Analysis of the Methods of Covering the Working Surfaces of the Parts with Vacuum Ion-Plasmas and the Change of Surface Layers

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ABSTRACT

This article discusses proposals and recommendations for increasing the duration of nitriding to obtain a layer thickness by studying the composition and structure of steel and contrast materials using vacuum-ion-plasma coating methods when restoring details of working surfaces.

Keywords: Detail, atom, molecules, cluster, vacuum ion-plasma, coatings, layer, ion-diffusion method.

To form a high-quality coating at lower temperatures of the parts, it is necessary to increase the energy of the particles condensing on them. When particles with sufficiently high energy collide with a solid surface in micro-volumes, conditions are created under which the formation of chemical bonds is ensured without volumetric heating of parts (which is the basis of all vacuum ion-plasma coating methods). Neutral and excited particles (atoms, molecules and clusters) with high energy (exceeding tens and hundreds of times the energy of thermal atoms and molecules) and ions, whose energy can be varied widely by changing the accelerating voltage, participate in the formation of the coating with these methods.

Vacuum ion-plasma coating processes are characterized by the following main stages: generation of atomic or molecular flow of a substance, its ionization, acceleration and focusing, and, finally, condensation on the surface of parts or substrate. To generate a flow of matter, heating by a flow of electrons and various forms of gas discharges are used (smoldering, arc with non-consumable thermionic cathode, arc with thermionic auto-emissive consumable, cathode).

In relation to the needs of mechanical engineering, vacuum ion-plasma coating methods and the creation of modified surface layers can be divided into four groups:

a) ion-diffusion methods carried out in a glow discharge;

b) methods based on the phenomenon of cathode sputtering in a DC discharge and in a high-frequency discharge;

c) ion deposition;

d) ion doping and implantation (implantation).

An example of the methods of the first group is ion nitriding, which can be carried out at lower temperatures and at a much higher rate (Table.1), than traditional (as a result of radiation stimulation, the rate of nitrogen diffusion increases many times). Ion diffusion methods can also be applied for saturation on top.

Table 1

Influence of ion nitriding modes on the thickness and hardness of the wear-resistant layer.

Steel	Temperature,°C	Duration of nitriding (in h) to obtain a layer thickness, mm					HV, MPa
		0,15-0,2	0,2–0,25	0,25-0,3	0,3–0,35	0,35–0,4	
40X	520	4-5	7-9	9-12	12-15	T 5-18	5000-5500
40XFA	520	4-5	6-8	8-10	12-15	15-18	5100-5600
18HGT	550	3-4	4-5	6-8	9-12	15-18	5300-6000
30X3MF	530	4-5	6-8	9-12	15-18	-	7000-7600
38X2MYA	550	4-5	5-7	7-9	9-12	15-18	9000-9500

When using methods based on the phenomenon of cathode sputtering, the coating is formed as a result of condensation of mainly neutral particles knocked out of the target by bombardment with inert gas ions (argon, krypton) having high energy. The energy of the particles of the applied material is at least an order of magnitude higher than the energy of the particles formed during evaporation in thermal vacuum methods. The methods make it possible to apply the most refractory and insufficiently stable compounds while preserving their stoichiometric composition, the application of which by vacuum methods is impossible. Systems with autonomous ion sources are used. Direct current spraying systems are used for coating of electrically conductive materials, high–frequency spraying systems are made of dielectrics.

The advantages of methods based on the phenomenon of cathode sputtering are most fully realized in magnetron sputtering systems in which the discharge is carried out in crossed electric and magnetic fields. Due to this, the performance of magnetron sputtering systems is of the same order with the performance of installations operating according to the CIB method (with an electric arc evaporator). Their advantages include the absence of a drip phase, which allows the coating to be applied almost without distortion of the original surface quality.

When using ion deposition methods, the particles of the deposited material, converted in one way or another into a gaseous or vaporous state, are ionized and accelerated in an electric field. The adhesion and service characteristics of coatings increase with an increase in the particle energy set by the accelerating voltage. In our country, the methods of CIB (condensation during ion bombardment), REP (inactive electron plasma spraying), etc. are used. Table 2 provides information on the wear resistance of coatings applied by the CIB method.

Table 2

Trib technical characteristics of TiN coatings applied to P6M5 steel by the CIB method, when friction with M14B2 grease on different materials (linear contact)

Counter body material	H_{200} of the counter body material, GPa	Specific volume wear, mm^3/mm		Coefficient of friction
		counter body ($\times10^9$)	покрытия ($\times10^{11}$)	
Copper M1	0,9	16000,600	58/5,4	0,11/0,09
Technical hardware E	1,6	9 000/140	110/80	0,12/0,08
Grey cast iron	3,2	70/2,1	40/3,5	0,13/0,03
Steel 45	5,6	2 100/1,4	17/2,7	0,11/0,08
Steel 20X2H4A (cement bathroom)	9,4	140/2,8	6,7/1,3	0,14/0,03
38HMUA steel (nitrided)	11,1	340/4,9	11/2,0	0,12/0,09

Note. In the numerator – the values for the coating in the initial state, in the denominator – after polishing.

Ion alloying, or implantation, is based on the phenomenon that at high energies ions penetrate into the crystal lattice to a great depth (thus alloying the surface layer of the part). This is facilitated by radiation-stimulated diffusion, thanks to which a layer is doped, the thickness of which is many times greater than the depth of the initial penetration of ions. The mechanical properties and wear resistance of the surface layers modified in this way also increase as a result of distortions of the crystal lattice that occur when ions of the alloying component are "driven" into it.

Ionic coating methods are carried out with the participation of both physical (the composition of the applied material does not change) and chemical processes (new compounds are formed). With such methods, called reactive, plasma chemical reactions occur with ions of the working gas or additives specially introduced into the chamber. In this way, it is possible to obtain coatings from a wide variety of materials and in the most incredible combinations. The production of pure metals, carbides, nitrides, silicides, chalcogenides, oxides, etc. has been mastered. It is possible to obtain coatings of complex composition (for example, oxy carbides), multilayer or variable in thickness composition.

Methods of applying diamond films with very high hardness have been developed. The formation of coatings using reactive (plasma chemical) processes occurs under nonequilibrium conditions. Due to this, chemical compounds can be formed in thin layers that differ greatly in composition, structure and properties from those observed for bulk materials (obtained under conditions close to equilibrium).

A number of developed methods of ion coating are already being used in industry. Ion nitriding is successfully used. The durability of non-sharpened tools made of high-speed steels and hard alloys, as well as die tools and tooling increases several times with ion reactive application of thin layers (up to 10 microns) of some refractory substances (carbides, nitrides, oxides, oxy carbides). MoS2 coatings without binder applied by cathode sputtering have high antifriction properties.

References.

1. Рубидинов, Ш. Ғ. Ў. (2021). Бикрлиги паст валларга совуқ ишлов бериш усули. *Scientific progress*, *1*(6), 413-417.
2. Тешабоев, А. Э., Рубидинов, Ш. Ғ. Ў., Назаров, А. Ғ. Ў., & Ғайратов, Ж. Ғ. Ў. (2021). Машинасозликда юза тозалигини назоратини автоматлаш. *Scientific progress*, *1*(5).
3. Nomanjonov, S., Rustamov, M., Rubidinov, S., & Akramov, M. (2019).

STAMP DESIGN. *Экономика и социум*, (12), 101-104.
4. Qosimova, Z. M., & RubidinovSh, G. (2021). Influence of The Design of The Rolling Roller on The Quality of The Surface Layer During Plastic Deformation on the Workpiece. *International Journal of Human Computing Studies*, *3*(2), 257-263.
5. Рубидинов, Ш. Ғ. Ў., & Ғайратов, Ж. Ғ. Ў. (2021). Штампларни таъмирлашда замонавий технология хромлаш усулидан фойдаланиш. *Scientific progress*, *2*(5), 469-473.
6. Рубидинов, Ш. Ғ. Ў., & Акбаров, К. И. Ў. (2021). Машинасозликда сочилувчан материалларни ташишда транспортер тизимларининг аҳамияти. *Scientific progress*, *2*(2), 182-187.
7. Рубидинов, Ш. Г. У., & Ғайратов, Ж. Г. У. (2021). Кўп операцияли фрезалаб ишлов бериш марказининг тана деталларига ишлов беришдаги унумдорлигини тахлили. *Oriental renaissance: Innovative, educational, natural and social sciences*, *1*(9), 759-765.
8. Рубидинов, Ш. F. У. (2021). Акбаров КИУ МАШИНАСОЗЛИКДА СОЧИЛУВЧАН МАТЕРИАЛЛАРНИ ТАШИШДА ТРАНСПОРТЕР ТИЗИМЛАРИНИНГ АХДМИЯТИ. *Scientific progress*, *2*(2), 182-187.
9. Рубидинов, Ш. Ғ. У., Ғайратов, Ж. Ғ. У., & Райимжонов, Қ. Р. Ў. (2021). ИЗНОСОСТОЙКИЕ МЕТАЛЛОПОДОБНЫЕ СОЕДИНЕНИЯ. *Scientific progress*, *2*(8), 441-448.
10. Рубидинов, Ш. Ғ. У., & Раимжонов, Қ. Р. Ў. (2022). ИЗМЕНЕНИЕ МИКРОРЕЛЬЕФА ПОВЕРХНОСТИ И ШЕРОХОВАТОСТИ ДОПУСКОВ ДЕТАЛЕЙ ПОСЛЕ ХИМИЧКЕ-ТЕРМИЧЕСКИЙ ОБРАБОТКИ БОРИРОВАНИЯ. *Scientific progress*, *3*(1), 34-40.
11. Akramov, M., Rubidinov, S., & Dumanov, R. (2021). METALL YUZASINI KOROZIYABARDOSH QOPLAMALAR BILAN QOPLASHDA KIMYOVIY-TERMIK ISHLOV BERISH AHAMIYATI. *Oriental renaissance: Innovative, educational, natural and social sciences*, *1*(10), 494-501.
12. Тураев, Т. Т., Топволдиев, А. А., Рубидинов, Ш. F., & Жайратов, Ж. F. (2021). ПАРАМЕТРЫ И ХАРАКТЕРИСТИКИ ШЕРОХОВАТОСТИ ПОВЕРХНОСТИ. *Oriental renaissance: Innovative, educational, natural and social sciences*, *1*(11), 124-132.
13. Рубидинов, Ш. Ғ. У., Ғайратов, Ж. Ғ. У., & Ахмедов, У. А. У. (2022). МАТЕРИАЛЫ, СПОСОБНЫЕ УМЕНЬШИТЬ КОЭФФИЦИЕНТ ТРЕНИЯ ДРУГИХ МАТЕРИАЛОВ. *Scientific progress*, *3*(2), 1043-1048.
14. Қосимова, З., Акрамов, М., Рубидинов, Ш., Омонов, А., Олимов, А., & Юнусов, М. (2021). ТОЧНОСТЬ ИЗГОТОВЛЕНИЯ ПОРШНЕЙ В ЗАВИСИМОСТИ ОТ ВЫБОРА ЗАГОТОВКИ. *Oriental renaissance: Innovative, educational, natural and social sciences*, *1*(11), 418-426.
15. Mamadjonov, A. M., & Shermahammad oʻgʻli, X. (2021). RAQAMLI DASTUR BILAN BOSHQARILADIGAN DASTGOHLAR UCHUN DETALLARGA ISHLOV BERISH DASTURINI ISHLAB CHIQISH. *Scientific progress*, *2*(1), 11-17.
16. Mamadjonov, A. M., & Ruzaliyev, X. S. O. G. L. (2021). SIEMENS NX 12.0 DASTURI YORDAMIDA RAQAMLI DASTUR BILAN BOSHQARILADIGAN DASTGOHLAR UCHUN TEXNOLOGIK JARAYONLARNI LOYIHALASH. *Scientific progress*, *1*(6), 397-401.
17. Ruzaliev, K. S. U. (2022). ANALYSIS OF RESEARCH ON THE TREATMENT OF DETAILS ON THE INNER CYLINDRICAL SURFACE LAYER. *Oriental renaissance: Innovative, educational, natural and social sciences*, *2*(4), 281-290.

18. Юсуфжонов, О. Ғ. Ў., Рўзалиев, Х. Ш. Ў., & Турғунбеков, А. М. Ў. (2022). ОБЗОР И АНАЛИЗ РЕГЕНИРАЦИИ АСФАЛЬТОБЕТОНА. *Oriental renaissance: Innovative, educational, natural and social sciences*, *2*(4), 528-540.
19. Тешабоев, А. М., & Рубидинов, Ш. Ғ. У. (2022). ВАКУУМНОЕ ИОННО-ПЛАЗМЕННОЕ ПОКРЫТИЕ ДЕТАЛЕЙ И АНАЛИЗ ИЗМЕНЕНИЯ ПОВЕРХНОСТНЫХ СЛОЕВ. *Scientific progress*, *3*(2), 286-292.
20. Тешабоев, А. М., Рубидинов, Ш. Ғ. У., & Ғайратов, Ж. Ғ. У. (2022). АНАЛИЗ РЕМОНТА ПОВЕРХНОСТЕЙ ДЕТАЛЕЙ С ГАЗОТЕРМИЧЕСКИМ И ГАЛЬВАНИЧЕСКИМ ПОКРЫТИЕМ. *Scientific progress*, *3*(2), 861-867.
21. Yulchieva, S. B., Olimov, A., & yusuf Yunusov, M. (2022). Gas Thermal and Galvanic Coatings on the Surface of Parts. *International Journal of Innovative Analyses and Emerging Technology*, *2*(2), 26-30.
22. Рубидинов, Ш. Ғ. Ў., Муродов, Р. Т. Ў., & Хакимжонов, Х. Т. Ў. (2022). ХАРАКТЕРИСТИКИ ИЗНОСОСТОЙКИХ ПОКРЫТИЙ И МОДИФИЦИРОВАННЫХ ПОКРЫТИЙ. *Scientific progress*, *3*(3), 371-376.
23. Mamirov, A. R., Rubidinov, S. G., & Gayratov, J. G. (2022). Influence and Effectiveness of Lubricants on Friction on the Surface of Materials. *CENTRAL ASIAN JOURNAL OF THEORETICAL & APPLIED SCIENCES*, *3*(4), 83-89.
24. Mamatov, S. A. (2022). Paint Compositions for the Upper Layers of Paint Coatings. *Middle European Scientific Bulletin*, *23*, 137-142.
25. Teshaboyev, A. M., & Meliboyev, I. A. (2022). Types and Applications of Corrosion-Resistant Metals. *CENTRAL ASIAN JOURNAL OF THEORETICAL & APPLIED SCIENCES*, *3*(5), 15-22.
26. Рубидинов, Ш. Ғ. У., Қосимова, З. М., Ғайратов, Ж. Ғ. У., & Акрамов, М. М. Ў. (2022). МАТЕРИАЛЫ ТРИБОТЕХНИЧЕСКОГО НАЗНАЧЕНИЯ ЭРОЗИОННЫЙ ИЗНОС. *Scientific progress*, *3*(1), 480-486.
27. Тешабоев, А. Э., Рубидинов, Ш. Ғ. Ў., Назаров, А. Ғ. Ў., & Ғайратов, Ж. Ғ. Ў.(2021). Машинасозликда юза тозалигини назоратини автоматлаш. *Scientific progress*, *1*(5).
28. Юсупов, С. М., Ғайратов, Ж. Ғ. Ў., Назаров, А. Ғ. Ў., & Юсуфжонов, О. Ғ. Ў. (2021). Компазицион материалларни борлаш. *Scientific progress*, *1*(4).
29. Юсуфжонов, О. Ғ., & Ғайратов, Ж. Ғ. (2021). Штамплаш жараёнида ишчи юзаларни ейилишга бардошлилигини оширишда мойлашни аҳамияти. *Scientific progress*, *1*(6), 962-966.
30. O'G'Li, O. G. A. (2021). SHTAMPLARNI TA'MIRLASH USULLARI TAHLILI. *Scientific progress*, *2*(1), 1628-1637.
31. Юсуфжонов, О. Ғ. Ў., Рўзалиев, Х. Ш. Ў., & Турғунбеков, А. М. Ў. (2022). ОБЗОР И АНАЛИЗ РЕГЕНИРАЦИИ АСФАЛЬТОБЕТОНА. *Oriental renaissance: Innovative, educational, natural and social sciences*, *2*(4), 528-540.
32. Djurayev, A., & Yuldashev, K. (2020). Dynamics of the Screw Conveyor for Transportation and Cleaning of Fiber Material. *International Journal of Advanced Science and Technology*, *29*(5), 8557-8566.
33. Юсупов, С. М., Ғайратов, Ж. Ғ. Ў., Назаров, А. Ғ. Ў., & Юсуфжонов, О. Ғ. Ў.(2021). КОМПАЗИЦИОН МАТЕРИАЛЛАРНИ БОРЛАШ. *Scientific progress*, *1*(4).
34. Marifovich, T. A. (2022). Theoretical Basis of Safety of Life Activity. *European Journal of Research Development and Sustainability*, *3*(1), 97-99.
35. Рустамов, М. А. (2021). Методы термической обработки для повышения прочности зубчатых колес. *Scientific progress*, *2*(6), 721-728.

36. Akbaraliyevich, R. M. (2022). Improving the Accuracy and Efficiency of the Production of Gears using Gas Vacuum Cementation with Gas Quenching under Pressure. *CENTRAL ASIAN JOURNAL OF THEORETICAL & APPLIED SCIENCES*, *3*(5), 85-99.
37. Акрамов, М. М. (2021). Повышение физико-механических свойств стальных деталей при пластической деформационной обработке. *Scientific progress*, *2*(6), 129-133.
38. Акрамов, М. М. (2022). Краткая Характеристика Горячих Цинковых Покрытий. *CENTRAL ASIAN JOURNAL OF THEORETICAL & APPLIED SCIENCES*, *3*(5), 232-237.
39. Косимова, З. М., & Акрамов, М. М. Ў. (2021). Технологические особенности изготовления поршней. *Scientific progress*, *2*(6), 1233-1240.
40. Мамуров, Э. Т. (2021). Металлларга кесиб ишлов беришда контакт жараёнларнинг виброакустик сигналга таъсири. *Science and Education*, *2*(12), 158-165.
41. Мамуров, Э. Т. (2021). Кесувчи асбоб ҳолатини ва кесиш жараёнини виброакустик сигнал асосида ташхислаш. *Science and Education*, *2*(12), 133-139.
42. Mamurov, E. T. (2022). Study of the Dependences of Specific Energy Consumption on the Elements of the Cutting Mode as an Informative Parameter of the Cutting Process. *Middle European Scientific Bulletin*, *24*, 315-321.