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Water pump shaft resource recovery technology

B Kh Norov, Sh U Yuldashev, A Li, and Z Sharipov

Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, 39, K.Niyazi str., Tashkent, Uzbekistan

E-mail: b.norov@tiiame.uz

Abstract. The article describes the technology of restoration of seats for bearings by plasma spraying based on the analysis of defects of the shaft of a centrifugal pump used in water industry. Based on the analysis of the wear of the shaft surfaces and the technological processes of restoration of the pump shafts, the method of plasma spraying of metal is selected. To achieve high adhesion, a multivariate experiment was conducted. The regression equation is described that describes the changes in the strength of the sprayed layer from the technological processing conditions. Recommended installation and technological conditions provide strength during plasma spraying.

1. Introduction

Under the current conditions, the accelerated technical and technological re-equipment of agriculture and water management, the introduction of modern, flexible economies of cost savings, the cost of production and the cost of production are key factors in the development of the agricultural sector.

Water management is one of the main areas of the Republic, and it addresses complex issues such as the use of water resources, the prevention of pollution and the delivery of water to consumers, the efficient operation and repair of hydraulic structures. Different hydraulic structures are used in the industry, and pumping is one of the main priorities.

The total area of irrigated land in the republic is 4.3 million, of which 2.4 million hectares are provided by pumping stations. The balance of the Ministry of Water Resources has 1,688 pumping stations and 5231 pumping units. Every year, on average, 3000 pumping units undergo current or major repairs[1, 2].

Pumping stations in the Republic are a complex of hydraulic structures and pumping units that provide uninterrupted water supply to the distribution networks of farms or irrigation systems, or drainage or sewage.

In the agro-industrial complex, centrifugal and axial pumps are widely used at pumping stations in melioration and water management systems, which are simple in structure and have high efficiency rates.

The main details of the centrifugal pumps include wheels, a housing, a steering apparatus, shafts, bearings, swings and etc.

A pump or water discharge unit is a set of equipment that ensures the pump's performance and is mounted under the maxcus scheme.

From the center, the wheels, which are fitted with the blades on the centrifugal and rotary pumps, rotate in the hull. The motor that drives the engine affects the fluid and gives it a certain amount of energy, which is used to generate pressure.

The design and layout schemes of pumps of type "K" are shown in Figure 1, which consists of basic details such as pump housing 1, pump screw 8, and working wheel 3.

2. Methods

The water pump valve is made of St45 steel with 0.8 microns of subwoofer surface, working wheels and working surfaces with a coupling coupling of 1.6 microns, and surface hardness of 30-40 HRC. A general view of the pump shaft is shown in Figure 1.

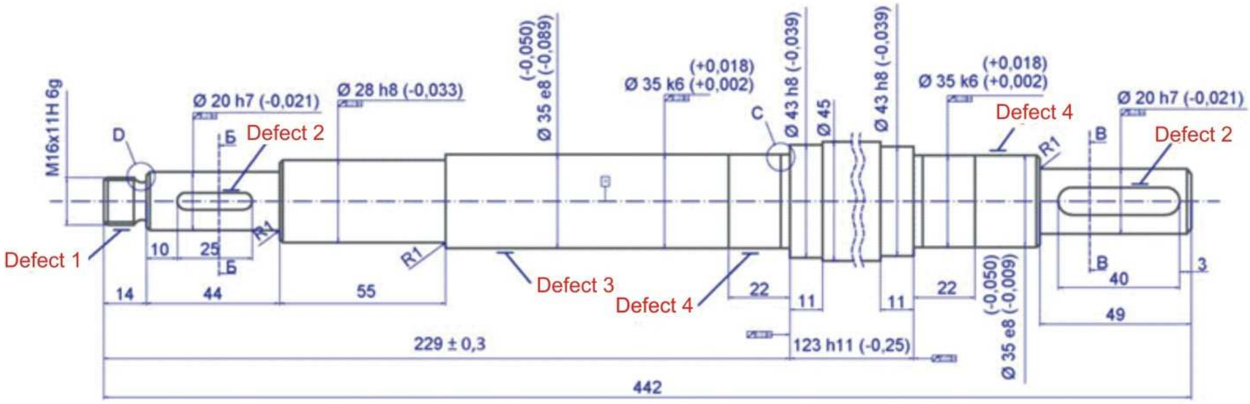

Figure 1. Pump screw repairs

These defects and their low durability require major upgrades of centrifugal pumps to improve the wear resistance of the working surfaces.

In the "SUVMASH" JSC, the method of metal melt coating is used to protect the water pump shaft.

Automatic liquefaction under the flux has a number of advantages as a method of detailing: high performance, low power and electrode metal, and the thicker layer (1.5-5 mm and thicker) can be made. The surface is flat, liquefied metal can be made with the necessary physical and mechanical properties; the quality of liquefied metal does not depend on the qualifications of the worker; Due to the absence of ultraviolet radiation the working conditions of welders are good.

There are also disadvantages of automatic liquefaction. For example, the detail is overheated, it is impossible to liquefy details with a diameter less than 40 mm due to the metal leakage and the difficulty of keeping the flux on the surface.

The recovered shafts in this method are 65-70% on average, which is due to the inability of thermal treatment.

As a result of the analysis of modern methods of valve repair, it is recommended to repair the shaft defects by means of metal coating and metal spraying.

3. Results and Discussion

Breakage of the shaft during operation leads to the complete failure of the pump, and the degradation is a complex process of metal remodeling under the influence of loads. Atoms are weakened and disconnected. Studies have shown that the causes of tire breakage are: metallurgical defects; residual stretch voltages; high local voltages in individual sections of shaft; inadequate radial passage between the walls and the bottom of the wedge; defects that occur during shaft repair. This is due to the fact that overloading of the shaft is caused by hydraulic forces in the flow side of the pump, especially when the operating mode is changed, heat expansion is uneven, and so on.

Repairing of centrifugal “K” shaft defects was performed and a diagram was made of the repair center of “Suvmash” JSC. Analysis of defect diagrams shows that fretting in bearing shafts is 60%, rack width - 30% wear, cracks - 20%, installation rods - 10%, work surface wear - 12%, breakage wire damage - 8%, fracture symptoms - 4%. The bending of the shaft is 10%, the repair of the shafts - 8%, the wear of the shafts - 24%, and other defects - 7%

In developed countries, metal spraying techniques are widely used for the repair of shaft-type details [3, 4]. However, as shown in the picture above, there are many species that need to be selected.

Advantages of the method:

- degrees of overheating of details (120 - 180^{0}C);
- high performance of the process;
- wear resistance of the coated surface;
- simplicity of the technological process and simplicity of the equipment used;
- ability to cover various metals and alloys up to 0.1-10 mm thick.

Disadvantages:

- relatively mechanical strength of coating;
- relatively low level of adhesion to detail surfaces.
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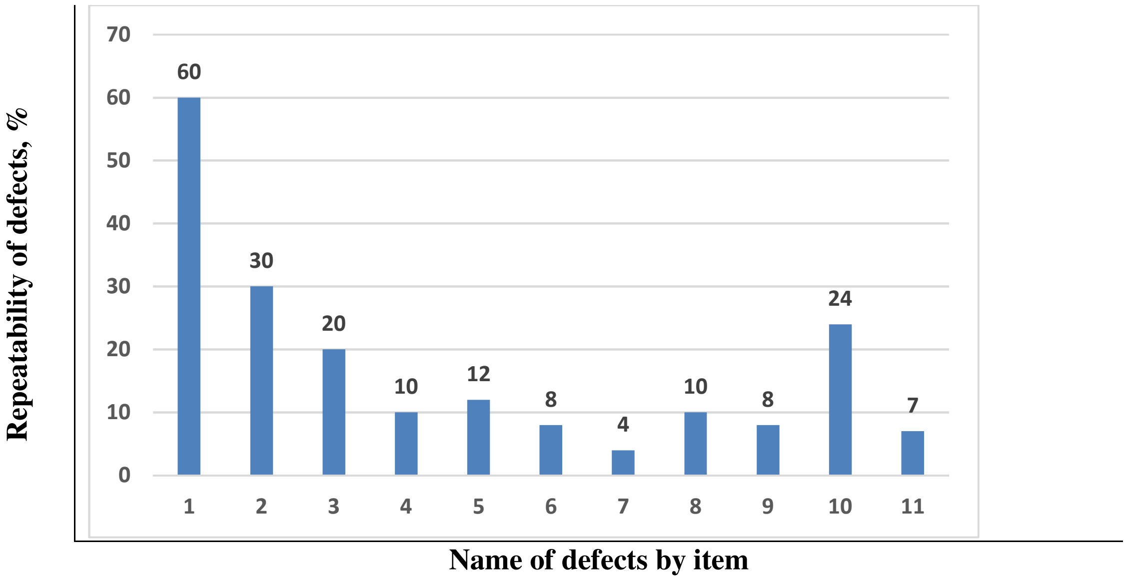

Figure 2. Diagram of shaft defects: 1 - folding between bearing and bearings, 2 - wide rod width, 3 - cracks, 4 - installation surfaces, 5 - working surface damage val bending, 9 - remont-sized shafts, 10 - valve tearing.

However, these disadvantages vary by species. Therefore, we will analyze some types of metal spraying. It is advisable to select plasma spray for different conditions, based on the analysis of gas flammable, electric arc, detane and plasma methods of metal spraying and the optimal method of recovery [5–16].

The issues of restoring the resource of parts by promising technologies with the use of special electrodes in surfacing, applying polymer materials, spraying powder materials were carried out by a number of researchers. In their works, they developed recommendations for the application of these technologies and substantiated the modes of application and processing of the increased layers[17–20].

The most common disadvantage of the valve operation is its wear on the subwoofer and the exhaust of the veneer, in many cases its value exceeds the set values. Therefore, it is recommended that these shafts be repaired and that their diameter is nominal only by plasma metal spraying on the surface.

Plasma Metal Coating Met-PCC (PLAS) and PS 50 Metallization Plasma Spray System are recommended.

Metal powder particle sizes are 70 ... 600 microns. In the case of less than 30 microns the coverage is high. Technological modes are as follows: current - 150 ... 200 A, voltage (120) 160 V, operating voltage - 40 ... 45 V, plasma gas consumption - 1.5 ... 2, 5 l / min, transport gas consumption - 5.7 l / min, consumption of gas - 16 ... 20 l / min, cooling water consumption - greater than 5 l / min, spray rate - 0.15 l / min. 0.18 m / min, distance from plasmatron to detail - 10 ... 18 mm. Figure 3 below shows the schematic diagram of the Plasma Plasma Met-PCC (PLAS) [21].

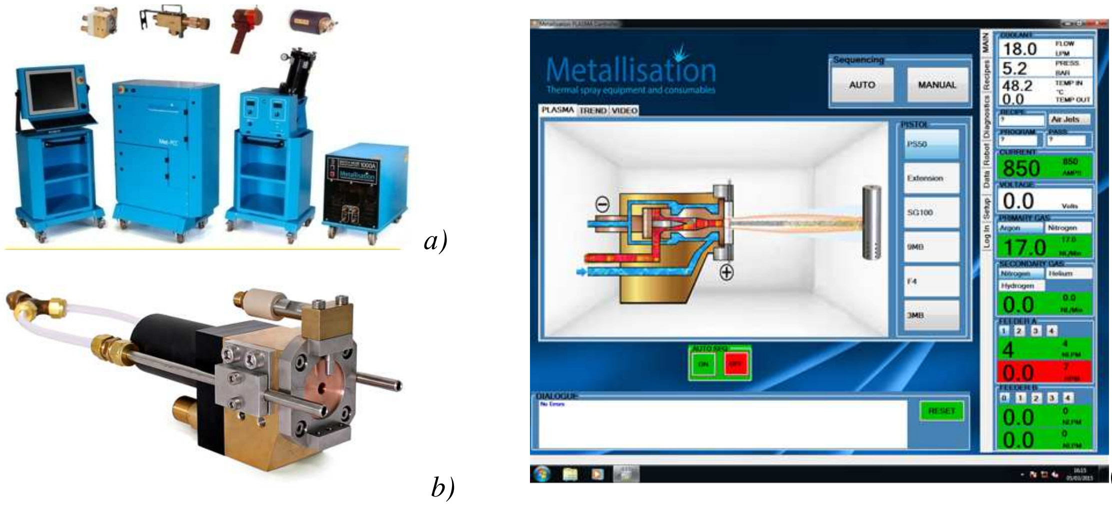

Figure 3. Plasma Met-PCC (PLAS) (a), plasmatron (b), and monitor (c).

A multivariate experiment was conducted to study the factors affecting the quality of recovery during the plasma metal spraying on the cervical neck and to develop a mathematical model that explains the strength of the coating adherence to changes in the value of selected factors.

The process is influenced by the following key factors that affect the quality of resource recovery:

X_1 - current, A - represents plasma formation rate and represents its rate of output.

X_2 - Plasmatron distance from detail surface, mm - temperature change of metal surface overheating.

Creation of the mathematical dependence of the coefficient of coating Y on the strength of the process X1 and the distance X2 during the processing.

The plan and results of the multi-factor experiments are presented in Table 1 below.

Table 1. Plan B_2 and the results of the experiment.

Name	Factors		Criteria for Optimization				Mean squared deviation
	I, A	L, mm	Coating adhesion strength, MPa				
	X_1	X_2	Y_1	Y_2	Y_3	Y_{av}	
High (+)	160	160					
Basically (0)	140	120					
Low (-)	120	80					
Plan of experiments							
1	-1	-1	173,78	174	173,5	173,7600	0,062800
2	1	-1	238,74	238,54	238,94	238,7400	0,040000
3	-1	1	166,9	167	166,7	166,8667	0,023333
4	1	1	231,86	231,56	231,76	231,7267	0,023333
5	-1	0	170,34	170,14	170,24	170,2400	0,010000
6	1	0	235,3	235,3	235,5	235,3667	0,013333
7	0	-1	202,66	202,4	202,5	202,5200	0,017200
8	0	1	195,78	196	195,98	195,9200	0,014800
						1615,1400	0,204800

All the coefficients of the regression equation describing the processing process were confirmed, and the resulting regression equation was:

$$Y = 199{,}25 + 32{,}5X_1 - 3{,}42X_2 + 3{,}55X_1^2 - 0{,}03X_1X_2 - 0{,}03X_2^2 \quad (1)$$

The following dependencies were used to convert the regression equation factor from the coded view to the natural one $x_1 = \frac{X_1 - 140}{20}$ and $x_2 = \frac{X_2 - 120}{40}$.

The view of the regression equation in the form of natural variables is as follows:

$$Y - 9{,}32 = 0{,}001375I^2 + 1{,}2445I - 0{,}07575L - 0{,}00001875L^2 - 0{,}0000375IL. \quad (2)$$

4. Conclusion

In repairing defective pump valves, it is recommended to repair the fretting corrosion (the value of wear 0.02-0.1 mm) by plasma spraying. The recovery quality of plasma spray treatment modes are the most optimal modes for plasma spraying using a model representing the strength of coating adhesion: current voltage of 160 A and the distance from the plasmatron detail surface up to 80 mm.

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