350°C and retains structural heterogeneity. At the same time, the surface coating does not affect the properties of the irradiated layer near the surface during wear [2, 3].

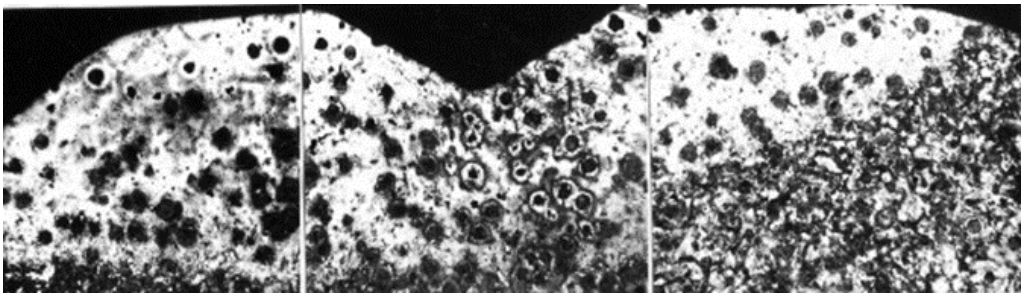

Figure 2 – Profile of the piston ring after irradiation

When laser machining piston rings, preference is given to irradiation with surface hardening, since it practically does not change the cleanliness of the irradiated surface. Based on this, among the studied irradiation modes, we recommended processing in the speed range of 7.6–11 mm/s at a power of 0.6 kW [1, 3].

Conclusions

1. The structure and properties of piston rings for armored vehicles after laser treatment were studied using optical microscopy, electron microscopy, X-ray diffraction analysis, microhardness measurements, laboratory and operational wear tests to investigate the strengthening potential of this processing method.

2. It has been established that the process of electroplating chromium is inefficient, the chromium yield is low, and the production waste is environmentally harmful. Laser processing methods are characterized by high productivity and efficiency. The results obtained indicate the prospects of using laser treatment to protect piston rings from wear and corrosion.

3. The analysis of experimental data shows that laser treatment with surface melting and hardening provides high wear resistance of the rings, which significantly exceeds the wear resistance of solid chrome rings.

4. An important result obtained was a significant reduction in the wear of the body-liner pair. It was found that the higher wear of the ring due to surface melting compared to quenching is due to the formation of austenitic areas on the friction surfaces, while the increased wear of the liner is due to the formation of harder areas of white hardened cast iron. An important role is played by a decrease in the proportion of graphite that appears on the surface, i.e., the lubricating effect.

5. The influence of the laser treatment mode on the depth, structure, phase composition, and properties of the irradiated layer of piston rings was investigated. The range of irradiation speeds at which fully, partially heated, and surface hardened layers are formed is determined. The irradiation modes under which layers with different proportions of austenitic, martensitic, and carbide components with properties that provide high wear resistance are formed are determined.

6. It was found that laser-treated cast iron is characterized by a high resistance to tempering when heated to 400°C due to the influence of silicon and other alloying elements.

7. The best wear resistance, which exceeds the wear resistance of solid chrome rings, was shown by rings irradiated in the following mode: W = 0.6 kW, $V_{irradiation}$ = 10–11 mm/s.

8. The results of the work have been implemented at the State Enterprise «Malyshev Plant».

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