INFLUENCE OF SURFACE HARDENING PROCESSES ON WEAR CHARACTERISTICS OF SOIL WORKING TOOLS- A REVIEW

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ABSTRACT

Wear of soil engaging components occurs because the materials used are normally softer than the natural abrasives in the soil. Most of the agricultural tools are manufactured by the small scale industries. Due to improper material and surface hardening treatments, the quality of tools does not conform to the Bureau of Indian Standards resulting in high wear rates and reduced life, which are hardly as per with the standards which affects operational life of tillage tool. So, there was a need to study wear characteristics of agricultural tools, as to provide the suitable tools.

KEYWORDS: *Surface hardening, wear, agricultural tool*

I. INTRODUCTION

India is a vast country with 329.5 million hectares geographical area with agriculture still as a main occupation of 70 per cent of Indian population. In the world's, India accounts about 2.4 per cent of the geographical area and 4 per cent of its water resources but has to support about 17 per cent of the world's human population and 15 per cent of the livestock. Agriculture is an important sector of the Indian economy, accounting for 14 per cent of the nation's Gross Domestic Product (GDP) from which about 11 per cent contributes its exports. Also about half of Indian population still relies on agriculture as its principal source of income. In addition it is a source of raw material for a large number of industries. Therefore, it is not only to accelerate the growth of agriculture produce but also to achieve an overall GDP target of 8 per cent during the 12^{th} Plan and meet the rising demand for food, and also to increase incomes of those dependent on agriculture to ensure inclusiveness in our society, Anonymous [1].

The growth of agricultural mechanization has been rapid during last four decades. The mechanization of Indian agriculture has assumed importance in increasing agricultural production, productivity and profitability by timely farm operations, saving in cost of operation, maximizing utilization efficiency of agricultural inputs by their judicious applications and reducing losses. The newly developed appropriate technology of farm mechanization with improvement in existing design, newer material and production techniques will cater the needs of farms (Manian *et al.*[2]. The growth in large scale adoption of agricultural tools and machinery in the country has been possible due to efforts not only by organized sectors but also by village craftsmen and small scale industries.

Different components in agricultural machines are mostly subjected to dynamic loads, abrasive wear and chemical action of the external environment during their operation. Wear as the common people understand is the deterioration due to continuous use. Fundamentally, it is an acceptable phenomenon but the scientists and engineers are more concerned with very case of wear and the search for remedial measures to increase the durability of equipments, hand tools and machines used for various farm operations in daily life. Machine breakdown hampers farm operations to a great extent if failure occurs at a crucial time. Therefore, increasing the service life of machines has become one of the important necessities of newly developing technology. The matter of increasing durability is clearly linked with a study of wear pattern of machine components when in operation. It helps in developing the quality material of machine parts to increase their working life.

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. It is classified as gouging, high stress grinding or low stress scratching abrasion. 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 13 422 000 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 [3].

Wear can be problematic whenever moving machine parts come in contact with each other. Wear is the major reason that limits the durability of many agricultural tools. Agricultural soil-cutting tools have their own characteristics of wear, which are different from other types, since they interact with soils of various textures, moistures and other unpredictable conditions in the field increasing wear. The basic surface modification techniques are used by many research scholars to improve the surface characteristics.

1.1. Wear of Agricultural Tools of different Materials

A variety of material characteristics have been shown to either from a correlation with abrasive wear or have some effect on it. These properties include hardness, elastic modulus, yield strength, microstructure and composition of the material. It has been shown experimentally and theoretically that the hardness of a material correlates with its abrasion rate. Any second phase particle present in the microstructure need to be hard tough and blocky to provide better protection against abrasive wear. A high hardness value makes them harder to cut. Toughness makes them resistant to breakage. Blocky particles also reduce crack propagation and breakage. Lastly brittle materials tend to crack and chip to a larger area than the cross section of the abrasive grain doing the damage.

A suitable combination of hardness and impact resistance can be achieved by heat-treating the steel to obtain an appropriate microstucture. The surface properties can also be modified by surface engineering. The selection of the heat treatment process/surface treatment is based on the material and the actual service conditions.

Zheng et al. [4] studied the influence of typical parameters such as hardness, shape, coating materials, etc. on wear resistance of cultivator tines. The influence of spring shank and rigid shank on wear of cultivator tine was also examined. The results showed that coating material increases wear resistance significantly.

Owsiak [5] investigated on steel samples in the laboratory and on ridger shares in field conditions. Wear was determined by measurements in the change of length, thickness of the shares and from the weight of samples. Relative resistance against abrasive wear was determined for four grades of steel while considering the type and condition of the soil. The effect of steel hardness and microstructure on wear was analyzed. It was found that the abrasive wear resistance of steel increased with a decrease of carbide size and with an increase volume fraction of carbide in the metal microstructure. The loss of share thickness due to wear was linearly proportional to the distance travelled. While the wear of cutting edges was related to the distance travelled and the distance of the measurement point from the share point by power functions. A mathematical model of wear of a symmetrical wedge-shaped tillage tool was determined.

Ferguson et al. [6] reported that in general conditions for the seeding and cultivation of cereal crops in Australia, higher wear was observed and this reduces the efficiency of Australian farmers costing millions of dollars annually. This work deals with the wear rates of commercial sweep shares at different sites in South Australia. The life of the shares at the different sites in terms of distance travelled ranged from 9 to 168km with wear rate being strongly dependent on the gravel content of the soil. At the sandy clay-loam the wear rate was found to increase as the soil water content decreased.

The damage to the tools and the mechanisms of wear were also investigated by metallographic analysis.

Owsiak [7] reported that correct evaluation and forecasting of durability of soil cutting parts are the decisive factors for proper operation of agricultural machinery. During operation of cultivators over two-fold difference in wear of cultivator points is observed which makes establishing of their exchange periods extremely difficult. So he conducted some research aimed for determination of relationship between arrangement of the points in individual cultivator rows and their wear. The research results emphasis the need for field experiments at compare wear of spring tine points made of different materials or of different designs to take into account differences in wear due to positioning of the points on cultivator frames.

Er [8] studied that the abrasive wear behavior of two boron steels. AISI 15B35H and AISI 15B41H boron steel are compared by considering hardness and abrasive wear rate. The test carried out heat treated and untreated cubic steel specimens. He observed that the hardness of untreated boron steel specimens are increased with increasing carbon content of the test material and this positively effect the abrasive wear resistance.

Gupta et al.[9] reported that the tines were fabricated out of various types of steel such as leaf spring steel (En47) (both from automobile strip indicated as 'used En47' and heat-treated virgin steel),En8, En19, En24 and mild steel (En3) with and without case carburisation. Field trials were carried out and agricultural implement used for secondary soil manipulation was equipped with tines known as duck foot sweeps. The trials were conducted on rainfed fallow, black cotton soil to a depth of 15 cm at a tractor speed of 1.03 m/s for cultivation time of 30 h. The performance of these experimental sweeps was evaluated and compared with commercially available sweeps made out of mild steel (En3), which were used as the 'control' for the performance evaluation. Microstructures and mechanical properties of the steel in heat-treated and in as received condition were also evaluated to establish the criteria of their performance for facilitating selection of appropriate materials for manufacture. The weight loss during the 30 h field test and the profiles of worn-out cutting edges have been considered as measures of wear and hence, performance criteria for the sweeps. The concluded that heat treatment is a simple, flexible and cost effective technique by which the desired mechanical properties such as hardness, strength, ductility and wear resistant can be achieved.

Mohsenin and Womochel [10] tested a wide range of materials of plough share with varying carbon content and other alloying materials under field and laboratory condition using rotating wheel type wear testing machine. Although, wear found to decrease with increase in hardness of the martial but no definite correlation was observed.

Banaj et.al. [11] conducted a study to determine the quality and wear of cultivator shovels at 225 ha of land planted with sugar beet and soya bean during two vegetation period at working depth of 4.10 cm. The highest mass loss of shovel marked M4 of 34.10 per cent (left) and 37.56 per cent (middle) was recorded when they were set behind the tractor. Moreover, the lowest mass loss of shovel made from material M3 of 12.02 per cent and the highest mass loss of shovel made from material M2 of 30.53 per cent was observed when the shovel was beyond the track of the tractor pneumatic tire. The lowest surface wear of 11.12 per cent was measured with shovels made from material M3 and the highest of 45.78 per cent with shovels made from material M1 with soil tillage beyond the track of tractor pneumatic tire. Shovels made from material M4 and material M3 set behind tractor tires lost 29.60 and 30.66 per cent of the initial surface. Side set shovels (left and right) on the cultivator section lost minimum mass of 13. 67 per cent (material M2) and surface 21.71 per cent (material M2) loss of maximum mass of 15.05 per cent (material M2) and surface 24.06 per cent (material M2).

Chahar [12] reported that the shovels used in cultivators are largely manufactured by the small scale industries. But due to improper material and surface hardening treatments, the quality of shovels does not conform to the Bureau of Indian Standards resulting in high wear rates and reduced life. Thus he studied to find out the wear characteristics of shovel with best surface hardening treatment at different soil and operational parameters.

Mahapatra [13] studied wear characteristics of rotavator tynes for power tillers. They found that spring steel with 0.6% carbon content, quenched and tempered at 400C for 30 minutes may provide most suitable combination of carbon content and hardness level (Rc55) to obtain good resistance for wear and impact for rotavator tynes. The specific wear loss of tynes material (mg/cm2 .km) decreased with increased in carbon content from 0.41% to 0.6% and hardness level from Rc 40.6 to 60.8 when tested under bonded abrasive as well as in different types of soil.

Chahar et.al. [14] studied wear of four shovels with different carbon content of 0.41, 0.50, 0.59 and 0.65 per cent. Abrasive sand at 10-15 per cent moisture content was used for the wear studies. Shovel with maximum carbon content wore out minimum at each interval. Cumulative wear loss in shovel decreased by 37.44% with increase in carbon content from 0.41 to 0.65 per cent. The shovels with same relative hardness, but having high carbon content, were more resistant to abrasive wear. The maximum wear occurred at the tip of the shovels. Dimensional wear was measured with respect to width and thickness of shovel. Test shovels wore out along the thickness. Change in length and width of shovels was negligible as compared to their thickness. The shovel with 0.65% carbon gave the best results.

Muammer and Tufan [15]studied the wearing behavior of coated layers on plowshares used in soil tillage. Plowshares produced from DIN EN 10 083 (30 MnB5) steel, widely used in plows, were coated with 20 μm hard chromium by electrolysis method, 20 μm electro-less nickel by chemical treatments, and 4 μm titanium nitride (TiN) by physical vapor deposition to increase wearing resistance. The coated plowshare specimens, together with uncoated plowshare specimens, were mounted on test equipment to analyze their wearing characteristics in a sandy clay loam soil at a speed of 5.8 km/h. The thickness of the coating and the mass loss of the plowshares were measured each 1.18 km up to 10.8 km for all the coated layers. Before and after tillage, the specimens were analyzed metallographically using a scanning electron microscope (SEM) and energy dispersive spectroscopy (EDS). Abrasive wear occurred on all the plowshares. They resulted that the wear values for the uncoated and coated plows were in a close range for the tillage length of 10 km in the soil bin. Over that distance, all coated layers showed wear together with the basic material of the plowshare body. The wear length of the electro less nickel coated specimen was higher than the others. However, the TiN coating had a higher wearing resistance than the hard chromium and electro less nickel coatings.

1.2. Abrasive Wear Behavior and Characteristics

Dynamic action of soil sliding over a metal surface, known as abrasion, involves the mechanical loss of metal due to friction, Murthy [16]. Under high normal loads, soil particles scratch, cut and gouge the surface to wear it away. Parameters of both the tool and the soil are important in abrasion. Soil properties that affect abrasion include hardness, shape and size of the particles, firmness with which particles are held in the soil mass and the soil moisture content. The metal characteristics that affect abrasion are hardness, strength and toughness. Dynamic parameters of an abrading system include the stresses on the sliding surface, duration and rate of sliding and stability of the sliding force. The complexity of the wearing process of tillage tool involves the continuous change of friction forces over the surface, non-uniformity of the abrasive medium and the dynamics of the process of contacting and displacement of particles of the abrasive medium. It is considered that the process of destruction of the surface of friction takes place as a result of combined action of the abrasive particles.

All the soil engaging parts are exposed to abrasive wear in a non-stationary abrasive mass i.e. soil. Every single particle on the friction surface, however, does not come in contact with the metal and the speed of relative displacement of the soil particles is considerably less than the transitional speed of the machine Severnev [17] reported that: (i) The actual area of contact of the abrasive particles with the metal surface, the number of points of contact and the duration of contact depended on their size and shape. Also, under same load, the metal wear in an abrasive medium of larger particles is more than in an abrasive mass of small particles. (ii) The actual area of contact of the particles and their involvement increased with increase in load. (iii) During the process of destruction of the surface, wear by plastic deformation is observed side by side with scratching. Some particles interacting with the surface and capable of overcoming the cohesive forces of the materials directly cause wear although their magnitude is small. (iv) Some abrasive particles may produce micro-cuts on the surface if the force of mutual contact between particles exceeds the force of internal cohesion of the wearing-out machine part and also when the load on them ensured deep penetration into the material.

Murthy [16] carried out a study to investigate the influence of soil type and operational parameters on the abrasive wear of cultivator shovel. Soils like pure sand, loamy sand, sandy loam, sandy clay loam, clay loam and light clay were included in the study. It was noted that the intensity of wear (mg/km) was more in soils having higher percentage of sand. The intensity of wear was observed more in soils like pure sand, loamy sand and sandy loam soil.

Moore and McLees [18] carried out wear tests on bonded commercial flint abrasives in the laboratory and in sandy clay loam soils in the field at speed between 0.25 and 7.0 m/s. The laboratory result showed about 90 per cent increase in the wear rate for steel with increases in speed from 0.25 to 5 m/s, but no increase was observed for copper. The final result showed the effect of speed on wear rate for different soil types and materials, with a maximum increase of about 180 per cent in the wear rate over the speed range of 0.25 to 7 m/s.

Singh et al. [19] reported that reducing the low stress abrasive wear of materials has emerged as a major challenge for researches conducted in the field of engineering and efforts were made for development of prediction model for abrasive wear rate of medium carbon steel like SAE 6150. Based on the influencing factors for precise prediction of wear rate and selection of appropriate levels of factors SAE 6150 steel is tested using dry sand abrasion test rig after heat treatment (annealing, intercritically annealing and quenched and tempered) and shot peening (ranging 0.17-0.47 A at an interval of 0.1 A). The hardness and abrasive wear resistance of as-received and annealed steel are significantly lower in irrespective of peening intensity. The peening intensity reduces the wear rate, if limited to a critical value of 0.17 A. The functional relationship between wear rate and the factors influencing it is found statistically significant and can be used for prediction of abrasive wear at a given level of factors.

1.3. Major factors affecting wear

There are three distinct groups of factors which affect the wear. The first of these relates to the soil. Some of the soils factors are root, trash, compactness, soil moisture and soil type. The second group of factors relates to the quality of material being used. Some of the important relevant factors are hardness, composition, heat treatment, strength, ability to scour, plastic deformation of material, speed of tool, its geometry and surface finish etc. The third factor which affects the wear is operational parameters, such as speed and depth of operation.

Koszeghy [20] studied the wear ability of rotary cultivators fitted with right-angle blades to bury green manure and in general its effect on soil mixing. Theoretically, the path described by the blade for different forward speeds to peripheral speed of the blade and the relationship between the relevant parameters were studied. The importance of operating the cultivator at the optimum speed was stressed. Blade wear greatly increased as a result of variations in speed.

Kurchania [21] undertook a study on the effect of soil moisture and operating speed on intensity of wear. Maximum cumulative wear of 16.5 gram was found below 5 per cent moisture content in silt clay loam abrasive medium under laboratory condition. Maximum wear in sand was found 67.3 per cent more than that in silt clay loam soil. Magnitude of wearing capability of this soil with respect to sand was found to 1.00, 0.45 and 0.33 in the moisture range of 0-5, 5.10-10 and 10.1-15 per cent respectively under laboratory conditions. He also reported that wear rate of shovels increased with the increase in operating speed. There was an increase of 41.7 per cent in wear rate when the speed was increased from 0.7 to 1.4 m/sec.

Fouda and Tarhuny [22] studied the wearing behavior of ploughshares in different soil moisture content and working time in sandy loam soil. Results showed that increasing working time from 10 to 60 hours for the front share at soil moisture content of 8 per cent increased share mass losses from 1.40 to 16.47, from 2.66 to 21.63 and from 3.79 to 25.66 per cent for the three used shares A, B and C respectively. Also at soil moisture content of 11 per cent under the similar conditions results showed that increasing working time from 10 to 60 hours increased share mass losses from 1.70 to 21.70;from 2.80 to 23.67 and from 3.70 to 26.40 per cent respectively.

Machado and Antonio [23] determined wear rate of soil engaging tools (planters furrow openers, chisel and subsoiler rippers) through loss of mass. The wear depended on various factors were the soil conditions and the geometric and constructive characteristics of the tool. The analysis of the variation of the geometric configuration of the tool was assessed through digital photography and software was used to design them. In this study furrow opener of a direct drill planter was employed as the soil-engaging tool. The results showed that the wear is affected by depth of operation, type of soil and material of tools. Increase depth of operation resulted in more wear of tools.

Kaur et al. [24] conducted experiment of wear in rotary soil bin in loamy soil and sandy loam soil. L-Shape blades of four different makes were mounted on the two flanges and their speed varied from 140-150 rpm. Two rollers along their stand were mounted on soil bin for compressing the soil. After running the blades for 50h in the soil bin, blades were weighted and loss in weight and dimensional wear loss was noted down. Similar procedure was followed for 100 h and 150 hr time intervals. It was observed that the weight loss of rotary blades was proportional to time.

1.4. Techniques to reduce abrasive wear

Critical components of agricultural machinery and implements are those coming into direct contact with the soil. They are exposed to abrasive wear and sometimes impact, therefore requiring a certain level of hardness to be wear resistant. The required mechanical properties are achieved through the process of surface hardening. To achieve the mechanical properties, one has to know the composition of steel and the level of hardness. Heat treatment of steel serves to modify hardness, strength and toughness of the work piece by transforming its structure. The basic procedure of heat treatment involves simply heating and cooling at a faster rate enough to develop the desired properties. The way in which the desired properties are incorporated depends on the temperature to which the steel is to be heated, time that the steel is to be held at this particular temperature and the rate at which the steel is to be cooled from this temperature.

To overcome the various types of wear problems of the steel, surface modification has emerged as an important process that improves the surface properties like hardness and wear resistance of the component. The surface modification techniques are divided in seven categories. They are electro deposition, vapour deposition, diffusion coating, surface hardening, thermal spraying, hard facing and cladding and ion implantation. Surface modification by electroplating comes under the category of electro deposition. The examples of diffusion coating are carburising, nitriding, carbo-nitriding, chromizing etc.

Nowadays nanotechnology is been used in many fields due to its typical property of anti wear and corrosion. A thin film is a layer of material ranging from fractions of a nanometer to several micrometers in thickness. Deposition of thin films by physical vapour deposition (PVD) techniques (Figure 1), such as sputtering, evaporation and reactive deposition has found wide spread use in many industrial sectors and there is an increasing demand for such coatings with enhanced properties. Sputtering is a process in which atoms are ejected from a solid target material due to bombardment of energetic particles and are deposited on substrate atom by atom. Chromium nitrate (CrN) coatings are principally applied where wear and corrosion protection are major concern. It generally increases the life of the substrate.

Case hardening is a process in which an alloying element, most commonly carbon or nitrogen, diffuses into the surface of a monolithic metal. Carburizing is the addition of carbon to the surface of low-carbon steels at temperatures generally between 850 °C and 950 °C (1560 °F and 1740 °F), at which austenite, with its high solubility for carbon, is the stable crystal structure. Hardening is accomplished when the high-carbon surface layer is quenched to form martensite so that a high-carbon martensitic case with good wear and fatigue resistance is superimposed on a tough, low-carbon steel core.

Carburizing process (Figure 2) increases the grains size due to permanence for a long time in the austenitic region of the phase diagram and makes necessary a posterior heat treatment to refine the grains. Classic quenching generates a martensitic hard but brittle material. On the order hand, intercritical quenching transforms the outward carbon-rich solid solution into martensite, while the internal microstructures present a mixture of martensite, producing a less-brittle material. The Pack carburizing, Gas carburizing and Liquid carburizing processes are commonly used in industrial application.

Hard facing is the application of a hard, wear resistance material to the surface of component by welding (Figure 3), spraying or allied welding processes to reduce wear or loss of material due to abrasion. Hardfacing by oxyfuel gas welding is an important method but it is limited to the agricultural equipments. It is a process in which the heat from a gas flame is used to melt the hard facing material on to the surface of work piece, during hard facing. Hard facing by the oxyfuel welding is versatile process and readily adoptable to all hardfacing forms.

Shot peening is a cold working process used to produce a compressive residual stress layer and modify mechanical properties of metals in this, working surface is hit repeatedly with a large number of steel, glass or ceramic shot (small balls) which make overlapping indentation on the surface this action causes plastic surface deformation at depth up to 1.25 mm using shot sizes that range from 0.125 mm to 5 mm in diameter.

Because the plastic deformation is not uniform throughout the part's thickness, shot peening causes compressive residual stress on the surface thus improving the fatigue life of the component. It is well known that crack will not initiate or propagate in compressively stressed zone since nearly all the fatigue and stress corrosion failures originated at the surface of the part, compressive residual stress produced at or under the surface of a part by shot peening is at least as great as half the yield strength of the being penned (Figure 4). Basically shot peening is kind of sand blasting, only difference is that shot peening operates by mechanism of plasticity while sand blasting works on abrasion. Shot peening processes are air blast and centrifugal blast wheel system.

Therefore, control and prevention of wear of cultivator shovels are vitally important for agro industrial applications. The wear of critical components has an economic significance, which may be largely controlled by surface modification such as hardfacing, carburizing and shot peening to increase the useful life shell of agricultural tools. In this context, there is a need of innovations, which may increase the life of agricultural tools and which in turn contribute towards the economy of the farmer as well as agriculture growth in India considerably.

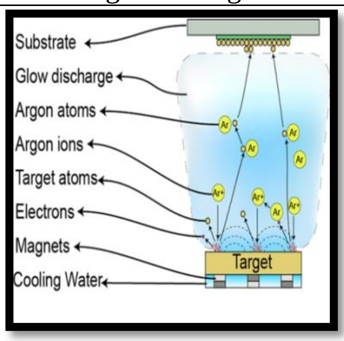

Figure 1. DC Magnetron Sputtering Technique

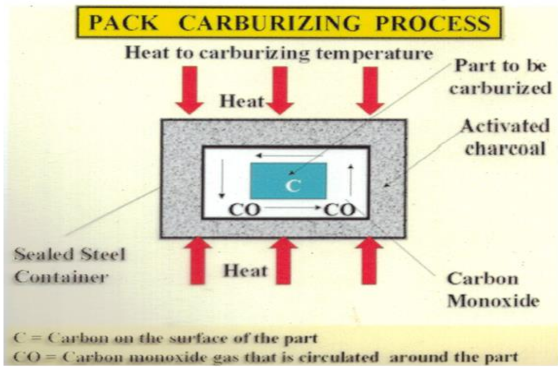

Figure 2. Carburizing

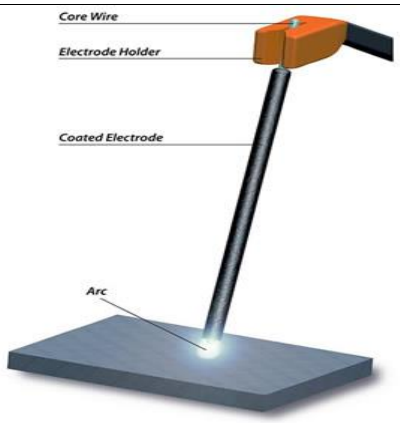

Figure 3. Hardfacing

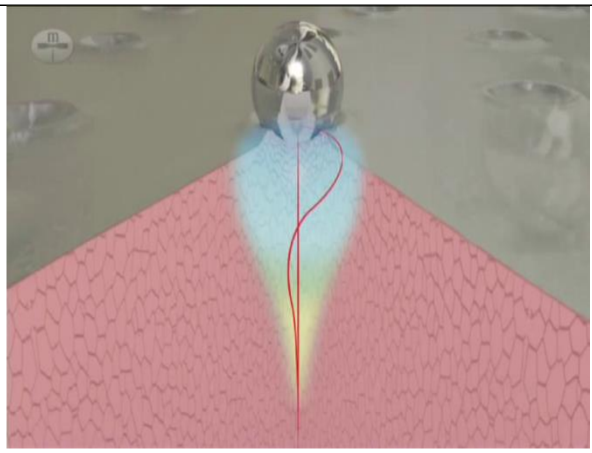

Figure 4. Shot peening

Horvat et. al. [25] studied that the comparison of wear of regular mouldboard plough shares and two plough shares made of different basic materials, steel EN 10027 (HF-1) and EN 50Mn7 (HF-2), hardfaced by a combination of two welding processes, namely shielded metal arc welding (SMAW) and high-frequency induction welding (HFIW). Wear was determined by measurements of the changes of dimensions and weight during ploughing of sandy clay soil in Croatia. They resulted that the dimensions and weight losses were lower for both types of hardfaced plough shares in comparison to regular shares, and lower fuel consumption and a higher rate of work were achieved with hardfaced plough shares. Hardfaced plough shares also offer lower production costs in comparison to regular plough shares.

Mondol et. al. [26] investigated the effect of shot peening intensity on the subsurface plastic deformation, surface and subsurface residual tress, field, depth of peening and microstructure evolution. AA2014 Al alloy have been shot peened to varying intensity levels (0.14 to 0.48 mm ALMEN 'N'). They reported that the wear rate reduced significantly due to mild shot peening. Intensive shot peening did not lead to any significant improvement in wear resistance, rather beyond a critical peening intensity, the wear resistance of material starts deteriorating.

Singh and Saxena [27] studied status of metallurgical techniques practiced by agricultural machinery manufacturers for fast wearing components in india. The study reveals that only 41% manufacturers were using steel conforming to BIS recommendations, based on the carbon percentage. The tested samples could be mild steel(10%), medium carbon steel(56%), high carbon steel(28%), and high carbon content(6%). The heat treatment was observed in rotavator blades, disc, chaff cutter blades. But due to improper heat treatment the grains of tempered martensite were found. Except in case of export, the manufacturers do not undertake chemical, mechanical, and structural testing.

Rautaray and Sharma [28] carried out investigation on shot peening to reduce wear of soil engaging components of tillage machinery, in international conference on shot peening and blast cleaning. They describes the effect of shot peening on wear characteristics of blade specimens. A blade of low carbon steel (0.19%C) with UTS 632.3 MPa and hardness of HRC 33.1 was taken for surface treatments. A comparisons was made of the results obtained through two methods of surface treatments, carburizing – hardening – tempering and carburizing - hardening – tempering and shot peening. The investigation mainly addressed the variation in wear percentage with surface work hardened layer induced by shot peening based on 50 hours run ,the percentage wear on mass basis, percentage dimensional wear and wear rate per hour and per km of run have been presented, the specimen being shot peened after carburizing hardening and tempering has shown improved wear performance as compared to other treatments tested in the study.

Singh et. al. [29] studied that the wear behavior of medium carbon boron steel with various heat-treatments (annealing, inter critical annealing, and quenching and tempering) and shot peening intensities. Shot peening intensity varies in the range 0.17-0.47 mm ALMEN 'A'. They observed that the wear rate of inter critical annealed and quenched and tempered steels are considerable less than those of as-received and annealed steels, irrespective of the peening intensity. They reported that the wear rate reduced significantly irrespective of hear-treatment schedule at the critical peening intensity of 0.27 A, mm ALMEN.

Chohan [30] studied abrasive and micro structural improvement in Duck foot sweeps as influence by shot peening. Study reveals that shot peening produced appreciable gain in wear rate and service life of sweep blade. A peening intensity of 0.27 mm A produced 97% on wear rate and and 33% gain in service life compared to virgin in Q&T and virgin samples at 50N loading. The quenched & tempered samples produced a gain at all loadings. Even virgin samples peened at 0.27 mm A peening intensity showed 36% gain at 50 N loading. Shot peening of specimen at 0.27 mm A gives average minimum wear rate of 1.6877 mg/m amongst all shot peening intensities. He concluded that shot peening improves the wearing capacity of Duck foot sweep implements.

Annappa and Basavarajappa [31]studied that three body wear behavior of normal plough tool and hardfaced plough tool materials. Hardfacing is done by manual arc welding using ZEDALLOY VB hardfacing electrode. They concluded that deposition of hardfacing alloy on the plough tool material will increase the surface hardness by retaining the toughness. They confirmed that hardfacing alloy deposit can very well be employed for improving the wear resistance.

Sekhon and Singh [32] modified that the wear resistance of hardfaced steel by heat treatment. The proposed material was alloy steel, because of its various applications in manufacturing the rotating parts where large amount of abrasive wear takes place. The manual metal arc welding (MMAW) process was used to deposit the hardfacing layers with two different hardfacing electrodes. Heat treatment was done to further increase the wear resistance of the material. They reported that hardfacing of the samples improved its hardness and wear resistance, but the heat treatment of the hardfaced samples has further improved the hardness and wear resistance properties.

Singh et. al. [33] studied that abrasive wear response of medium carbon steel under three heat treatment processes (annealing, inter-critical annealing and quenching and tempering heat treatment process) and three load condition (75, 200 and 375 N). They observed that under low load (75 N) condition, both the inter-critical annealed and quenched and tempered SAE-6150 medium carbon steels gave identical wear resistance. However, inter-critically annealed material under medium load (200 N) condition and quenched and tempered material under high load (375 N) condition exhibited supremacy in terms of abrasive wear resistance. They suggested that the soil working components of agricultural machinery may be appropriately heat treated for better resistance to abrasive wear and enhanced service life.

Singh and Mondal [34] studied that quenching and tempering process and shot peening intensity on wear behavior of medium carbon SAE-6150 steel. Treated and un-treated specimens are shot peened from 0.17 A to 0.47 A intensities at an interval of 0.1 A. They resulted that quenching and tempering processes reduced the wear rate considerably and improved the mechanical properties such as hardness, strength and percentage elongation significantly. They also observed that shot peening further reduced the wear rate of the steel if restricted to a certain peening intensity.

II. CONCLUSIONS

1. Wear resistance of agriculture implements can be increased by process of heat treatments of substrate material and by the surface modification of the implements.
2. Heat treatment techniques used by various researchers are Annealing, Tempering, Water quenching, Oil quenching, Case hardening, Precipitation hardening, etc.
3. Many researchers have also suggested surface modification techniques like Electro deposition, Vapour deposition, Shot peening, Hard facing, Diffusion coating and Thermal spraying for wear resistance.
4. Material hardness, moisture content, abrasive particle size, length of abrasive path, speed and normal load play significant role on abrasive wear of soil working elements.

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