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The Effect of Hard Facing on Tribological Wear, Thermal and Transient Analysis of Agricultural Equipment

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ABSTRACT: Metal parts often fail their intended use not because they fracture, but because they wear, which causes them to lose dimension and functionality. This wear may be due to metal to metal wear. As wear is a surface or near surface phenomenon, it has long been realized that the wear resistance of a component can be improved by providing a surface of different composition from that of the base material. Hard facing which is also known as hard surfacing is the application of build up or wear resistant weld metal to a part's surface by means of welding or joining. In agricultural field, hard facing is normally done on cheaper base metals like cast irons and cast steels. For facing alloys such as cobalt, chromium, tungsten carbide, chromium-manganese are commonly used. All these alloys are good for extreme abrasion, severe impact and high temperature applications. The objective of this investigation is to analyze the increase in the wear resistance after hard facing a cultivator blade which is made of low alloy steel by determination of type and degree of wear, selection of an appropriate hard facing alloy, applying on the base metal and conducting the wear testing and analysis. To analyze thermal deformation and damping factor before and after hard facing.

KEYWORDS: Abrasion wear, Hard facing, Manual Metal Arc Welding (MMAW), Microstructure.

I.INTRODUCTION

In materials science, wear is the erosion of material from a solid surface by the action of another solid. The study of the processes of wear is part of the discipline of tribology.

Wear can also be defined as a process in which interaction of the surfaces or bounding faces of a solid with its working environment results in dimensional loss of the solid, with or without loss of material. Aspects of the working environment which affect wear include loads (such as unidirectional sliding, reciprocating, rolling, and impact loads), speed, temperature, type of counter body (solid, liquid, or gas), and type of contact (single phase or multiphase, in which the phases involved can be liquid plus solid particles plus gas bubbles). In the results of standard wear tests (such as those formulated by the respective subcommittees of ASTM Committee G-2); the loss of material during wear is expressed in terms of volume. The volume loss gives a truer picture than weight loss, particularly when comparing the wear resistance properties of materials with large differences in density.

Classification of Wear: Wear situations exist whenever there is relative motion between two mating parts. Broadly speaking the motion can be unidirectional or reciprocating either sliding or rolling. Depending on the nature of the movements or the media involved in an interaction under load, the types of wear to which metallic components may be subjected in service are:

1. *Frictional wear:* The Metal-to-metal frictional wear is determined by the comparative hardness of the mating surfaces, their frictional co-efficient and galling tendencies, surface films, lubricity and plasticity.
2. *Abrasive wear:* In this case the wear is caused by a hard and sharp edge non-metallic material such as cement and sand. It is of three types:
 - a) *Scratching abrasion,* also known as low stress abrasion, in which the abrasive particles are usually smaller and unconstrained, scratches the surface continuously to cause wear. It is less severe than grinding and gouging

abrasion. The wear is more due to velocity than the abrasiveness of the material. Sand slingers and dredge pumps are examples of equipment involved in scratching abrasion.

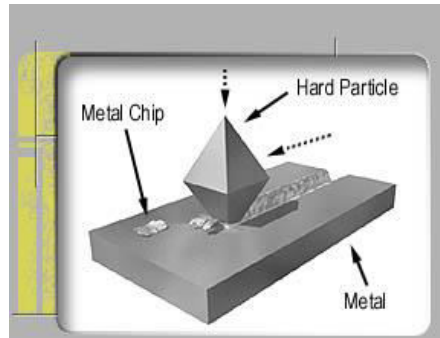


Fig. 1: Scratching Abrasion

b) *Grinding abrasion*, is indicated by the fragmentation of small, hard, abrasive grains (rocks < 50mm in diameter) usually between metal surfaces. The particles are fractured or ground-up during service.

c) *Gouging abrasion*, the abrasive particles are usually large (rocks > 50mm in diameter), the abrasive particles gouge or groove the surface during service.

3. *Impact wear*: Impact means repeated hammering effect in service. When impact causes only deformation of the surface, it is termed as light. When it causes both elastic and plastic deformation, it is termed as medium.

Causes for wear:

- Abrasive action of hard particles in work material.
- By plastic deformation.
- Chemical decomposition of contact surfaces.
- Diffusion between work and tool material.
- Welding at asperities between work and tool.

Wear Measurement Methods: The most common way of measuring wear consist of examination of sliding materials before and after wear and difference in weight of the material being attributed wear. The common methods used to determine wear rate of materials is as follows:

1. Loss of weight method.
2. Displacement method.
3. Optical method.
4. Loss of dimension method.

Loss of weight method: The pin specimen is cleaned with acetone or alcohol and weighed initially (w_1) in the electronic weighing balance before conducting the test. After conducting the wear test, the pin specimen is cleaned with acetone and weighed in the electronic weighing balance to get the final weight (w_2). Thus the difference between the initial weight (w_1) and final weight (w_2) gives the loss of weight of the pin specimen in the form of percentage. Out of these methods we have selected loss of weight method because it is very easier and simplest method of finding wear rate of any type of material.

Surfacing of materials: Surfacing is the process of applying a hard wear resistant layer of metal to surface or edges of worn out parts by arc or gas welding to obtain the desired properties or dimensions. It is considered as one of the most economical methods of conserving and extending the life of machines, tools and construction equipment. Thus the process may involve building up of worn shafts, gears or cutting edges of tools. There are several types of surfacing, such as 1) Cladding, 2) Hard Facing, 3) Buildup, 4) Buttering, 5) Metalizing.

Hard Facing: Hard facing is a type of surfacing and it involves the process of depositing by one of various welding techniques. A layer or layers of metal of specific properties on certain areas of metal parts that are exposed to wear. According to American Welding Society, "*Hard Surfacing*" or hard facing is defined as; 'The deposition of filler metal on a metal surface to obtain the desired properties and/or dimensions', the desired properties being those that will resist abrasion, heat and corrosion.

II. DESIGN AND FABRICATION

Procedure adopted for fabricating the hard faced agricultural equipment:

1. Selection of the agricultural component.
2. Selection of the welding process.
3. Selection of the electrode.
4. Selection of the test methods.
5. Preparation of the specimen from the cultivator spike.
6. Hard facing.
7. Finishing.
8. Testing

1. Selection of the Agricultural Component: There are variety of agricultural equipments which undergo various types of wear like frictional wear, abrasive wear, impact wear, corrosive wear and high temperature wear. In manual agricultural work like in farming and cultivating, we use chisel, cultivator blade, and ploughshare points. These tools experience scratching abrasion wear.

2. Selection of the Welding Process: Manual Metal Arc (MMA) is the most common type of welding process which can be widely used with extruded and tubular welding electrodes available for build-up and hard surfacing applications as well as for joining application.

3. Selection of the Electrode: As our work is on agricultural tools like cultivator blade which undergoes scratching abrasion, since we are using this to minimize the abrasion rate, DUROID 650 is recommended for solid particle erosion, low stress abrasion. The composition of the electrode is Iron (Fe), Chromium (Cr), manganese (Mn).

4. Selection of the Test Methods: As the hard faced agricultural equipment experiences scratching abrasion so the following tests are conducted as the main mechanical properties which are to be considered are hardness and low stress abrasion when used in a sandy soil.

- a) Hardness test
- b) Abrasion test
- c) Microstructure test

5. Preparation of the specimen: The specimen has to be prepared as per the standards required for wear testing in ABRASIVE WEAR TESTING MACHINE as per the standards of ASTM G65. For this the following methods was followed:

- a) Cutting.
- b) Machining to the required dimension.
- c) Surface finishing

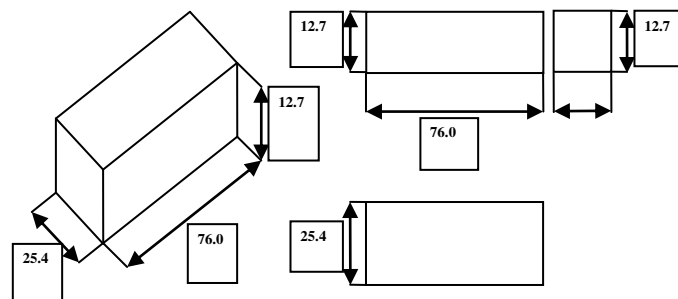


Fig. 2: Specimen dimensions

6. Hard facing: Clean the surface to be hard faced thoroughly to remove the rust, scales and all other foreign matter. Use only enough amperage to provide sufficient heat to maintain the arc. This is very important to prevent dilution of the deposit by the base metal. Arrange the work so that it is in flat position. Most hard facing electrodes are designed to be run in the flat positions only. Maintain a medium long arc and do not allow the coating of the electrode to touch the base metal. In making the deposit, use either a straight or weaving bead.

7. *Finishing*: The specimen are fixed onto a work holding device and tightly clamped. Then using an automatic grinding machine, the base metal specimens and all the hard faced metal specimens are grinded. Care is taken so that no blow holes appear and a shining mirror like finish is obtained.

8. *Testing*: i) *Hardness Test: Rockwell Hardness Test*: The most widely used hardness test in most of the countries is the Rockwell hardness test. Its general acceptance is due to its speed, freedom from personal error, so simple to perform, no special skills are required, and ability to distinguish small hardness difference in hardened steel and the small size of the indentation. So that finished heat treated parts can be tested without damage.

Table 1: Tabulation of Readings and Results:

SL. NO	ROCKWELL HARDNESS NUMBER			
	Base Metal	Single Layer	Double Layer	Triple Layer
01	30	62	52	44
02	31	65	51	43
03	29	63	51	45
04	31	63	52	42
05	33	64	52	41
06	33	61	54	42
07	29	60	53	42
08	29	58	52	42

Load: 150kg

Indenter: Diamond cone of vertex angle 120° and tip radius 0.2mm

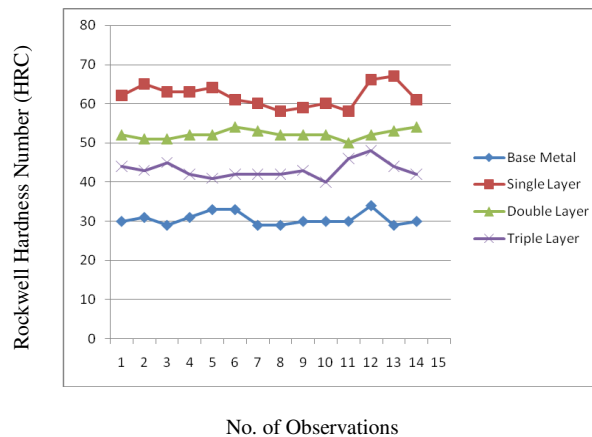


Fig. 3: Rockwell Hardness Number v/s Number of Observations.

ii) *Abrasive Wear Test*: The Dry Abrasion Test Rig TR-50 has been designed to conduct “Dry Sand / Rubber Wheel Abrasion Test” in conformity with ASTM G65. The test specimen is pressed against a rotating wheel, while a controlled flow of grit abrades the test surface. The rotation of the wheel is 200rpm along the sand flow. The duration of test is 300sec and force applied is varied as per ASTM standard is 7Kg. Specimen is weighed before and after the test, loss in mass is recorded.

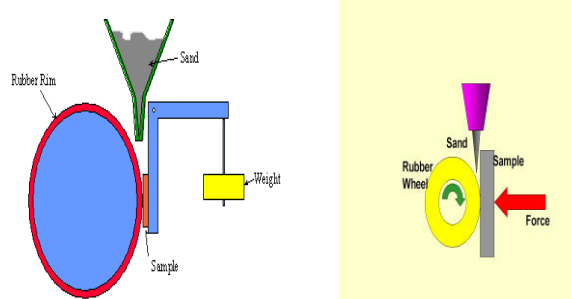


Fig. 4: Mechanism of Operation

Table 2: Tabulation of readings and results:

Sl. No	Specimen	W ₁ in gm	W ₂ in gm	W = (W ₁ -W ₂) in gm	V = (W/ρ) in mm ³
01	Base metal	197.4360	196.5468	0.8892	0.1104
02	Hard faced with 1 layer	187.6750	186.9860	0.6890	0.0855
03	Hard faced with 2 layer	185.4649	184.8653	0.5996	0.0745
04	Hard faced with 3 layer	186.9763	186.4026	0.5727	0.0712

Where, W₁= Wt. of the specimen before testing,

W₂= Wt. of the specimen after testing.

W= Loss in Weight in gm, ρ = Density in gm/ mm³,

V = Loss in Volume in mm³

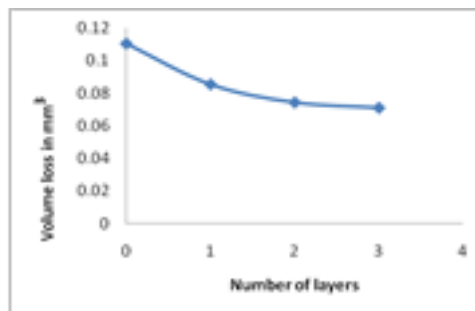


Fig. 5: Volume loss v/s Number of Hard Faced layers

iii) *Microstructure Test:* Microstructure plays an important role in a wide variety of behaviors (mechanical, thermal, electrical, optical, and magnetic). In general when we refer to microstructure we are referring to the size, shape and distribution of each phase in a polycrystalline and/or multiphase material. Microstructure is largely developed during processing. Micro structural evaluation ranges from simple determination of certain parameters such as grain size or coating thickness through porosity and pore structure to full characterization of multi-component systems or evaluation of degradation or failure mechanisms. SEM microstructure as shown in Fig.6.

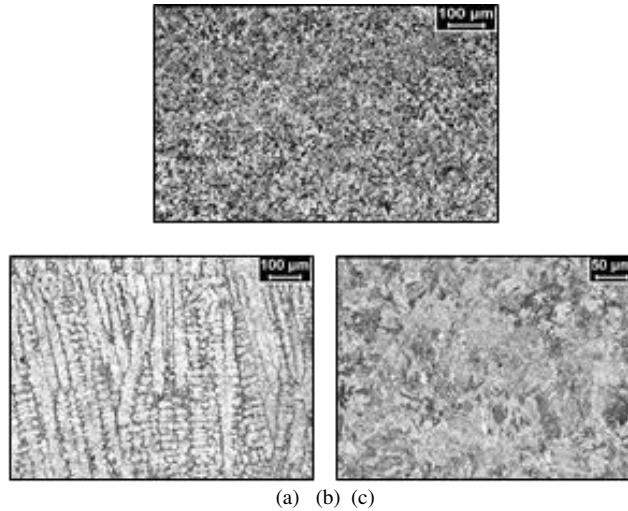


Fig. 6: Microstructure a) Base metal, b) Weld, c) Heat affected zone

III .THERMAL ANALYSIS USING FEM

A 3 D model of the cultivator spike is created as per the drawings supplied using Solid Works software; the PARASOLID format of the model is taken into ANSYS platform and analysis is carried out. A steady type thermal analysis is carried out to determine the temperature distribution of the cultivator spike as the working temperature is 60⁰ C. Finite element model is created using solid 90 elements. It has 20 nodes with a single degree of freedom, temperature, at each node. The 20-node elements have compatible temperature shapes and are well suited to model curved boundaries. An ambient temperature of 30⁰ C is applied on the outer surface areas and a temperature of 60⁰ C is applied on the inner surface. The results of the conduction analysis are available in Fig. 7.

After solving the conduction problem, the results of the thermal analysis were saved. The elements were switched from thermal solid to structural solid. All the nodes on the mounting area of the cultivator spike used for fitment of the cultivator spike are fully constrained to have no degree of freedom. The following material properties of base metal without hard facing were used for analysis:

Coefficient of Thermal expansion: 14.825e-6,
Thermal conductivity: 54 W/mk.

The results of the thermal deformation of the cultivator spike base metal are available in Fig.7. Similarly using the same procedure thermal analysis is also done for base metal with single layered hard facing. The following material properties of base metal with single layered hard facing were used for analysis: Coefficient of Thermal expansion: 6.22e-6, Thermal conductivity: 22 W/m k. The results are shown in Fig. 8.

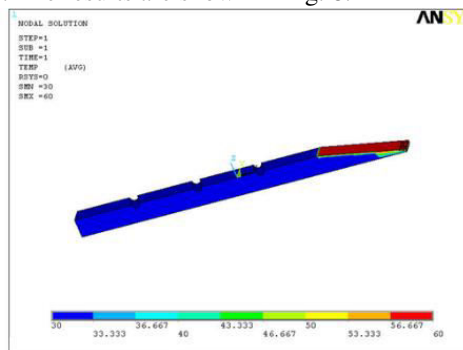


Fig. 7: Temperature distribution

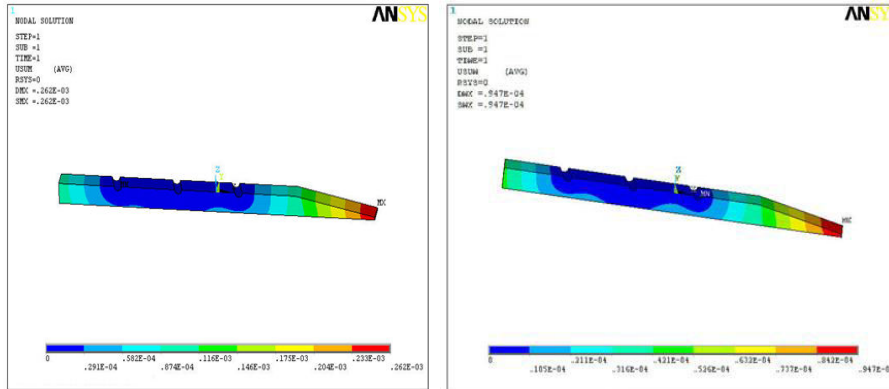


Fig. 8: Thermal deformation in cultivator spike without and with hard face

Table 3: Comparison of theoretical and ANSYS results

Sl. No	Specimen	Theoretical values (mm)	ANSYS values (mm)
1	Base metal	0.28627	0.262
2	Single layer hard faced base metal	0.1314	0.0947

From the above table, it can be observed that the results obtained from ANSYS are found to be in good correlation with theoretical results.

IV. TRANSIENT ANALYSIS USING FEM

In certain cases the amount of damping may be small and in other cases large. When damped free vibration takes place, the amplitude of vibration gradually becomes small and finally is completely lost. “Damping is the resistance offered to the motion of vibrating body”. The rate, at which the amplitude decays, depends upon the type and amount of damping in the system. The aspects we are primarily interested in damped free vibrations are i) The frequency of a damped oscillations and ii) The rate of decay.

Damping Factor: Damping factor or damping ratio (ζ) may be defined as the ratio of damping coefficient to the critical damping coefficient.

$$\zeta = c/c_c \text{----- (1)}$$

Where, c = damping coefficient, c_c = critical damping coefficient.

Logarithmic Decrement: Logarithmic decrement defines the ratio of two successive amplitudes for an undamped system, vibrating freely, is constant and is a function of damping only.

Transient Analysis: Transient dynamic analysis (sometimes called time-history analysis) is a technique used to determine the dynamic response of a structure under the action of any general time-dependent loads. This type of analysis is used to determine the time-varying displacements, strains, stresses, and forces in a structure as it responds to any combination of static, transient, and harmonic loads. The time scale of the loading is such that the inertia or damping effects are considered to be important. Time response curve as shown in Fig.9.

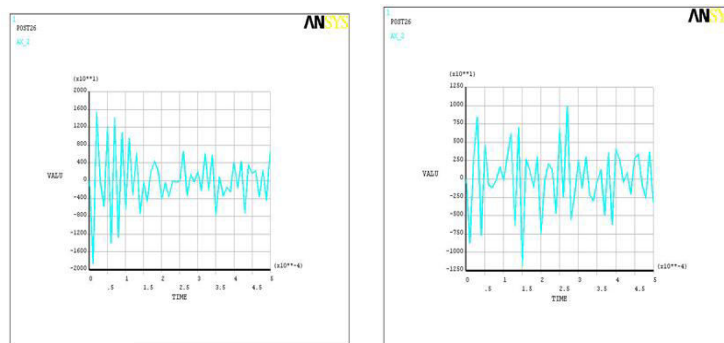


Fig. 9: Time Response Curve of cultivator spike base metal without and with hard face (Maximum duration of 4seconds)

Determination of damping through logarithmic decrement:

$$\text{Logarithmic decrement } (\delta) = \ln \frac{X_n}{X_{n+1}} \text{ ----- (2)}$$

$$\text{On solving, we get, } (\xi^2) = \frac{\partial^2}{4\Pi^2 + \partial^2} \text{ ----- (3)}$$

1. For cultivator spike base metal

$$X_1 = 15400$$

$$X_6 = 6200$$

$$n = 6$$

$$\delta = (1/n) \ln (X_1/X_6) \text{ and}$$

The calculated value is $\delta = 0.1516$

$$\xi = 0.0241$$

2. For cultivator spike base metal with single layered hard facing

$$X_1 = 8400$$

$$X_6 = 2675$$

$$n = 6$$

$$\delta = (1/n) \ln (X_1/X_6) \text{ and}$$

The calculated value is $\delta = 0.1907$

$$\xi = 0.0303$$

The transient analysis was carried out analytically by FEM method using ANSYS. The analytical value of modal damping factor “ ξ ” was found to be 0.0241 for cultivator spike base metal while the analytical value of modal damping factor “ ξ ” was found to be 0.0303.

V. CONCLUSION

From the experimental results, we see that the loss in weight goes on decreasing from the base metal and the ones which are hard faced in 1, 2 and 3 layers respectively. This is because of the reducing dilution by the base metal with the weld deposits. So with the increase in the weld passes, hardness decreases but the wear resistance of the cultivator spike increases. So, we come to the conclusion that the life of the agricultural equipment can be increased by hard facing and the capability of hard facing as an important source of savings. The cost of its application can be estimated.

From the thermal analysis, it can be observed that the results obtained from ANSYS are found to be in good correlation with theoretical results. From the thermal analysis it is cleared that thermal deformation is less in cultivator spike of single layer hard faced base metal compared to without hard faced base metal.

The transient analysis was carried out analytically by FEM method using ANSYS. From the transient analysis it is cleared that modal damping factor can be increased by hard facing.

REFERENCES

1. E.O. Correa, N.G. Alcantara, D.G. Tecco, and R.V. Kumar, Development of an Iron-Based Hard facing Material Reinforced with Fe-(TiW) C Composite Powder the Minerals, Metals & Materials Society and ASM International Volume 38A, May 2007, 937-945.
2. Yilmaz Bayhan, Reduction of wear via hard facing of chisel ploughshare, Tribology International, Volume 39, Issue 6, June 2006, Pages 570-574.
3. Kown-yeong Lee & Sung-hoon Lee, Division of Materials Science and Engineering, Hanyang University, Seoul 133-791, South Korea Division of Materials Science and Engineering, Pusan National University, Pusan 609-735, South Korea 28 May 2003.
4. S.Chatterjee & T.K. Pal, Weld procedural effect on the performance of iron based hard facing deposits on cast iron substrate, Journal of Materials Processing Technology, Volume 173, Issue 1, 30 March 2006, Pages 61-69.
5. P. L. Hurricks, Some Aspects of the Metallurgy and Wear resistance of Surface coatings, Swansea Tribology Centre, Swansea University, Swansea (Gt. Britain), June 26, 1972.
6. John Anthony Francis, Principles for Open-Arc Weld Deposition of High-Chromium White Iron Surface Layers, Department of Mechanical Engineering, the University of Adelaide July 1999.
7. A.K. Jha, B.K. Prasad, R. Dasgupta, & O.P. Modi, Influence of Material Characteristics on the Abrasive Wear Response of Some Hardfacing Alloys, JMEPEG (1999) 8:190-196.



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| DOI:10.15680/IJIRSET.2023.1211066 |

8. Enda Keehan, Effect of Microstructure on Mechanical Properties of High Strength Steel Weld Metals, Department of Experimental Physics, Chalmers University of technology and Goteborg University, Goteborg, Sweden, 2004
9. V.E. Buchanan, D.G. McCartney and P.H. Shipway, A comparison of the abrasive wear behaviour of iron-chromium based hard faced coatings deposited by SMAW and electric arc spraying, Wear Volume 264, Issues 7-8, 15 March 2008, Pages 542-549.
10. Giachino weeks, “Welding Skills and Practice”, Fifth Edition, ATP Publication (American technical publishers).



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