

## REPAIR OF ENGINE RADIATOR BY MEANS OF COLD GAS SPRAYING

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### Abstract:

The article is devoted to the performance restoration technology development of the aluminum radiator of tractor «John Deer 7830».

The distinctive feature of the suggested technology is cold gas spraying application, which provides air tightness restoration of the radiator made of thin-walled aluminum parts and having complicated form that causes troubles to technological operation fulfilment.

The carried out experimental investigations resulted in determining rational technological parameters of gas dynamic spraying: nozzle angle of the facility and the distance from the nozzle exit to the spraying surface, providing optimal mechanical characteristics of the repair coating.

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### 1. INTRODUCTION

Machine exploitation is impossible without manifestation of moral and physical ageing processes. It results in their technical and economic indicators decrease.

Difficult economic conditions in the country and in the world, weakening rouble, and also substantial increase of price level for imported and domestic agricultural machinery deprive the majority of enterprises of the opportunity to purchase new machinery. Because of this, machine and tractor fleet ageing is observed; it results in operating condition loss, failures number increase and economic loss increase because of machine fault time.

For this reason for the moment the question of rational management of machine technical state is the question of vital importance, which can be solved by means of improving the processes of technical servicing and repair. But with balance cost increase of agricultural machinery expenditures for its repair are increasing considerably too. Significant increase in spare parts costs also contributes to it.

The way-out of the following situation can be to supply the agro industrial complex with spare parts on account of renovation – restoration of worn parts. It allows reusing life time of a part, save considerable material, labour and fuel and energy resources. Thus, worn parts restoration is an important reserve in material and technical resources saving and enterprise economic efficiency increase.

The collaborative work experience of Belgorod State Agrarian University and Orel State Agrarian University and also the Belgorod affiliate service department of LLC OOO «Jupiter 9» [1] allowed finding out the number of parts of tractors «John Deere», which at the sufficient high cost have high factor of fault repetition and can be restored in the repair and technical enterprise conditions.

Radiator RE226366 of tractor «John Deere 7830» is one of these parts. Radiator consists of thin-walled flat-oval aluminum tubes, canted into upper and lower tanks. In space between tubes the honeycomb filler from thin aluminum sheet is mounted.

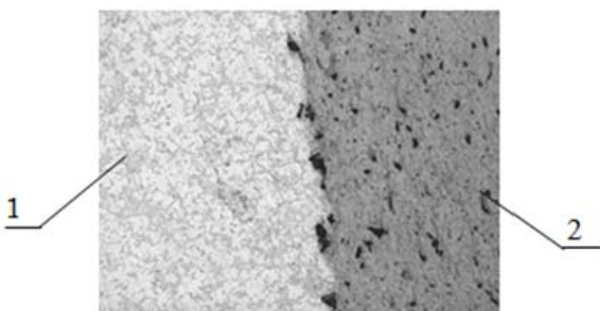
While in tractor operation break of air tightness of “tube-tank” connections takes place because of considerable vibrations.

Tube plugging is technologically impossible. Repair by the use of special hermetic added into cooling liquid is forbidden by the tractor manufacturer, the usage of argon-arc welding is constrained because of limited access to the place of air tightness and very small wall thickness of the tube (approximately 0,5 mm). For this reason, at the present time representatives of the official service centre recommend to replace a radiator.

However a new radiator cost is rather high. In present conditions of limitations and financial saving, purchasing of new high-value item for common agricultural enterprise that uses similar machinery is a great problem.

For that reason, as a means of performance restorations of radiator RE226366 of tractor «John Deere 7830» we suggest supersonic gas dynamic spraying (GDS) [2-3]. At the present time this method of coating formation is known in the world as “cold spraying”. Powder material being in the solid state is accelerated by supersonic gas flow to the speed of 500-800 m/s and is directed to the part restored surface. Bumping into the surface in the process of supersonic impact particles consolidate on it forming a uniform coating [4-8].

The structure peculiarity of the coatings being obtained by supersonic GDS is the following: they are considered as a composite material consisting of metal matrix and ceramic particles incorporated in it (or other metal particles) [7-9]. The typical structure of the coating being obtained by GDS is presented in Fig.1.



**Fig. 1.** Microstructure of coating being obtained by GDS: 1– steel base; 2 – coating, sprayed by powder A-80-13. Magnification ×200

To the main advantages of GDS it is possible to refer:

- The absence of heating of the sprayed item (surface temperature does not exceed 100–150

°C), and, hence, distortions and strength reduction of the protected and restored items;

- The absence of high temperatures, harmful gases, flame and radiation;
- Low labor intensity and simplicity of equipment;
- high reliability and compactness;
- relatively low equipment cost.

**2. MATERIALS AND METHODS**

For coating formation gas dynamic spraying facility DYMET – 405 was used (Fig.2) [3]. The main technological characteristics of the DYMET– 405 facility are presented in Table 1.

**Table 1.** Main technical of facility DYMET– 405

Parameter	Value
Set dimensions, mm	550×260×470
Mass, kg:	
Spraying unit	1,3
Set in total	15
Pressure of consumable compressed air, MPa (kg/cm <sup>2</sup> )	0.5-0.9 (5-9)
Compressed air consumption, m <sup>3</sup> /min	0,45
Electric supply, V/kW	220/3.3
Productivity according to mass of sprayed coating on the aluminum base, g/min (cm <sup>3</sup> /min)	1-6 (0.3-2)
Number of set temperature modes	5
Number of powder feeders	2



**Fig. 2.** General view of test facility DYMET–405: 1– nozzle SK-6; 2 – silicone adaptor; 3 – sprayer DM-43; 4- powder delivery button; 5 – powder delivery tube; 6 – sprayer pneumatic valve; 7 – gauge; 8 – monitor and control unit MCU-03; 9 – feeder FV-43.

Before spraying to provide GDS facility nozzle access to the depressurization space the honeycomb filler was removed from the radiator.

Spraying along the contact line "tube-tank" was done with powder of trade mark A-10-01, containing the particles of pure aluminum and corundum [4], with the layer of thickness 1,5 – 2,5 mm.

### 3. RESULTS AND DISCUSSION

As the result of powder spraying the depressurization space turned out to be covered with solid layer with hardness of 618 MPa. Consequently, the possibility of gas dynamic spraying application to restore the examined RE226366 radiator fault of tractor «John Deere 7830» was proved experimentally.

It is necessary to stress, that at gas dynamic spraying, it is recommended to take into consideration spraying angle of powder material, because this to a great extent influences on the quality of the formed coatings [5-12]. If the nozzle is located at low angle relatively the surface the adhesion of the powder and the surface can get worse and the phenomenon of intense abrasive wear of the spraying coating can be observed [13-16]. In our case it can result in occurrence of different tube faults.

At the radiator performance restoration due to the hindered access to the remote part of joint «tube-tank», the angle of nozzle location towards the spraying surface was near-critical. That is why it was necessary to do a number of tests to find out technological parameters of the spraying process (nozzle angle and spraying distance), that allow obtaining sound coating with undamaged walls of the radiator tubes.

The nozzle angle was measured by angle meter 5AM GOST 5378-88 with the help of accessory (Fig.3), and spraying distance was measured by a metal ruler.



**Fig. 3.** Nozzle angle setting by means of accessory

As a part of the study it was found that maximum adhesion of the coatings is observed at orthogonal spraying. This correlates with the data of other researchers [14,15,17]. However, technologically, it is quite difficult to meet these conditions at radiator faults elimination by the GDS method. That is why we selected minimal nozzle angle positioning in relation to the surface being sprayed, providing the possibility to obtain sound coating and absence of restored unit tubes faults.

The carried out number of tests allowed determining rational modes of gas dynamic spraying at the radiator performance restoration the spraying angle was not less than 80-82°, spraying distance was 6-8 mm. Besides, at the above mentioned rational parameters of spraying before GDS, it is recommended to remove not less than 70 mm of the honeycomb filler of the radiator tubes. Consultations with service engineers confirmed the fact that removal of the honeycomb filler does not produce considerable effect on the radiator operation efficiency. General view of the restored radiator is presented in Fig.4.



**Fig. 4.** General view of the restored radiator

### 4. CONCLUSION

The developed technology provides complete restoration of radiator operation condition and safe life equal to life time of a new item.

It can be successfully implemented in different technical service enterprises which are specialized in repair of tractors and automobiles.

Further prospects of this technology development should be connected with the possibility of obtaining coatings with physical and mechanical and performance properties unavailable to the majority of conventional gas thermal spraying methods, and also with simplicity, portability of the applied equipment and high efficiency.

REFERENCES

- [1] Company LLC «Jupiter 9». <http://www.jupiter9.ru> (accessed April 2016).
- [2] Production of DYMET®. <http://www.dimet.info/products/index.html> (accessed February 2016).
- [3] Facility for metal spraying DYMET 405. <http://regionfox.ru/katalog/oborudovanie-dlya-napyleniya-metalla/ustanovka-dlya-napyleniya-metalla-dymet-405> (accessed 23.05.2016).
- [4] S.V. Strebkov, A.P. Slobodyuk, A.V. Bondarev, Efficiency assessment of import substitution of agricultural machinery spare parts, Challenges and opportunities of innovative development of agrotechologies, Materials of the XIXth International scientific and production conference, 24-26 May 2015, Belgorod, Russia.
- [5] S.V. Strebkov, A.P. Slobodyuk, A.V. Bondarev, Restoration of accessory equipment of import machinery, Materials of State Scientific Institution of All Russian Research Technological University, 2014, p.1.
- [6] S.V. Strebkov, A.P. Slobodyuk, A.V. Bondarev, Restoration of working capacity of parts of foreign agricultural machinery, Materials of the International distance research and practice conference «Important directions of scientific investigations of the XXIth century: theory and practice»: collection of research papers, Voronezh, Russia, 5 (2014), pp.268-272.
- [7] D.A. Gerashhenkov, A.S. Oryshhenko, Alumino-matrix functional coatings with high microhardness obtained from composite powders of system AL-SN+Al<sub>2</sub>O<sub>3</sub> by means of Cold Gas Spraying, Questions of material sciences. 5 (2015) 100-107.
- [8] Yu.A. Kuznetsov, V.V. Goncharenko, K.V. Kulakov, Analysis of the equipment for Cold Gas Spraying, Machinery and Equipment for a village. 11 (2013) 40-44.
- [9] M.E. Avakumov, M.V. Rufitsky, Reliability and quality of coating at application of Cold Gas Spraying method, Materials of the International Symposium Reliability and quality. 2 (2013), pp.112-113.
- [10] P.I. Burak, A.V. Serov, N.V. Serov, Review of research in the field of Cold Gas Spraying, Materials of State Scientific Institution of All Russian Research Technological University. 114 (2014) 169-174.
- [11] A.P. Alkimov, A.N. Papyrin, V.F. Kosarev, N.I. Nesterovich, M.M. Shushpanov, Gas dynamic spraying method for applying a coating, U.S. Patent 5 302 414, 12 April 1994.
- [12] Yu.A. Kusnetsov, Resource saving technologies of gas thermal spraying at machine repair, Vestnik Orel SAU. 1 (2009) 13-15.
- [13] L.Kh. Baldaev, V.N. Borisov, V.A. Vakhalin, Gas thermal spraying: workbook for higher educational establishments, Under the general editorship of L. Kh. Baldaev, Russia, Market DS, 2007.
- [14] A.I. Kashirin, A.V. Shkodkin, Method of gas dynamic spraying of metal coatings: development and modern state, Hardening technologies and coatings. 12 (2007) 22-32.
- [15] A.P. Alkhimov, S.V. Klinkov, V.F. Kosarev, Cold gas dynamic spraying, Theory and practice, Under the editorship of V. M. Fomin, Russia, 2010.
- [16] Yu.A. Kusnetsov, V.V. Goncharenko, K.V. Kulakov, Innovative methods of gas thermal spraying of coatings, Publishing house Orel SAU, Russia, 2011.
- [17] D. Milošević, Ž. Adamović, A. Ašonja, Diagnosis and forecasting the state machine the power and thermal plants, Tehnička dijagnostika. 13 (2014) 7-12.