Effect of Chromium Content Variation on Wear Resistance of Rotavator Blades

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Abstract - *Chromium is a vital constituent of Rotavator blades and affects the hardness of blades. Rotavator blades face abrasive wear when it is used in fields to condition the soil, which severely affects its working life. The objective of this study was to increase the life of the rotavator blade made of EN-42J spring steel by means of hard facing. Two types of iron-based hard facing electrodes with range of Chromium (23% – 29% approximately by weight) were used to deposit on the rotavator blade. Two different hard facings namely H-23Cr and H-29Cr were deposited by manual metal arc welding (MMAW) on rotavator blade. Pin-On-Disc (ASTM G99) test was done to calculate wear rate of the hard faced and un-hard faced samples of rotavator blades. The results showed that the hard faced EN-42J has shown high wear protection as compared to un-hard faced EN-42J. The wear rate was minimum in case of H-29Cr hard facing. The H-29Cr–EN-42J hard facing-substrate combination showed maximum wear resistance. From the test result the wear rate of the un-hard faced blade was 1.679 gm/hr, while those of the H-29Cr and H-23Cr hard facing alloys were 0.112 gm/hr and 0.239 gm/hr respectively.*

***Key Words*: Rotavator blade, Abrasive wear, Hard-facing, Manual metal arc welding, Pin-on-disc.**

1. INTRODUCTION

In agriculture tools, sugar industry, mining and others, the weld deposition of hardfacing metal is used to increase hardness and abrasive wear resistance of the mechanical components. Degradation of materials by wear results in very high losses in industries, agricultural, constructional, metal working etc. The surface characteristics of engineering materials have a significant effect on the service life of a component which cannot be neglected in design. Surface engineering deals with methods for achieving the desired surface characteristics and their behaviour in service for engineering components. [9]Wear is a surface phenomenon and occurs mostly at outer surfaces. Every part that moves in service will be subjected to wear at the contact point between two Parts. The consequence result of this wear is that the parts need to be replaced, which increase cost and downtime on the equipment. The surface characteristics of engineering materials have a significant effect on the serviceability and life of a component which cannot be neglected in design. Abrasion is one of the important and common wear factor which counts for the maximum of wear losses. Wear resistance of materials can be improved through surface modification techniques. [9] Surface treatment is recent and gaining importance. There are numerous techniques and materials existing for modification of the surface properties of substrates. But, their success rate depends on an appropriate selection of the techniques/materials depending on the application of the modified components. Among many techniques of surface modification, hardfacing has been significantly effective in cases where close dimensional tolerances are not required.[7] In this study, Hardfacing technique, done by mode of Manual Metal Arc Welding, while depositing material with different chromium content to improve abrasive wear resistance of rotavator blades has been discussed.

2. EXPERIMENTAL WORK

In this experiment, EN-42J has been used as a test material, which is the material of rotavator blade. EN-42J is hard faced with two welding electrodes having different chromium composition and hard faced specimen is subjected to abrasive wear with the help of Pin-On-Disc (ASTM G99) test and corresponding weight loss was noted and calculated to analyze the wear improvement result. The following is the composition of base material [EN-42J] and hard facing electrodes [H-23Cr and H-29Cr]–

Table 1

Composition of EN42J

C%	Mn%	Si%	P%	S%	Cr%	Cu%
0.80	0.76	0.25	0.032	0.028	0.35	0.13

Table 2

Chemical Composition of H-23Cr Electrode by wt%

C%	Mn%	Si%	S%	P%	Cr%	Mo%	Nb%
4.5	1.6	0.8	0.03	0.03	28.8	1.3	0.6

Table 3

Chemical Composition of H-29cr Electrode by wt%

C%	Mn%	Si%	S%	P%	Cr%	Mo%	Nb%
4.8	0.7	2	0.03	0.03	12.5	1.6	0.5

Selection of the hardfacing electrodes was done on the basis of the chemical composition of the rotavator blades. From the literature survey it was found that number of alloying elements like Cr and C etc. can be added into the substrate in the form of weld consumables to improve wear resistance. The welding electrodes, H-23Cr and H-29Cr have different composition with 23% and 29% chromium respectively, which is the alloying element responsible for increasing the hardness and wear resistance of hard faced surface. The reason for selecting chromium as hardfacing element is that the literature survey has suggested that chromium is most effective element helpful in enhancing abrasive wear resistance.

HARDFACING PROCEDURE

Hardfacing is a low cost method of depositing wear resistant surfaces on metal components to extend service life. Among the surface modification techniques used in engineering applications, hardfacing probably is the most common one to improve the wear resistance of the components.Hard facing has been done on the EN-42J specimens with the help of Manual Metal Arc Welding. Welding with stick electrodes is called Manual Metal Arc Welding (MMAW) or Shielded Metal Arc Welding (SMAW). In this process heat required for fusion is generated by the electric arc formed between a metallic electrode and the base metal as shown in Fig 1. The electrode is consumed in the arc and provides the filler metal on the substrate. The extremely high arc temperature of over 5000°C permits it to supply a large amount of heat. Among the arc processes, manual metal arc welding is the most common, versatile, inexpensive one, and has advantages in areas of restricted access.

MMAW PROCESS

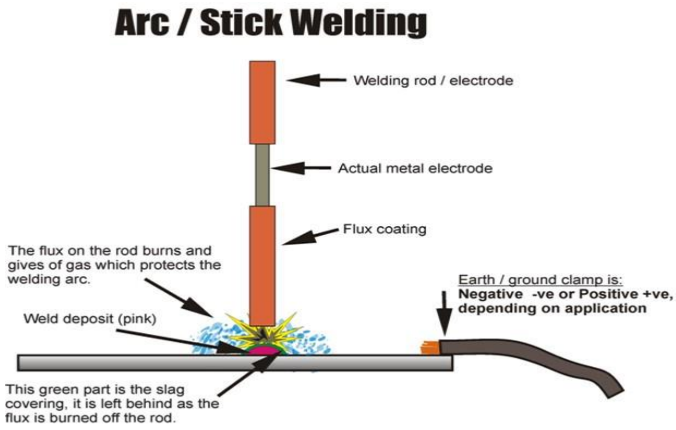

Figure 1. Manual Metal Arc Welding (MMAW) [9]

MMAW Power Source

Drooping or constant current type power source was used, the reason being that with this type of characteristics, the welding current remains substantially constant, irrespective of small variation in arc length and consequent slight change in arc voltage, which are unavoidable even in the case of a skilled worker. As the welding current is fairly steady, the weld quality is consistent. MMAW requires a high current (50-300A) but relatively low voltage (10-50V), high voltage mains supply (240 or 440V) must be reduced by a transformer. To produce DC, the output from the transformer must be rectified. Direct Current was used for in welding because DC has the advantage of two polarities, which means that the electrode can be made negative or positive. Straight polarity (i.e. electrode negative) can be used for MMAW of all steel, but not for most non –ferrous metals. With straight polarity, more of the arc heat is concentrated on the electrode and consequently melting and deposition higher deposition, welding is more rapid and the distortion of work piece is less.

Specimen Preparation

The Test pins were hardfaced for laboratory tests by using four different types of commercial hardfacing consumables in the rod form used as per the direction of the electrode manufacturers. The substrate material used for sample preparation for laboratory tests is spring steel EN-42J having diameter 14 mm and length 60 mm. The pins of diameter 14 mm and length 60 mm were prepared on lathe machine.

Figure 2. Preparation of test pins

Figure 3. Hardfaced pins

Hardfacing was done on these samples by using two different types of commercial hardfacing electrodes by MMAW process. Due to high hardness of the deposited layers the samples were machined on cylindrical grinding machine. After the completion of the hardfacing process upon the cylindrical pins which is done only at one end, there was the lathe operation on the pins to attain the final length of 30mm. After this, there was the grinding operation to smooth the surface and to attain final diameter of 8 mm to meet the specifications required for the proper tests to be performed upon the pin on disk wear testing machine.

Fig 4: Cylindrical pins (30mm x 8mm) prepared for pin on disc test

For laboratory tests, figure 4 shows the samples which were prepared in the form of cylindrical pins having final diameter of 8 mm and length of 30 mm with the help of lathe machine on the surface and cylindrical grinding machines.

WEAR TEST (ASTM G-99)

The specimens were then subjected to wear tests on a pin-on-disc test apparatus, which is shown schematically in Figure 5. The pin-on-disc test is generally used as a comparative test in which controlled wear is performed on the samples to study. The mass lost allows calculating the wear rate of the material.

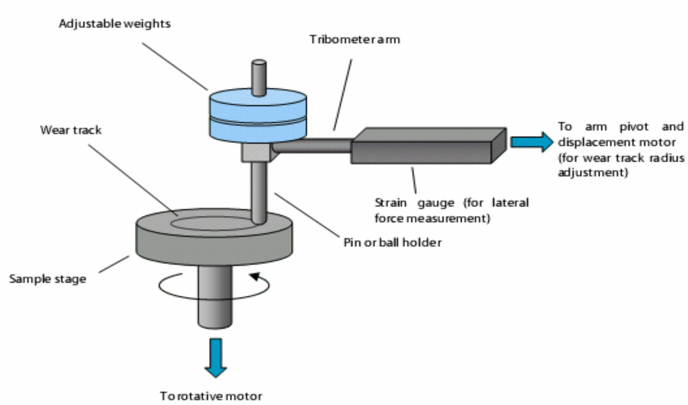

Figure -5. Schematic illustration of the pin-on-disc wear test

It is equipped with a variable speed motor and the speed can be changed at any time during the tests. All weight measurements were carried out on a 0.1mg precision balance. The counter face disc was made of carbon steel EN-31 of 62-65 HRC in hardness. The tests were carried out under loads of 30 N, 40 N and 50 N. During the tests, the specimens were located 80 mm away from the disk centre and disk was revolved at 239 rev. /min. Wear tests have been carried out in 3 cycles of 10 min, 20 min and 40 min duration. Mass losses for pins were measured after each cycle to determine the wear loss. A Linear Variable Differential Transducer (LVDT) measures wear between specimen pin and disc. The maximum wear of 2 mm can be measured. Frictional force between pin and rotating disc is measured by a load cell.

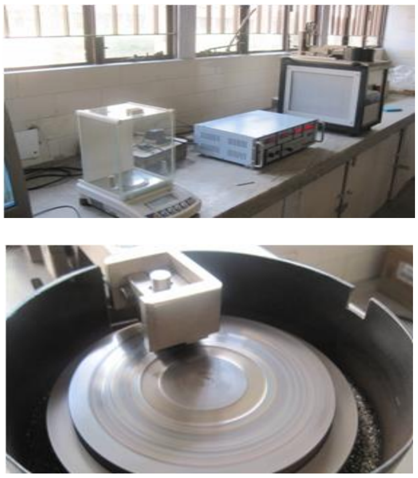

Figure 6 Wear Testing Apparatus as per ASTM G99 standards

III. RESULTS & DISCUSSIONS

The tables are formed for weight loss of material and graphs are made for the comparison of effect of different hard facing electrodes. Results of Laboratory tests have been reported and the following results are obtained after experimentation.

WEIGHT LOSS DETERMINATION

The weight loss of all samples are calculated by subtracting the final weight of sample after abrasive wear from initial weight of samples before abrasive wear and on the basis of same, the rates of wear of samples per unit time have been determined both for hardfaced as well as un-hardfaced samples and comparison made among the different types of samples. The weight loss is measured three times in every cycle of 10-20-40 minutes for the proper determination of the readings. This makes the complete cycle of 60 minutes as discussed above. Same precision is followed for the each weight loss reading to measure. The following table shows the weight loss of hardfaced and un- hardfaced material which are tested upon the pin on disc machine in laboratory.

Table- 4 Wear Loss Of Hardfacing Electrode H-29Cr.

Hard facing Type	Load (N)	Time (min)	Initial wt. (gms)	Final wt. (gms)	Weight. Loss (gms)
H-29Cr	30	10	13.8124	13.8120	0.0004
		20	13.8120	13.8112	0.0008
		40	13.8112	13.8096	0.0016
	40	10	15.1049	15.1042	0.0007
		20	15.1042	15.1031	0.0011
		40	15.1031	15.1012	0.0019
	50	10	14.3436	14.3429	0.0007
		20	14.3429	14.3419	0.0010
		40	14.3419	14.3397	0.0022

Table- 5 Wear Loss Of Hard Facing Electrode H-23Cr

Hard facing Type	Load (N)	Time (min)	Initial wt. (gms)	Final wt. (gms)	Weight. Loss (gms)
H-23Cr	30	10	14.3404	14.3402	0.0021
		20	14.3402	14.3400	0.0023
		40	14.3400	14.3383	0.0040
	40	10	15.3560	15.3557	0.0027
		20	15.3557	15.3543	0.0041
		40	15.3543	15.3534	0.0050
	50	10	13.3356	13.3351	0.0027
		20	13.3351	13.3345	0.0033
		40	13.3345	13.3322	0.0056

Table- 6 Wear Loss of Un- Hard Faces Base Material EN-42J

Hard facing Type	Load (N)	Time (min)	Initial wt. (gms)	Final wt. (gms)	Weight. Loss (gms)
Spring Steel EN 42J	30	10	11.8563	11.8477	0.0265
		20	11.8477	11.8346	0.0396
		40	11.8346	11.8014	0.0728
	40	10	10.9796	10.9657	0.0408
		20	10.9657	10.9393	0.0672
		40	10.9393	10.8942	0.1106
	50	10	11.1636	11.1446	0.0460
		20	11.1446	11.0986	0.0920
		40	11.0986	10.9533	0.1453

From the tables, it is shown that the sample of H-23Cr hardfacing has also undergone the greater weight loss as compared to the H-29Cr sample. The following figures show the comparison between the hardfaced and un- hardfaced material in the graphical representation at 30N, 40N and 50N load. The graphs are plotted between weight loss and the sliding distance on the disk i.e. 1m/s. the vertical line shows the weight loss and horizontal line shows the sliding distance. All the hardfaced and un-hardfaced graphs plotted collectively at different loads for comparison.

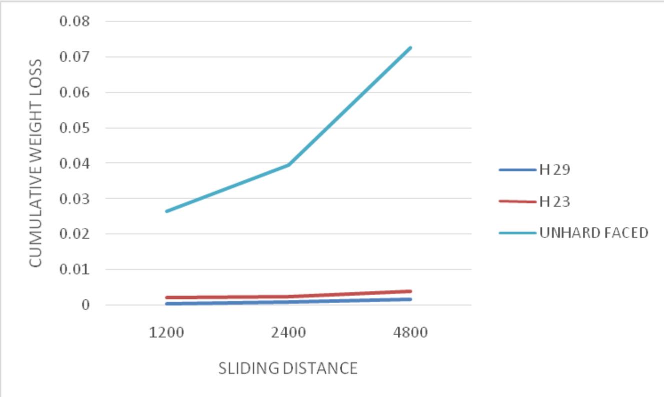

Fig -7 Weight loss at 30N

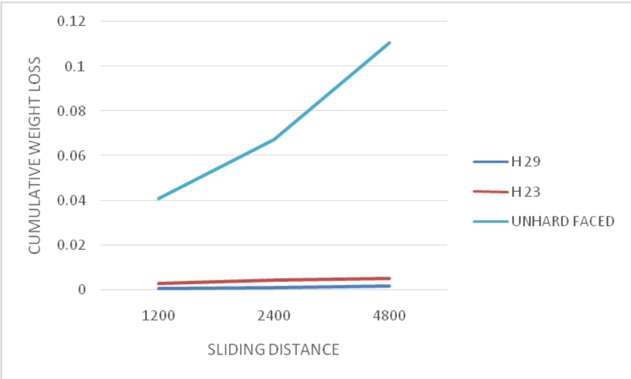

Fig- 8 Weight loss at 40N

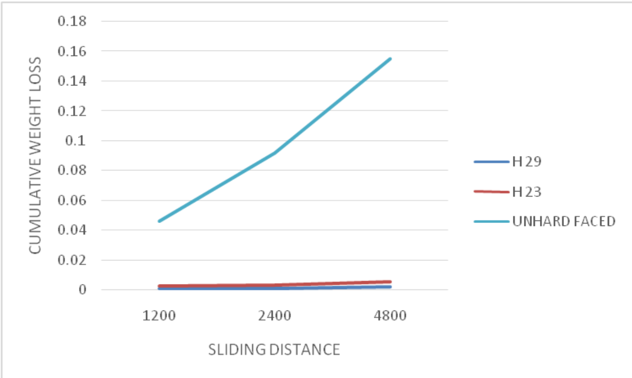

Fig- 9 Weight loss at 50N

As shown from the graphs, all the hardfaced as well as un-hardfaced samples have undergone increasing wear w.r.t. increase the load acting. The variation in the weight losses with respect to increase in load has been plotted for the comparison of wear rate among the hardfaced as well as un-hardfaced samples. The overall order of increasing wear rates of hardfacing alloys deposited on EN-42J are given as below:

H-29Cr < H-23Cr < Un-hard faced.

The result shows that the wear loss is very minimum in the H-29Cr sample even at higher speeds and greater loads. It is due to the enrichment of chromium content in that as compared to the other sample as well as un- hard faced sample. So it shows that as greater will be the hardness as less will be the damages of the material. H-29Cr Electrode with more chromium provided more hardness to the hardfaced surface and hence showed more wear resistance as compared to H-23Cr electrode with less chromium content.

IV. CONCLUSION

Based upon experimental results obtained in the present work, the following conclusions have been drawn:

1) H-23Cr and H-29Cr hardfacing alloys have successfully been deposited on EN-42J substrate using MMAW process.
2) The specimen's hardfaced with H-23Cr and H-29Cr alloy on steel EN-42J showed significantly lower weight loss as compared to uncoated EN-42J substrate.
3) Weight loss for hardfaced and un-hardfaced (EN-42J) specimens increases with increase in load.
4) The H-29Cr hardfacing alloy and substrate combination has shown minimum weight loss among all the two combinations. The wear resistance for hardfacing-substrate combinations in their decreasing order (at 30N, 40N & 50N) is H-29Cr –EN-42J > H-23Cr -EN-42J.
5) It is observed that the life of blade hardfaced with H-29Cr alloy is enhanced approximately by 15 times as compared to un-hardfaced blade.

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