www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; SP-10(7): 261-264

www.thepharmajournal.com
Received: 01-05-2021
Accepted: 03-06-2021

Ch. Ramulu
(1) Former Ph.D. Research Scholar, Department of Farm Machinery and Power Engineering, GBPUAT, Pantnagar, Uttarakhand, India
(2) Former Research Scholar, Department of Farm Machinery and Power Engineering, IGKVV, Raipur, Chhattisgarh, India

M Arjun Naik
Research Scholar, Department of Farm Machinery and Power Engineering, GBPUAT, Pantnagar, Uttarakhand, India

AK Dave
Professor, Department of Farm Machinery and Power Engineering, IGKVV, Raipur, Chhattisgarh, India

I Srinivas
Principal Scientist, ICAR-Central Research Institute for Dry land Agriculture, Hyderabad, Telangana, India

Corresponding Author:
Ch. Ramulu
(1) Former Ph.D. Research Scholar, Department of Farm Machinery and Power Engineering, GBPUAT, Pantnagar, Uttarakhand, India
(2) Former Research Scholar, Department of Farm Machinery and Power Engineering, IGKVV, Raipur, Chhattisgarh, India

Cost economics of electro spark coated rotavator blades

Ch. Ramulu, M Arjun Naik, AK Dave and I Srinivas

Abstract
Rotavator has been most popularly used implement in agricultural field equipment. But the problem is that if abrasion conditions become too severe for ground engaging tools, the wearing of blades takes place. It adds the cost of equipment downtime and also it requires more frequent parts replacement. In this article, mainly focus on cost economics of electro-spark coated on rotavator blades. Electric spark coating (ESC) techniques was evaluated with tungsten carbide, stellite-21 and chromium carbide coating materials to improve the life of rotavator blade. The payback period of electro-spark coated tungsten carbide blade was found about 460 working hours or 1 year.

Keywords: rotavator blade, electro spark coating, wear loss, abrasion, electrodes, payback period

Introduction
Wear in agricultural machinery is mainly abrasive in nature as their soil-working tools come in contact with the soils which are abrasive due to quartz, stone and sand contents. Abrasive wear occurs when hard particles such as sand, stone pieces or hard materials slide or roll over the tool surface with certain pressure. Digging parts of tillers, seeding and excavating machines are exposed to abrasive wear in a non-stationary abrasive mass of soil. Tool wear can be reduced by hardening, shot peening and annealing. The surface of tiller blade, which is normally heat treated by the manufacturer, can be further improved upon to achieve higher wear resistance and strength by surface engineering techniques as high velocity oxy fuel (HVOF), thermal spray coating and gas tungsten arc welding (GTAW) (Mruthunjaya and Parashivamurthy 2014 & Karoonboonyanan *et al*. 2007) [3, 6]. Thermally sprayed coatings (WC-Co-Cr, Cr3C2NiCr and Stellite-2) were showed significantly improves the wear resistance rotavator blades (Kang *et al.*, 2012) [2]. Abrasive resistant coatings have been widely used to reduce or eliminate wear, extending the lifetime of products. Moreover, abrasive resistant coatings have been employed to strengthen mechanical properties, such as hardness and toughness (Linmin Wu *et al.*, 2014) [4]. However, studies on different surface treatments on rotavator blades are scarce.

Electro-spark deposition (ESD) is a pulsed-arc micro welding process using short-duration, high current electrical pulses to deposit an electrode material on a metallic substrate. It is one of the few methods available by which a fused, metallurgically-bonded coating can be applied with such a low total heat input that the bulk substrate material remains at or near ambient temperatures (Roger *et al*., 1986) [10].

Electro-spark coating is a deposition process that replaced the detonation-gun or HVOF processes, and provided orders of magnitude increase in wear and damage resistance, a five-fold improvement in corrosion performance, lower friction, and more than a 50% saving in cost, with the same material. Electro-spark coatings are reported to be resistant to wear and corrosion, they can be applied to ship propeller components, casting moulds, fuel supply system components, exhaust system components, and other machine components. The electro-spark deposited coating is characterized by non-etching structure. It remains white after etching. The surface layer is constituted in environment of local high temperature and high pressure (Alexander *et al*., 2003) [1]. Coating hardness is a function of the size d of grains (Musil, 2012) [8]. The surface of the tiller blade, which is normally heat treated by the manufacturer, can be further improved to achieve higher wear resistance and strength by surface engineering techniques, HVOF thermal spray coating, Gas Tungsten Arc Welding, and Electro Spark Coating. Electro Spark Coating is a deposition process replaced the detonation-gun or HVOF processes and provided orders of magnitude increase in wear and damage resistance, a five-fold improvement in corrosion performance, lower friction, and more than a 50% saving in cost, with the same material.

Considering all these points, conducted the study on two blades i.e. blade 1 and blade 2, coated on their surface where wear takes place by ESC using three hardened material electrodes i.e. Tungsten carbide, Stellite-21 and Chromium Carbide with 3 modes for each material.
No study has been conducted with ESC on rotavator blades. The present study was undertaken to examine the effect of ESC using tungsten carbide, stellite-21 and chromium carbide electrodes on wear properties of rotavator blades, and find appropriate electrode to reduce soil-engaging tool replacement cost.

Materials and Methods

The present study was undertaken at central research institute for dry land agriculture (CRIDA). Two types of new L-shaped rotavator blades (Blade 1 and Blade 2) were selected from two different manufacturing companies. The metallurgical compositions of these blades are given in Table 1. The technical specifications of the blades are given in Table 2.

Table 1: Element composition of selected rotavator blades

Blade/ Parameter	Unit, %								
	C	Si	Mn	S	P	Cr	Mo	Ni	Fe
Blade 1	0.29	0.22	1.30	0.012	0.024	0.37	0.05	0.19	97.544
Blade 2	0.28	0.32	1.33	0.014	0.038	0.38	0.03	0.14	97.468

Table 2: Wear loss of selected rotavator blades on weight and volume basis

Blade	Wear loss, % per hour	
	Weight basis	Volume basis
Blade 1	1.810	5.660
Blade 2	1.802	3.729

Before application of ESC proposed coating on front and back cutting edge surface of a rotavator blades, the surface was polished by using a mechanical polisher with blade grit 36 and diameter of 127 mm. After coarse grinding with mechanical polisher, blades were cleaned in solvent varnish to remove the paint layer and SiC (grit P180) to thinly remove the metal.
ESC coating was done using tungsten carbide, chromium carbide, and stellite-21 on the working surface of both Blade 1 and Blade 2 blades where wear takes place. To know the wear pattern a wear test study was conducted on field of uncoated blade. The coating area has been taken on this basis of wear pattern of uncoated blade. The wear damage appears to be starting from the outer end of the leading edge and moving inwards, towards the base of the blade (Kang *et al.*, 2012) [2].
Carbide coatings are sometimes preferred for tribological applications. Among various carbides, tungsten carbide and chromium carbide are most preferred. These kinds of coatings consisting of hard phases of carbides and tough matrix phase of metal, has been found to be one of the most promising materials and are one of the most extensively researched coatings (Murthy and Venkataraman, 2006) [7]. As the rotavator blade is mainly subjected to an abrasive wear, tungsten carbide, chromium carbide and Stellite-21 were selected as the coating materials on high tensile steel blades because of their good wear resistance characteristics (Mohanty *et al.*, 1996) [5]. Composition of tungsten carbide, stellite 21 and of chromium carbide is given Table 3. Table 4 and Table 5 respectively (Ramulu *et al.* 2018) [9]. Electro-spark coating (ESC) was done using three different hardened electrodes of tungsten carbide, stellite-21 and chromium carbide on rotavator blades by using ESC machine (Model ARCI 6M). The view of ESC coated rotavator blades before and after field operation is shown in Fig. 1.

Fig 1: A view of ESC coated rotavator blades (a) before, and (b) after field operation

Table 3: Composition of tungsten carbide

S. No.	Element	Composition (%)
1	Tungsten, W	75
2	Nickel, Ni	11.5
3	Carbon, C	5.6
4	Chromium, Cr	5.6
5	Iron, Fe	0.5
6	Others	0.8

Table 4: Chemical compdosition of Stellite 21

S. No.	Element	Composition (%)
1	Cobalt, Co	59
2	Chromium, Cr	29
3	Molybdenum, Mo	6
4	Nickel, Ni	3.7
5	Silicon, Si	1
6	Manganese, Mn	1
7	Carbon, C	0.3

Table 5: Composition of chromium carbide

S. No.	Element	Composition (%)
1	Chromium, Cr	58.5
2	Nickel, Ni	34
3	Carbon, C	7.5

The cost of different coating materials has been taken as per the prevailing market rates at the industry and it has same for all types of modes. On the basis of the area prone for wearing were identified for coating purpose. The specification of both blades is given in the Table. 6.

Table 6: Specifications of Blade-1 and Blade-2

Specifications	Blade-1	Blade-2
Horizontal length of blade (inch)	4.38	4.54
Width of blade (inch)	3	3.08
Effective Vertical length of blade (inch)	4.2	4.4
Thickness of blade (inch)	0.3	0.28
Cutting edge thickness (inch)	0.08	0.08

The total area of the coating for blade-1 and blade-2 were calculated about 32.21 inch² and 32.33 inch² respectively by taking 5.5 inch² as additional coating area for lab test.

Cost of electro spark coating per square inch area of coating by using different electrodes like Tungsten Carbide, Stellite-21 and Chromium Carbide are 30 Rs, 80 Rs and 100 Rs. respectively. The cost of one set (36 blades) electro spark coated blades 1& 2 are given in the Table 7&8 respectively.

Table 7: Electro spark coating cost for 1 set of coating treatments of Blade - 1 rotavator blades

Total surface area to be coated for 1 blade (inch²)	Cost of tungsten carbide coating		Total cost of stellite-21 coating		Total cost of chromium carbide coating	
	Cost of coating for 1 blade (30 Rs @ inch²)	Cost of coating for 1 set (36 No) Rs	Cost of coating for 1 blade (80 Rs @ inch²)	Cost of coating for 1 set (36 No) Rs	Cost of coating for 1 blade (100 Rs @ Inch²)	Cost of coating for 1 set (36 No) Rs
32.21	966	34776	2576	92736	3221	115956

Table 8: Electro spark coating cost for 1 set of coating treatments of blade 2 rotavator blades

Total surface area to be coated for 1 blade (inch²)	Cost of tungsten carbide coating		Cost of stellite-21 coating		Cost of chromium carbide coating	
	Cost of coating for 1 blade (30 Rs @ inch²)	Cost of coating for 1 set (36 No) Rs	Cost of coating for 1 blade (80 Rs @ inch²)	Cost of coating for 1 set (36 No) Rs	Cost of coating for 1 blade (100 Rs @ inch²)	Cost of coating for 1 set (36 No) Rs
32.21	969	34884	2586	93096	3223	116028

Results

Cost economics of electro spark coated blades

A cost economic of different coating treatments for rotavator blades were worked out. The tungsten carbide coatings were found to be better at different coating thickness modes and can be recommended for coating to improve the life of the blade (Ramulu *et al*. 2018) [9]. Hence the cost economics of Tungsten carbide coating has been worked out and it is given in Table 9.

Table 9: Cost economics of the tungsten carbide coating rotavator blades

Particular	Normal blade	Coated blade
Numbers blades for 1 set of blades 200 Rs @1 blade	36	36
Cost of coating	0 Rs	35000 Rs
Cost for1 set of blades	200 X 36 = 7200	42000 Rs
Cost of rotavator	95000 Rs	95000 Rs
Cost of the system	1,02,200 Rs	1,37,000 Rs
Hiring charges of rotavator per hour	300 Rs	300 Rs
Life for blade	200 hours	450 hours
The total amount received for the system if it given on hiring per 1 year	300 X 200 = 60,000 Rs	300 X 450 = 135000 Rs
Comparison	The time required for recovering the cost of system was 340 hours or 1 yr. 8 months	The time required for recovering the cost of system was 460 hours or 1 year

We can recover the cost of whole system within one year of rotavator operation with ESC tungsten coated blades.

Conclusion

The life span of ESC coated rotavator blade increases twice than uncoated rotavator blade with different electrodes (Ramulu *et al*. 2018) [9]. The payback period for recovering the cost of coated rotavator blades system was 340 annual working hours or 1 yr. 8 months.

References

1. Alexander VR, Orhan S. The use of bipolar current pulses in electrospark alloying of metal surface. Surface Coating Technol. J Vac. Sci. Technol 2003;168(2-3):129-

135.
2. Kang AS, Grewal JS, Jain D, Kang S. Wear behavior of thermal spray coatings on rotavator blades. J Therm. Spray Technol 2012;21(2):355-359.
3. Karoonboonyanan S, Salokhe VM, Niranatlumpong P. Wear resistance of thermally sprayed rotary tiller blades. Wear 2007;263:604-608.
4. Linmin Wu, Xingye Guo, Jing Zhang. Abrasive resistant coatings- A review. Lubricants 2014;2:66-89.
5. Mohanty M, Smith RW, Bonte MD, Celis LP, Lugscheider E. Sliding wear behavior of thermally sprayed 75/25 Cr3C2/Ni Cr wear resistant coatings. Wear 1996;198:251-266.
6. Mruthunjaya M, Parashivamurthy KI. Microstructural study and tribological behavior of wc-co coatings on stainless steel produced by HVOF spray technique. Int. J Mech. Eng. Technol 2014;5(1):132-139.
7. Murthy JKN, Venkataraman B. Abrasive wear behaviour of WC-Co Cr and Cr3C2-20(Ni Cr) deposited by HVOF and detonation spray processes. Surf. Coat. Technol 2006;200:2642-2652.
8. Musil J. Hard nanocomposite coatings: Thermal stability, oxidation resistance and toughness. Surf. Coat. Technol 2012;207:50-65.
9. Ramulu C, Dave AK, Srinivas I, Dhimate AS. Effect of Electro-spark Coating on Wear Loss of Rotavator Blades. Journal of Agricultural Engineering 2018;55(3):12-20.
10. Roger N, Johnson Sheldon GL. Advances in the electrospark deposition coating process. J Vac. Sci. Technol 1986;A4(6):2740-2746.