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Studies on wear characteristics of selected rotavator blades

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■ **ABSTRACT :** Tillage is the most important unit and more energy consumption operation in agriculture. The most widely accepted method of tilling land is ploughing with plough and cultivators. These invert the upper soil layer, without proper mixing of soil, hence, these needs additional operations of rotavator and harrow to improve soil tilth on the ploughed land. The tractor mounted rotavator holds promise for overcoming these problems. Rotavator under dynamic loading, blades are subjected to fatigue and abrasive wear. Abrasive wear has been emerged as a serious problem in rotavator blades. It increases the down time and maintenance cost. The objective of this study was to identify the suitable material for reducing of wear of rotavator blades. For this study a preliminary survey was conducted in the region (Telangana) to know the popularity of rotavator and types of blades being used by farmers, it was found that L types of blades are more in numbers in the region with the two make of rotavators, from this study we have selected a two rotavator blades *i.e.* blade1 and blade 2 .The study revealed that there was wide variation in element composition and mechanical as well as micro-structural properties of these rotavator blades, the wear loss percentage of blade1 higher than the blade 2 and It was also found in the study blades which are selected manufactured locally are hardly at par with the standards in terms of material.

■ **KEY WORDS :** Rotavator, Abrasive wear, Tillage, Hardness, Wear loss

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Tillage is the most important operation and more energy consumption operation in agriculture. It is done mainly to loosen the soil, to mix with fertilizer and to remove weeds. The implements used for tillage are MB plough, cultivator, disc plough, rotavator etc. The energy required in wheat cultivation for tractor drawn cultivator and disc harrow was about 3828 MJ/ha and for rotavator was about 2586 MJ/ha (Singh *et al.*, 1989). From the above statement tractor drawn rotavator saves 32.4 per cent energy than tractor drawn cultivator and disc harrow in wheat cultivation. Now-a-days the adoption of rotavator was risky for farmers due to wearing of soil engaging parts. This wear problem is caused due to when soil engaging parts penetrate into the soil, soil resistance forces, frictional forces etc. acted upon soil engaging parts.

The chemical composition of the steels to be used for the manufacture of rotavator blades shall be as follows: carbon steel: carbon 0-70 to 0.85 per cent, silicon 0-10 to 0-40 per cent, manganese 0.50 to l.0 per cent, sulphur 0.05 per cent, max phosphorus 0-05 per cent, max. silica, manganese steel: carbon 0.50 to 0.60 per cent, silicon 1.50 to 2.00 per cent, manganese 0-50 to 1.00 per cent, sulphur 0.05 per cent, max phosphorus 0.05 per cent, max IS: 6696 (1981).

The wear in agricultural machinery is basically abrasive in nature because such tools usually come in contact with the soils which are abrasive due to quartz, stone and sand contents etc. Abrasive wear means removal or displacement of material from solid metallic surface due to pressure exerted by continuous sliding of hard soil particles. Abrasive wear occurs when hard particles such as sand, stone pieces or hard materials slide or roll over surface with certain pressure all the digging parts of tillers, seeding and excavating machines are exposed to abrasive wear in a non-stationary abrasive mass of soil. An estimation of material loss in cereal cultivation in Turkey indicates that for cultivating an area of 13422 000 hectare twice, an amount of 9700 tonnes of steel is lost due to wear and abrasion and that the energy equivalent of this material loss has been found to be 897 GJ (Karamis, 1987).

When abrasion conditions become too severe for ground engaging tools, or when the cost of equipment downtime requires more frequent parts replacement. There must be a need to study on wear characteristics of rotavator blade as well materials and methods to reduce wear.

■ METHODOLOGY

A preliminary survey was conducted in the region to know the popularity of rotavator and types of blades being used by farmers. The review was also done to have the stock of situation in reference to type of blades. It was found that L types of blades are more in numbers in the region with the two make of rotavators *i.e.* blade 1 and blade 2. The blade 2 and blade 1 are shown as a and b in the Plate A.

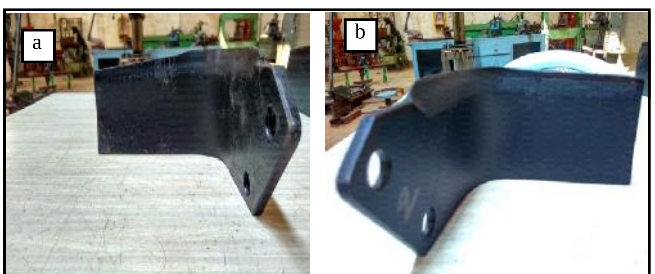

Plate A : Selected rotavator blades

The composition of these blades was determined by using optical emission spectrometer (Plate B). As per the standard methodology, it is necessary to have a sample piece of blades having at least 1 sq inch area for the purpose of element analysis.

Plate B : A view of optical emission spectrometer

Hardness means resistance to penetration. In this study the hardness was measured by using rockwell hardness tester. Testing is typically performed on flat or cylindrical samples. Smooth parallel surfaces, scale and gross contamination, are required for testing. The size of samples about 1 inch dia and 7.5 mm thick were tested. Samples 6 in. (150 mm) thick or larger can be accommodated. The minimum sample size depends on the sample hardness and test scale. Cylindrical samples are as small as 1/8 in. (3 mm) in diameter, and thin sheets 0.006 in. (150 μm) thick, are the minimum size for testing.

Determination of wear loss :

An area of 9.20 ha in CRIDA Hyderabad was selected for testing of coated blades during September 2015 to April 2016. The field was free from any cultivation. The whole field was divided in two parts for testing of blade 1 and blade 2 separately. The rotavator was operated for three different durations *i.e.* 2, 7.5 and 10 hour. The time period was selected looking to field condition which was fully dried, which allows to judge the coating performance. The same time of duration was also suggested in review of literature, if field is fully dried. By doing so, the wear characteristics of blades in field conditions were observed. The general condition of soil in this area was hard, dry and clay loam soils with stones. The bulk density of soil was 1.35g/cm^3.The high abrasiveness of the soil and high impact load on the blade surface results in a significant acceleration of the wear of the blades. The experiments were conducted on February 2016. The rotavator was driven by a tractor (5245 DI Massey Fergusson, Planetary drive, 47 HP, 3-cylinder, Forced water cooled) through its power take-off (PTO) shaft at the speed of 540 rpm@1790Erpm. Average traveling speed was about 1.21 km/h, yielding theoretical field capacity of about 0.72 acre/h. The average depth penetrated in the soil about 7.4cm and fuel consumption was 2.65lit/hr.

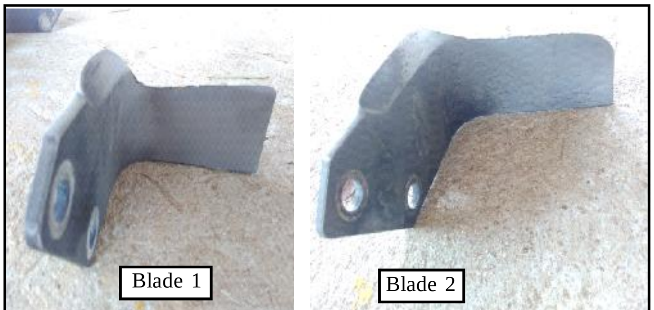

Plate C : Selected rotavator blades after field operation

This test blades were fitted onto the tractor mounted rotavator in place of the standard blades randomly and the field experiment was carried out on a test field for a 10h. In this study the readings were taken at different time intervals *i.e.* 2.0h, 7.5h and 10h for measuring wear loss on weight and volume based. The weight readings were taken by using electronic weigh machine before operation and after operation (Plate D).

Plate D : A view of measurement of volume and weight of blade

The wear of the blades was assessed by weighing each blade before and after each experimental period to determine the wear loss. The percentage of wear (weight based) loss defined as the ratio of differences of rotavator blades weights before and after experimental period divided by weight of rotavator blades before experimental period.

$$\text{Wear loss (weight based) (\%)} = \frac{\text{Weight before the operation} - \text{Weight after the operation}}{\text{Weight before the operation}} \times 100 \quad (1)$$

Volume losses of blade were also assessed by measuring the volume of each blade before and after each experimental period to determine the volume loss. For measuring volume of the blades one bucket of 20 lit capacity with scaled on it was taken. Then it was filled upto 5 lit of water. After this we kept the blade into that bucket. Then the volume of that bucket would be increased. Then taken the reading after volume increased. The volume of blade would be the volume of water after keeping blade minus the volume of water before keeping blade. Likewise we have measured the volume of all the treatments before and after field operation.

Percentage of wear loss (volume based) is defined as the ratio of differences of rotavator blades volume before and after experimental period divided by volume of rotavator blades before experimental period. Percentage of wear loss was used as indicator of amount of wear or performance of blade. Lower the percentage of wear, the performance more or lesser amount of wear.

$$\text{Wear loss (volume based) (\%)} = \frac{\text{Volume before the operation} - \text{Volume after the operation}}{\text{Volume before the operation}} \times 100 \quad (2)$$

The microstructure study was observed by using SEM (scanning electron microscope). The size of samples used for measurement of microstructure was about 10x15x7mm^3, the sample should be prepared like mirror surface prior to observing with SEM. The sample which is to be tested was polished by using different silicon carbide papers of different grits 180,200, 400, 800, 1200 and final finishing was done by using mechanical polisher. After this step the sample was etched by 100g nital solution (3-5g H_2SO_4 and 95-97g ethanol). The microstructure study was observed both the blades before and after operation.

■ RESULTS AND DISCUSSION

In this study two types of rotavator blades namely blade 1 and blade 2 were selected for determination of element composition, hardness and wear characteristics. The composition of these blades was determined by using optical emission spectrometer. The chemical composition is shown in Table 1.The control blades were used for tillage operations and the wear loss on weight and volume basis were recorded. The results of control blades are shown in Table 2. The hardness of blades was also measured to know the wear characteristics the results are shown in Table 3. However, their comparative analyses with coated blades are described in further sub sections.

Blade 2 has the more wear loss compared to blade

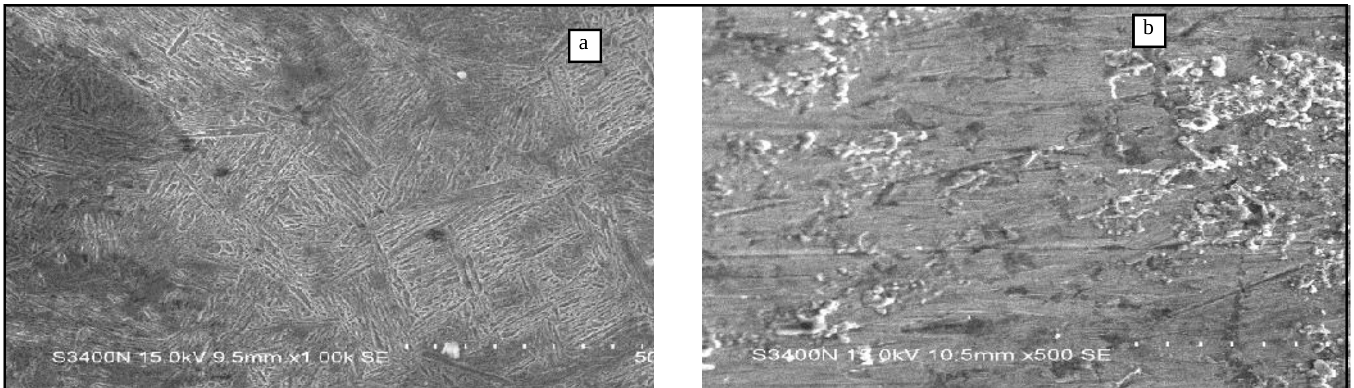

Fig. 1 : Micro structure of control blade 1 before and after operation

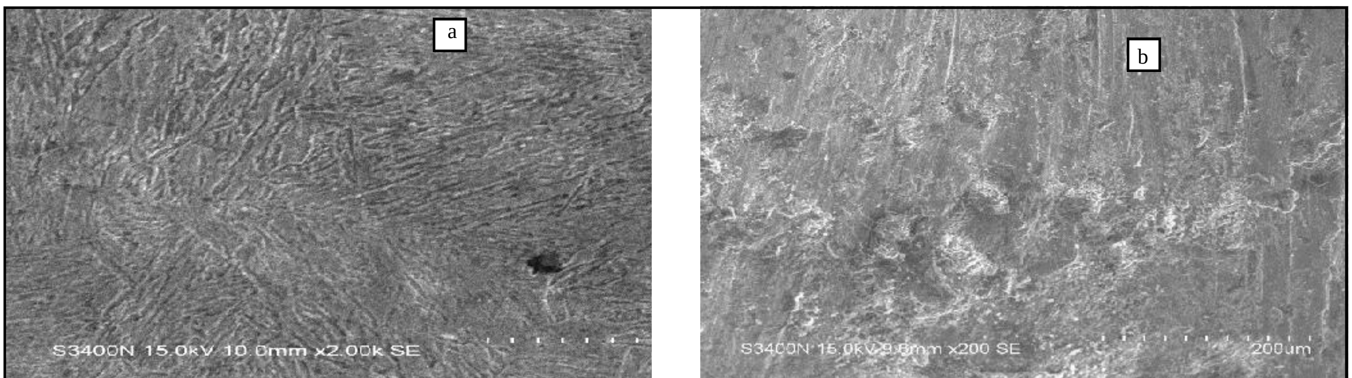

Fig. 2 : Micro structure of control blade 2 before and after operation

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

Table 3 : Hardness of selected rotavator blades

Blade	Hardness, HRA
Blade 1	44.66
Blade 2	45.33

1 it means blade 1 has the more wear life than blade 2. The hardness of blade 2 was more than blade 1. Fig. 2 that blade 2 had the Cr and Si more than blade 1 Cr and Si composition. Chromium has significant effect on fatigue life. Higher hardness and strength in boron and chromium steel is due to mixed martensite-bainitic microstructure (Bhakat *et al.*, 2007). Blade 1 had higher wear resistance and hardness it might be due to this above mentioned statements.

Microstructure study of blade 1 :

The microstructures of blade 1 and blade 2 were shown in Fig. 1 and 2. The both rotavator blades have martensitic structure on their surface, it is shown in Fig. 1(a) and 2(a). Rough wear tracks also observed in both blades, it was shown in Fig. 1(b) and 2(b). Blade 2 has shown the marten sic structures clearly than blade 1. Marten sic structure improve the wear resistance of blades. In this study also blade 2 had higher wear resistance than blade 1.

Conclusion :

After conducting the above study, the study concludes that.

- The wear loss on weight and volume basis was on higher in case of blade 1 in comparison to blade 2
- The hardness was also on lower side in case of blade 1. It concludes that blade 2 having lower wear loss and higher hardness value.
- From the microstructure study also blade 2 had higher wear resistance than blade 1.
- From the comparison of both elements composition blade 2 has Si, P and Cr content more than blade 1 it might be concluded that Si, P and Cr composition increases wear resistance.

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