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TECHNOLOGICAL METHODS OF INCREASING WEAR RESISTANCE AND DURABILITY OF DETAILS

Olena Trukhanska, PhD, Associate Prof.
Vinnytsia National Agrarian University

Труханська Олена Олександрівна, к.т.н., доцент
Вінницький національний аграрний університет

Improving the reliability and service life of machines, components, units is an important factor in reducing the cost of restoration, downtime of equipment in repair, reducing the number of spare parts.

The introduction of the latest technologies of agricultural production, as well as constant modern improvement, the complexity of agricultural machinery is a natural result of its development.

Parts restoration technologies are among the most resource-saving, because compared to the manufacture of new parts costs are reduced by up to 70%. The main source of resource savings is the cost of materials.

At longtime use of machines wear of details is followed by decrease in operational indicators, causes deterioration of quality of products.

The tractor PTO shaft is subjected to significant static and dynamic loads. The high wear rate is due to constant friction with the grafting disc, gear, inner bearing rings. The production of a new power take-off shaft requires significant costs, so the development of new technological processes of repair and restoration is relevant.

It is rational at restoration of the previous sizes and return of a detail of normal mechanical properties. The remanufactured part is consuming its life, like a new part, and may exceed the service life of the new part.

With the increase in the equipment of agricultural production with more advanced equipment, the conduct of complex mechanization and increasing the efficiency of the use of equipment, repair production is developing and changing. The development of the field of restoration of worn parts is based on close cooperation of repair production with branch and basic science, and achievement of scientific and technical progress.

A promising direction of restoration technology in the organizational plan is the deepening of the method of group restoration technology - the creation of a unified group equipment for the restoration of surfaces. It is established that the majority of details of the restored cars are rejected at the expense of insignificant wear of working surfaces, making no more than 1% of initial weight of details. Experiments and practice show that the repair of agricultural machinery is technically impossible to avoid. Most worn parts have a high residual value: their restoration consumes 20-30 times less metal and materials than the manufacture of new ones, which is economically feasible.

Problems are considered: the choice of technological process of restoration, the choice of technological equipment, tools.

Key words: *plasma, spraying, powder material, reduction, shaft, equipment.*

F. 1. Fig. 1. Table. 1. Ref. 8.

1. Definition of problem

Restoration of details is a technically justified, economically justified measure. This allows repair shops to reduce downtime of faulty machines, improve the quality of maintenance and repair to positively affect the reliability of the use of machines.

To restore the efficiency of worn parts requires 5-8 times less technological operations compared to the manufacture of new ones [1, 2].

Restoration of parts allows to obtain a considerable economic effect, as the consumption of metal and auxiliary materials is much lower, and the cost of the restored part is 60-80% of the cost of new ones.

Therefore, to make this recovery process effective, it is necessary to introduce new processing and recovery methods, as well as to improve existing equipment. The production of a new power take-off shaft requires significant costs, and the detection of new technological processes of repair and restoration is relevant.



2. Analysis of the latest research and publications

With prolonged use of machines, wear of parts is accompanied by a decrease in performance, which causes a deterioration in the quality of products [1]. It is rational not only at restoration of the previous sizes, but also return of a detail of normal mechanical properties. The remanufactured part has the same service life as the new part, and may exceed the service life of the new part.

A promising area of restoration technology in organizational terms is the deepening of the method of group restoration technology to create a unified group equipment for surface restoration [3].

The article is devoted to the problem of increasing wear resistance and restoration of machine parts with high performance.

Problems are considered: the choice of technological process of restoration, the choice of technological equipment, tools.

3. Aim of research

The purpose – research of methods of increase of wear resistance and durability of the restored detail by a productive method with use of the special device.

4. Results of the research

The main method of restoration is plasma spraying, which does not cause deformation of the part and does not require significant costs for machining.

At this time, production practice has established that most parts of restored machines are discarded due to minor wear of working surfaces, amounting to no more than 1% of the initial weight of the parts. If we take into account that 65-75% of parts are suitable for reuse by the time of decommissioning, then the organization of restoration of worn parts is not only an important reserve to meet the needs of the economy with spare parts, but a significant reserve to improve repair quality and reduce material and labor costs.

The quality of the restoration of the part depends more on the correct choice of technological process, as well as strict compliance with all design parameters.

The development of the technological process of restoring the PTO shaft for tractors type MTZ-80 is to analyze the operation of conjugate surfaces.

During operation, the PTO shaft receives the following defects:

- 1) wear of slots is connected with a disk of inoculation;
- 2) wear of the hub under the ball bearing.

All these defects occur due to wear of the following types:

- abrasive wear;
- superficial fatigue;
- corrosion wear.

The manufacture of a new PTO shaft requires significant costs, so the development of new technological processes of repair and restoration is a rational goal not only to restore its previous size, but also to return it to normal mechanical properties. The PTO shaft experiences significant static and dynamic loads. The high wear rate is due to constant friction with the grafting disc, gear, inner bearing rings [4].

In the process of restoring the power take-off shaft, the following methods can be used: electric arc surfacing, carbon dioxide surfacing, flux-cored wire surfacing, gas-flame surfacing, electromechanical recovery, plasma and galvanic reduction.

Welding and surfacing are the most common ways to restore parts in the car repair industry. In gas-flame surfacing, we obtain unsatisfactory strength characteristics due to the fact that air will pass into the zone of molten metal, which is harmful to the deposited layer [1, 5].

Restoration of a surface of a detail is possible by means of the following methods.

1. Under the layer of flux: is that in the combustion zone of the arc formed between the part and the electrode wire, which moves continuously, a flux is fed, which, melting, creates an elastic shell that protects the bath of molten metal from oxidation.

In production it is used for restoration of cylindrical surfaces with a diameter not less than 50 mm.

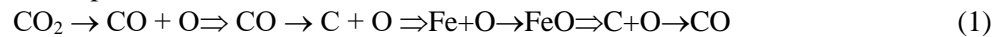
2. Vibro arc surfacing: is that the electrode wire is fed to the surface of the part, which is under current with oscillations, due to which there is a periodic short circuit and opening of the electric arc.



Vibration of the electrode reduces the thermal impact on the part. The disadvantage of this method is the heterogeneity of the structure, the density and porosity of the weld metal, which reduce the strength and cause fatigue of the part [6].

3. Reduction in the environment of carbon dioxide: the arc burns between the electrode and the part in the environment of CO₂, which causes damage from gas formation.

This method is 1.2-1.5 times more economical than other methods of surfacing, no harmful effects on the deposited metal layer. Disadvantages: in the process of surfacing in the arc zone there are reactions of decomposition of CO₂ to its components:



As a result, gas bubbles are formed on the surface, and this requires the introduction of deoxidizers (Mn, Si) into the surfacing wire.

4. Plasma spraying: the essence of the method is that the powder filler material is fed by a transport gas in the area of action of the plasma, which, melting the powder, sprays it on the part. The method is effective for obtaining new bimetallic products with special properties (heat resistance, corrosion resistance, etc.). Ability to apply the coating at different speeds in the range of 20-64 (HRC) [1, 5].

The reason that reduces the use of this method is the higher material costs compared to others.

It is not advisable to use surfacing under the flux layer to restore the gear shaft of the MTZ-80 tractor because a large amount of heat is released during melting, which will lead to torsion and deformation of the thin-walled part.

The most expedient method of restoration is plasma spraying, because during spraying the surface of the restored part is heated to 200°C.

A plasma jet is used as a heat source for plasma spraying. Plasma is a partially or completely ionized gas heated to a high temperature and has the property of electrical conductivity. Plasma jet is obtained in special devices called plasma torches or plasma burners. The plasmatron consists of two main parts: cathode and anode. In order to obtain a plasma jet between the cathode and the anode, an electric arc is created, and a plasma-forming gas is introduced in the combustion zone, which, passing through the arc gap, is heated to a high temperature, ionized, decomposes into positively and negatively charged ions [5, 6].

Argon, nitrogen, helium, hydrogen and mixtures thereof are used as plasma generators. Plasma jet of argon has the highest temperature (up to 15000...20 000°C) and supersonic speed (1000...1200 m/s).

The spray material in plasma spraying is introduced in the form of powder or wire. Powder surfacing takes place in two ways: by feeding the powder directly into the plasmatron with transport gas, or into the plasma jet by a dispenser.

The quality of the coating depends on the heating temperature of the particles and the speed of their application to the surface of the part. The rate of application of metal particles is determined mainly by two factors: the strength of the arc current and the consumption of plasma-forming gas. Depending on the value of these factors, it can be reached 150...200 m/s. The highest melting rate of metal particles is reached at a distance of 50...80 mm from the nozzle of the plasmatron. The high rate of application of the powder particles and the high temperature of their heating at the moment of contact with the surface of the part provides higher than with other methods of application, the mechanical properties of the coating and its stronger connection with the surface of the part.

Coatings obtained by the method of plasma spraying have higher physical and mechanical properties than coatings sprayed by other methods, but they are in some respects inferior to the coating of the same materials obtained by surfacing. All the properties of plasma coatings can be significantly improved by introducing into the technological process of restoration of parts of a relatively simple operation – melting the coating.

When the coating melts, only the most fusible component of the alloy melts. The metal of the part is only heated, but remains in a solid state. The liquid phase contributes to a more intense diffusion process.

Coatings obtained by the method of plasma spraying have higher physical and mechanical properties than coatings sprayed by other methods.

The main mechanical and economic indicators of the considered methods are summarized in table 1 [7].

Taking into account the data of theoretical data, we take the most optimal method of plasma spraying for the restoration of the power take-off shaft, in which the thermal and dynamic properties of the plasma arc are used to melt and transfer metal to the surface of the part. Argon (Ar) is used as the plasma forming gas.

Argon plasma has the highest temperature up to (15000 - 20000°C) and above the speed of sound (100...1200 m/s) at high enthalpy (heat capacity).



When using this method we can get a relatively high economic effect. The proposed process option allows to significantly improve the surface quality and performance of the parts to be restored, as well as to reduce the recovery time. The manufacturer, which will use the developed technology in production, will operate in certain market conditions.

Table 1

The main mechanical and economic indicators

№	Indexes	Unit of measurement	Surfacing under a layer of Flux	Vibro arc surfacing	Surfacing in the environment of Carbon dioxide	Plasma surfacing
1	Part of the base metal in the weld	%	27-60	8-20	12-45	Absence
2	Gear strength	MPa	650	500	550	45
3	Decreased fatigue resistance	%	15	35	15	25
4	Deformation	---	Significant	Non Sign.	Signif.	Absence
5	Coefficient of productivity	---	1.62-1.45	0.85-0.72	1.82-1.77	1.68-1.47
6	Coefficient of technical and economic efficiency	---	0.436	0.25	0.403	0.39

Potential consumers of the company's products are various organizations that use or are engaged in the restoration of shafts. In the Vinnytsia region there are about 140 such enterprises, and the fleet of cars and tractors is more than 10,000 units. However, only 85% of them use finished products. The device belongs to the devices that generate plasma for heating and surface treatment of various products. This plasmatron is widely used for spraying powder materials. The powder is fed at the nozzle outlet. For spraying usually use a powder with a particle size of 40-100 microns.

The principle of operation of the plasmatron: the current is supplied to the tungsten electrode 1 and the copper anode 3 through the pipeline 4, through which the coolant is supplied. The working gas is supplied through the fitting 7 into the hole of the housing of the insulator 2. The sprayed powder together with the transport gas is fed through a hose 5 into the hole of the sprayer 6. The sprayer is fastened with four screws 10 to the cylinder 9. Tightness is achieved by sealing rings 12.

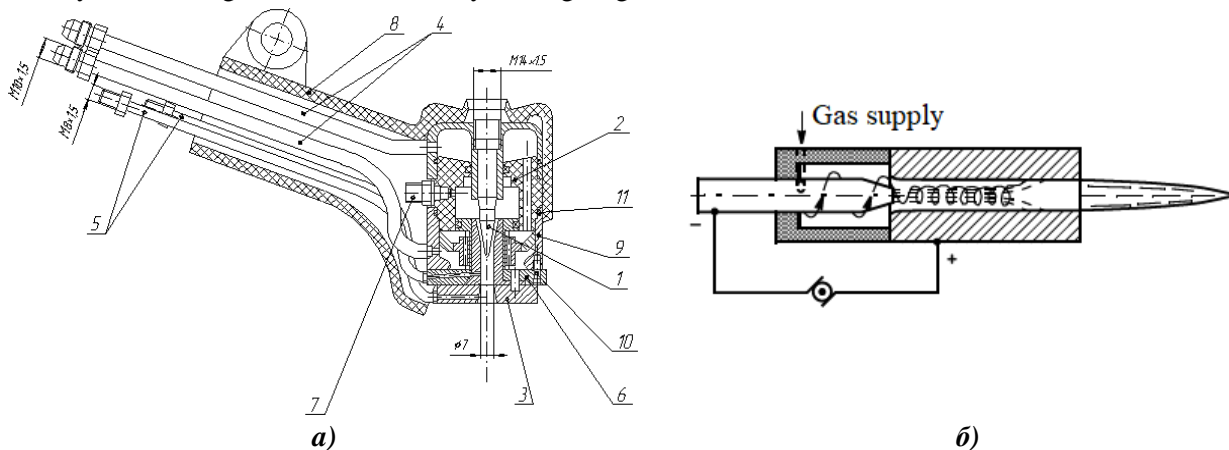
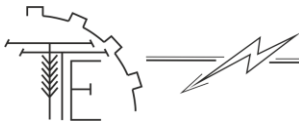


Fig. 1. Plasmatron for spraying:

a) Radial cut; b) Schematic diagram; 1 – Tungsten electrode; 2 – insulator housing; 3 – copper anode; 4 – pipeline; 5 – hose; 6 – spray; 7 – fitting; 8 – mouthpiece; 9 – the cylinder; 10 – screw; 11 – cuff; 12 – sealing rings

The device refers to devices that generate plasma for heating and surface treatment of various products. This plasmatron is widely used for spraying powder materials. The powder is fed at the nozzle outlet.

For spraying use a powder with a particle size of 40...100 mm.



To restore worn surfaces by spraying, self-fluxing powder alloys of the Ni-Cr-B-Si system have been widely used, to which carbides, borides of refractory metals (tungsten, vanadium, chromium, molybdenum) are often added to form composite alloys with higher physical and mechanical properties.

During the supply of current to the cathode and anode, a plasma arc occurs between them and is supported by an inert gas (Ar) \neg . At this time, it is fed through a hole that sprays powder. The plasmatron is attached to the eye, which is located on the housing 8 in the machine for spraying A1756.

The choice of powder material for the recovery operation by plasma spraying.

In recent years, domestic industry and foreign companies ["Metko" (Italy), "Castolin" (Switzerland) and others] are expanding the production of bimetallic thermoregulatory powder alloys, which have exothermic properties that increase the bond strength of the coating with the base, and physical and mechanical properties in general. They are used as a sublayer for spraying the base layer. They consist of particles of spherical or close shape. Each particle of exothermic powders consists of a nickel core coated with a thin layer of fine aluminum. These powders are used not only as wear-resistant coatings for the restoration of machine parts. They can be used as heat-, heat-, corrosion-resistant coatings for parts that operate at elevated temperatures, in oxidizing environments, which helps to increase the durability of the part.

Powders PG-12H-01, Pg-10H-01 are made on a nickel basis of the Ni-Cr-B-Si-C-Fe system. Hardness is regulated by the content of C, B, Cr. The sprayed connections have low coefficient of friction, high admissible working temperature (to 800 °C). They are used to restore cast iron parts such as "shaft" [4, 8].

Powder PS-12-NVK-01 (HRC 57-64) consists of compositions: powder PG-10H-01 (65%) + tungsten carbide powder WC (35%). Coatings with this composition have high wear resistance. They are used to restore movable and immovable connections. The coating is treated by grinding.

Powder PN55T45 (melting point 1240°C) is used as a wear-resistant coating for parts such as "shaft". It has high resistance in alkaline and oxidizing media. The bond strength of the coatings is 45-50 MPa. The coating is treated by grinding.

To restore the PTO shaft from this range of powders, we choose the powder PG-12H-01, it most satisfies both the technological and economic characteristics for the restoration of the PTO shaft.

5. Conclusions

Plasma spraying, as a method of restoration, does not cause deformation of the part and does not require significant costs for machining.

The process modernization option allows to significantly improve the surface quality and performance of the parts to be restored, as well as to reduce the recovery time. Progressive moral aging and reduction of the machine-tractor park of farms affects the level of utilization of production capacities of repair and maintenance enterprises of the agro-industrial complex of Ukraine. Recently, there has been a tendency to increase efficiency. About 25% of service companies increase the volume of service work, including the restoration of worn and damaged parts.

The method of plasma spraying with powder material differs in that in a very short period of time it is possible to restore a significant number of parts and give them physical and mechanical properties that can't be obtained by other methods.

Improved quality of refurbished parts in combination with their slightly low price will contribute to the growth of popularity and conquest of the consumer market.

References

- [1] Sidashenko, O. I., Naumenka, O. A., Ahrosvita, K. (2014). Remont mashyn ta obladnannia : pidruchnyk , 665 s. [in Ukrainian].
- [2] Baranovsky, V, Truhanska, O., Pankiv, M, Bandura, V. (2020). Research of a contact impact of a root crop with a screw auger. *Research in Agricultural Engineering*, 66. 33–42. [in English]
- [3] Truhanska, O.O. (2018). Pidvyschennia yakosti remontu i tekhnichnoho obsluhovuvannia silskohospodarskoi tekhniky. Vseukrainskyi naukovo – tekhnichniy zhurnal «*Tekhnika, enerhetyka, transport APK*», №3(102). 52–62. [in Ukrainian].
- [4] Amelyn, D. V., Rymorov, E. V. (2007). Novye sposoby vosstanovleniya y uprochneniya detalei mashyn elektrokontaktnoi navarkoi. M.: Ahropromyzdat. [in Russian]
- [5] Tysarenko, T.S., Aharev, V. A., Kvytka, A. L., Ponkov, V. H., Umanskyi, E. S. (2006). Soprotiv lenie materyalov. Kyiv: Vyshcha shkola [in Russian]



- [6] Shvets, L. V. Paladiichuk, Yu. B., Trukhanska, O. O. (2019). Tekhnichniy servis v APK. Tom I. Navchalnyi posibnyk. Vinnytskyi natsionalnyi ahrarnyi universytet. [in Ukrainian].
- [7] Dokunikhin, V. Z., Burdeinyi, V.S., Zahuzov, M.M. (2004). Proektuvannia ratsionalnoi orhanizatsiinoi struktury ta struktury upravlinnia pidpriemstvamy tekhnichnoho servisu APK. Zhytomyr: DAU. [in Ukrainian].
- [8] Truhanska, O.O. (2020). Perspektivni napryamki tekhnologii vidnovlennya detalej mashin. Vseukrainskyi naukovo – tekhnichniy zhurnal «Vibracii v tekhnici ta tekhnologiyah». Vinnytsia, №3(98). 104–110. [in Ukrainian]

ТЕХНОЛОГІЧНІ МЕТОДИ ПІДВИЩЕННЯ ЗНОСОСТІЙКОСТІ ТА ДОВГОВІЧНОСТІ ДЕТАЛЕЙ

Підвищення показників надійності і термінів служби машин, вузлів, агрегатів є важливим чинником зменшення витрат на відновлення, простоювання обладнання у ремонті, зменшення кількості запасних частин.

Впровадження новітніх технологій сільськогосподарського виробництва, а також постійне сучасне удосконалення, ускладнення сільськогосподарської техніки є природним результатом її розвитку.

Технології відновлення деталей відносяться більш ресурсозберігаючих у порівнянні з виготовленням нових деталей.

При довготривалому використанні машин зношування деталей супроводжується зниженням експлуатаційних показників, що викликає погіршення якості виробів.

Висока швидкість зношення поверхні валу відбору потужності пояснюється постійним тертям з диском щеплення, шестернею, внутрішніми кільцями підшипників. Виготовлення нового валу відбору потужності потребує значних витрат, тому актуальним є розробка нових технологічних процесів ремонту та відновлення.

Це раціонально не тільки при відновленні попередніх розмірів, а й повернення деталі нормальних механічних властивостей. Відновлена деталь відпрацьовує такий самий термін, як і нова, а може і перевищувати строк служби нової деталі.

З підвищенням росту оснащення сільськогосподарського виробництва більш удосконаленою технікою, веденням комплексної механізації і підвищенням ефективності використання техніки розвивається і змінюється ремонтне виробництво. Розвиток галузі відновлення зношених деталей базується на тісному співробітництві ремонтного виробництва з галузевою і фундаментальною наукою, та досягнення науково-технічного прогресу.

Перспективним напрямком технології відновлення в організаційному плані є поглиблення методу групової технології відновлення створення уніфіковано-групового оснащення для відновлення поверхонь. Встановлено, що більшість деталей відновлених машин вибраковуються за рахунок незначного зносу робочих поверхонь, складаючи не більше 1% початкової маси деталей. Як показують дослідження і практика, з одного боку, ремонту сільськогосподарської техніки уникнути технічно неможливо, а з іншого – він є економічно доцільний. Адже більшість зношених деталей має високу залишкову вартість: при їх відновленні витрачається у 20-30 разів менше металу і матеріалів, ніж при виготовленні нових.

Розглядаються проблеми: вибір технологічного процесу відновлення, вибір технологічного обладнання, інструменту.

Ключові слова: відновлення, вал, плазма, напилення, порошковий матеріал, оснастка.

Ф. 1. Рис. 1. Табл. 1. Літ. 8.

ТЕХНОЛОГИЧЕСКИЕ МЕТОДЫ ПОВЫШЕНИЯ ИЗНОСОСТОЙКОСТИ И ДОЛГОВЕЧНОСТИ ДЕТАЛЕЙ

Повышение показателей надежности и сроков службы машин, узлов, агрегатов является важным фактором уменьшения затрат на восстановление, простоя оборудования в ремонте, уменьшение количества запасных частей.

Внедрение новейших технологий сельскохозяйственного производства, а также постоянное современное усовершенствования, осложнения сельскохозяйственной техники является естественным результатом ее развития.



Технологии восстановления деталей относятся более ресурсосберегающих по сравнению с изготовлением новых деталей. При длительном использовании машин износа деталей сопровождается снижением эксплуатационных показателей, вызывает ухудшение качества изделий.

Высокая скорость износа поверхности вала отбора мощности объясняется постоянным трением с диском прививки, шестерней, внутренними кольцами подшипников. Изготовление нового вала отбора мощности требует значительных затрат, поэтому актуальным является разработка новых технологических процессов ремонта и восстановления.

Это рационально не только при восстановлении прежних размеров, но и возвращение детали нормальных механических свойств. Восстановлена деталь обрабатывает такой же срок, как и новая, а может и превышать срок службы новой детали.

С повышением роста оснащенности сельскохозяйственного производства более усовершенствованной техникой, ведением комплексной механизации и повышением эффективности использования техники развивается и меняется ремонтное производство. Развитие области восстановления изношенных деталей базируется на тесном сотрудничестве ремонтного производства с отраслевой и фундаментальной наукой, и достижения научно-технического прогресса.

Перспективным направлением технологии восстановления в организационном плане углубления метода групповой технологии восстановления создания унифицированы-группового оснащения для восстановления поверхностей. Установлено, что большинство деталей восстановленных машин выбраковываются за счет незначительного износа рабочих поверхностей, составляя не более 1% начальной массы деталей. Как показывают опыты и практика, с одной стороны, ремонта сельскохозяйственной техники избежать технически невозможно, а с другой - он экономически целесообразен. Ведь большинство изношенных деталей имеет высокую остаточную стоимость: при их восстановлении расходуется в 20-30 раз меньше металла и материалов, чем при изготовлении новых.

Рассматриваются проблемы: выбор технологического процесса восстановления, выбор технологического оборудования, инструмента.

Ключевые слова: технология, восстановление, деталь, плазма, напыление, порошковый материал, оснастка.

Ф. 1. Рис. 1. Табл. 1. Лит. 8.

ВІДОМОСТІ ПРО АВТОРА

Труханська Олена Олександрівна – к.т.н., доцент кафедри агроінженерії та технічного сервісу Вінницький національний аграрний університет (вул. Сонячна, 3, м. Вінниця, 21008, Україна, e-mail: seaswallow@ukr.net).

Труханская Елена Александровна – к.т.н., доцент кафедры агроинженерии и технического сервиса Винницкий национальный аграрный университет (ул. Солнечная, 3, г. Винница, 21008, Украина, e-mail: seaswallow@ukr.net).

Olena Trukhanska – Ph.D, Associate Professor, the Department of Agroengineering and Technical Services of the Vinnytsia National Agrarian University (Sonyachna St.3, Vinnytsia, 21008, Ukraine e-mail: seaswallow@ukr.net).