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Study on wear characteristics of tractor drawn rotavator blade of different steel materials

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■ **ABSTRACT :** A rotavator is popularly used to reduce the amount of time and labour spent in field preparation. However, wear of rotavator blades is very high, especially in sandy soil, which significantly affects its working life. The wear test of selected rotavator blades were conducted in circular soil bin made up of different steel materials like medium carbon steel (M_1), high carbon steel (M_2) and boron steel (M_3) to observe the effect of different steel materials on wear. The wear rate of M_1 blade, M_2 blade and M_3 blade were 26.36, 24.96 and 24.05 mg/min, respectively. The boron steel blade was found having maximum hardness 41.8 Rc followed by high carbon steel blade (41.3 Rc) and medium carbon steel blade (39.9 Rc).

■ **KEY WORDS :** Rotavator blade, Steel material, Wear test, Hardness of blade

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The rotavators do simultaneous ploughing and harrowing before and after rains. It can remove sugarcane stubbles or incorporate every kind of crop residue into soil mainly to improve soil organic health. It retains soil moisture, increases the soil porosity and aeration, a condition for enhanced germination and crop growth. It can be used for dry and wetland cultivation. This feature is attributed to the growing popularity of rotavators amongst Indian farmers.

In recent years rotavators are becoming popular among the farmers for land preparation where two or more crops are taken in a year. The results show that the rotavator saved 30-35 per cent of the time and 20-25 per cent in the cost of operation as compared to tillage by cultivator (Ramulu *et al.*, 2016). It gives a higher quality of work (25-30%) than as cultivator. Rotavator produces a perfect seedbed in fewer passes. It is well known that one operation of rotavator equal to one MB plough and 2 harrow operations.

A rotavator has a useful life of 2400 h (8 years) with an annual usage of 300 h. The local blades need replacement after 80-200 h of their use; however, imported blades need replacement after 250-30 h in normal soil. The local and imported blade sets are changed 23 times and 7 times, respectively during their entire service life. It is estimated that around 5 lakhs blades are required annually towards replacement and for new machines (Saxena, 2010). So the durability of the rotavator blade has to be increased to achieve the profit.

Most of the rotary blades are manufactured locally which are hardly at par with the standards in terms of material, shape, and size which affects the operational life of rotary tool (Kaur and Singh, 2013). Therefore, proper design of these blades is necessary in order to increase their working life and reduce farming costs.

The material used for making the rotavator blade is medium carbon steel since the wearing rate is more there is a need for the introduction of carbon and boron to the steel. As these materials have the ability to increase the hardness and wear resistance (Sapkale, 2017).

■ METHODOLOGY

A preliminary market survey was done to identify and select different materials used for fabrication. It has been observed that medium carbon steel is widely used for making the rotavator blades. Blades are mainly of 3 types L shape, C shape and J shape among these L shaped blades have the following advantages: It is the most common as it is better for killing weeds and in heavy trash. It causes less soil pulverization as compared to the C-shaped blade which is more suitable for wet soil as it has fewer tendencies to clog the rotor (Sakai, 1975). L shaped blade gives the greatest forward thrust/push to the tractor (Beeny and Khoo, 1970).

On this basis, three blades made up of medium carbon steel, high carbon steel and boron steel were selected as they are more commonly used in rotavators. A sample of Rotavator Blade is shown in Fig. A and the blade specifications are given in Table A.

Fig. A : Rotavator blade

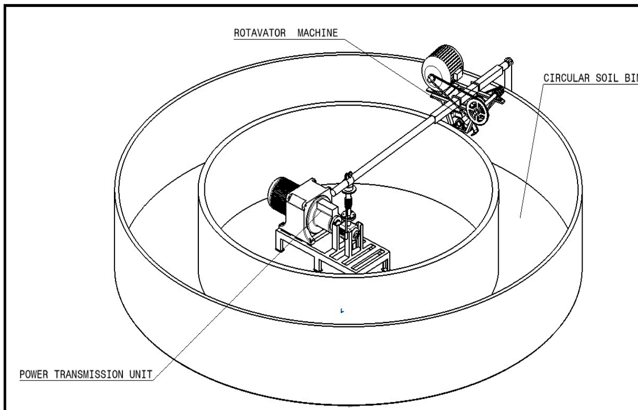

Fig. B : Experimental set up

Experimental set up:

Experimental setup was developed at Department of Farm Machinery and Power Engineering of CTAE, Udaipur (Fig. B).

– Indoor circular soil bin
– Control panel
– Power transmission unit
– Wearing unit

Test procedure:

Experimentation was carried out at farm machinery

Table A : Specifications of rotavator blade

Type	L shape		
Material	Medium carbon steel	High carbon speed	Boron steel
	Dimensions of blade		
Overall thickness	7.54 mm	7.40 mm	7.40 mm
Bevel edge thickness	0.95 to 2.8 mm	0.9 to 2.3 mm	0.9 to 2.3 mm
Length of bevel edge	227 mm	227 mm	227 mm
Width of bevel edge	18.9 to 21.80 mm	18.46 to 21.51 mm	18.46 to 21.51 mm
No of holes	two	two	two
Size of holes	Φ 11.53 mm	Φ 11.37 mm	Φ 11.37 mm
Spacing of holes	57.43 mm	57.42 mm	57.42 mm
Weight of the blade	1030. 5 g	1097.3 g	1097.3 g
Hardness	39.9 Rc	41.3 Rc	41.8 Rc

laboratory of CTAE, Udaipur where the experimental set up was installed. During the experimentation following steps were followed.

– Circular soil bin was filled with abrasive sand to the height of 600 mm. The height of abrasive sand was maintained uniform in the soil bin.

– One set of sample blade (it includes blade of each treatment) were carefully cleaned with water followed by acetone to remove dust and corrosion. It was then dried thoroughly. Now the blades were ready for observation.

– For gravimetric wear measurement, the blades were weighed by electronic digital weighing balance.

– For dimensional wear loss calculations, width and thickness of blade were measured by vernier caliper at 8 different sections of the blade.

– The gravimetric wear loss of blades was determined by taking the difference in weights of blades before and after operation. The reduction in dimensions with respect to width and thickness of each section was recorded for dimensional wear. Reduction in volume of blades was recorded for volumetric wear. Blades profile tracing on the graph paper was recorded to know wearing pattern.

RESULTS AND DISCUSSION

The effect of different steel materials like medium carbon steel (M_1), high carbon steel (M_2) and boron steel (M_3) on gravimetric wear, dimensional wear and hardness of rotavator blades was observed by using sand as an abrasive medium. The experiments were conducted at a depth of 100 mm, 0.7 m/s forward speed and five set of observations were taken at a regular interval of 20 hours in sandy soil.

Effect of working period:

The cumulative wear loss of medium carbon steel, high carbon steel and boron steel was recorded for 100 hours at an interval of 20 hours. It is evident from Fig. 1 that cumulative wear loss in all the blades increased with increase in working time. A linear relationship between cumulative wear and period of work was observed. The wear loss was found to increase 5 times as the working

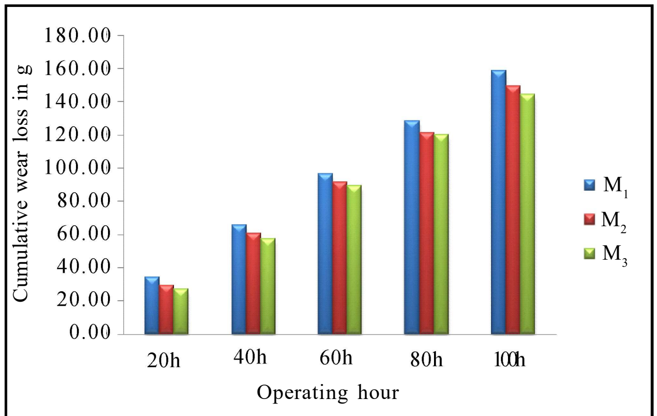

Fig. 1 : Effect of operating hour on blades of different steel materials

Table 1 : Wear rate of different blades after 100 h of operation

Sr. No.	Materials	Wear loss after 100 h, g	Wear rate, mg /min
1.	Medium carbon steel- M_1	158.2	26.26
2.	High carbon steel- M_2	149.8	24.96
3.	Boron steel- M_3	144.3	24.05

Table 2 : Analysis of variance for the effect of materials (M), operating hour (t) and forward speed (S) on gravimetric wear loss

Source of variance	DF	SS	MS	F	SE (m)
Material (M)	2	5412.195	2706.098	145.7366**	0.004462
Operating hour (t)	4	478363	119590.7	6440.546**	0.00446
Forward speed (S)	1	18500.03	18500.03	996.3173**	0.001
M x t	8	141.4866	17.68582	0.952468**	0.009978
M x S	2	297.0311	148.5155	7.998287**	0.0004
t x S	4	1062.754	265.6884	14.30862**	0.001
M x t x S	8	163.3853	20.42317	1.099887**	0.3639
Error	53	0.0149263	0.00029563		

** indicate significance of value at P=0.01, CV = 0.92

time increased from 20 h to 100 hours.

The overall wear rate for above three blades after 100 working hour is shown in Table 1. The wear resistance and hardness increases as the carbon percentage in steel is increases. The wear rate of boron steel is 24.05 mg/min which is 0.091 per cent more than the medium carbon steel after 100 h of operation.

Analysis of variance for the effect of treatment and time of gravimetric wear loss:

Statistical analysis was also carried out to find the significant differences between the treatments. ANOVA presented in Table 2 shows that the interaction effects of steel materials (M), operating hour (t) and forward speed (S) were highly significant on wear. The analysis further reveals that the interaction effect of steel materials x operating hour x forward speed, (M x t x S) was also found significant.

Dimensional wear:

Dimensional wear loss was measured for each section of the blade from section S_0 to S_7 and presented in Fig. 2 for all treated blade sample. In general, the blade with all treatments wore out along the width. There was negligible change in length. The wearing pattern shows that the width of the blade decreases from section S_7 to S_0. Reduction in width in all three types of blades follows the same pattern. It also shows that wear loss was maximum at the tip (S_0) of the blade and it gradually decreased while moving towards section S_7. This was due to the resultant of the soil reactions acting around the tip of the blade. The rate of wear was directly proportional to the magnitude of confining stress. The confining stress increases with the depth of operation of a blade. Therefore, the part of the blade which was close to the soil surface has minimum rate of wear.

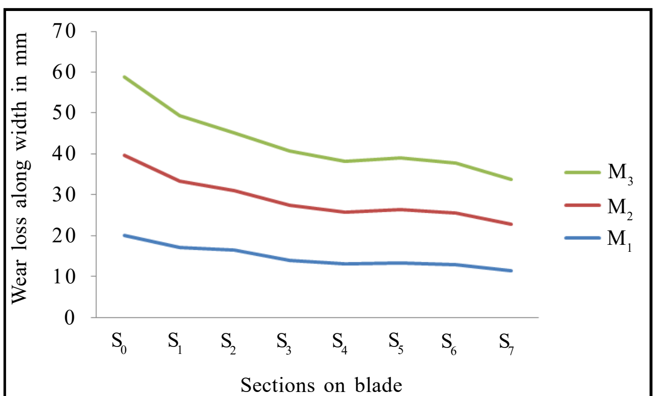

Fig. 2 : Wear along width of different blade at different section

Determination of hardness:

Hardness of sample rotavator blade was measured on the rockwell hardness testing machine. The boron steel blade was found having maximum hardness 41.8 Rc followed by high carbon steel blade (41.3 Rc) and medium carbon steel blade (39.9 Rc). The hardness of different steel materials was shown in Fig. 3.

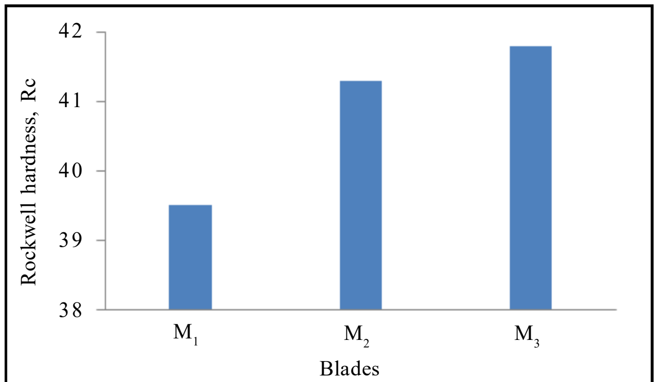

Fig. 3 : Hardness of blade

Conclusion:

– The wear rate of boron steel blade (M_3) is 24.05 mg/min which is 0.091 per cent more than the medium carbon steel after 100 h of operation. The hardness of the boron steel was found 41.8 Rc which was followed by high carbon steel (41.3 Rc) and medium carbon steel (39.5 Rc).

– The rotavator blades with different blades wore out along width and thickness**.** There was negligible change in length. The reduction in width in all the blades followed the same pattern. The wear loss was at the tip of the blade and it gradually decreased while moving away from the tip of the blade.

– Boron steel blade (M_3) was found best rotavator blade and gave minimum wear rate compare to other two blades.

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