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TRIBOLOGICAL ASPECTS OF AGRICULTURAL EQUIPMENTS: A REVIEW

Parvinkal Singh Mann[1], Navjeet Kaur Brar[2],

[1&2] *Assistant Professor, Department of Mechanical Engineering, Chandigarh University, Punjab, India-140413*

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Abstract - *Wear is known to be as the degradation of material under plethora of service conditions and is considered as one of the major issue of the material used in engineering, having an estimated direct cost of 1-4% of gross national product. Many types of wear have been recognized such as abrasive, erosive, corrosion, oxidation etc. Abrasive wear is probably the most significant cause of mechanical damage of equipment components coming in contact with abrasive bodies. For combating with wear problem various methods have also been developed such as hardfacing, cryogenic treatment, coating and heat treatment of components which are chosen on the basis of various conditions under which the component has to perform the desired work. The wear of the component depends on its surface characteristics like roughness, microstructure and hardness. The abrasive wear in agriculture equipments is the most common problem. The high wear rate of ground engaging tools led to huge loss of material, recurring labor, downtime and replacement costs of worn out parts. Hardfacing is commonly employed method to improve surface properties of tillage tools. The paper deals with the wear problems faced in agriculture equipments, particularly in ground engaging tools.*

Key Words: wear, abrasive wear, agricultural equipments, ground engaging tools.

1. INTRODUCTION

Surface engineering is one of the most relevant current fields of research. The events that occur on the surface, such as wear, corrosion or stress concentration create regions prone to crack nucleation, which under static or dynamic loading will eventually lead to most components and structures failures [1]. Wear is the degradation of metal surface, showing a continuous loss of material, due to relative motion between that main metal surface and another materials or substances whichever come in the contact with the original one. Wear is a major problem in industry and its direct cost is estimated to vary between 1 to 4% of gross national product [2]. Wear is a major problem in the excavation, earth moving, mining, automobiles, machines and mineral processing industries and occurs in a wide variety of items, such as bulldozers blades, excavator teeth, drill bits, crushers, slusher, ball and roll mills, chutes, slurry pumps and cyclones [3]. The wear behaviour of material is related to parameters such as shape, size of component, composition and distribution of micro constituents in addition to the service conditions such as load, sliding speed, environment and temperature [4]. The complex nature of wear has delayed its investigations and results in isolated studies towards specific wear mechanisms. The wear of the component depends on its surface characteristics like roughness, microstructure and hardness. Friction and wear of materials are generally considered important properties in engineering practice [5].

Many types of wear have been recognized such as abrasive, erosive, adhesive, corrosion, oxidation and surface fatigue wear etc. Wear of solids is treated as the mechanical process. However, other chemical processes, oxidation and corrosion are exceptions of this rule. The abrasive wear and the contact fatigue are the most important from technological point of view. It was estimated that the total wear of component can be identified 80-90% as abrasion and 8% as fatigue wear. Contribution of other types of wear is small [6]. So, abrasive wear is probably the most significant cause of mechanical damage of equipment components coming in contact with abrasive/erosive bodies. The abrasive wear is caused by sharp particles sliding or flowing across a metal surface at varying speeds and pressure, thereby grinding away material like small cutting tools.

It has been estimated that 50% of all wear problems in industry are due to abrasion, and as such, much laboratory work has examined and sought to rationalise the abrasive wear behaviour of a wide range of material [8]. However two body abrasive wear generally arise when particles are in sliding movement, between hard and rough surface, and are able to move freely. Machinery that is operating in sandy environment is vulnerable to sand particles entering and becoming entrapped between components, causing abrasive wear [9]. In a study Hokkirigawa et al (1978) observed three abrasive wear mechanisms using scanning electron microscopy (SEM): microcutting, microploughing and wedge formation. Fig.1 (a) shows the microcutting mechanism, whereas Fig.1 (b) shows the microcutting with less deep grooves. Fig.1(c) shows the micro-ploughing mechanism and Fig.1 (d) shows the wedge formation.

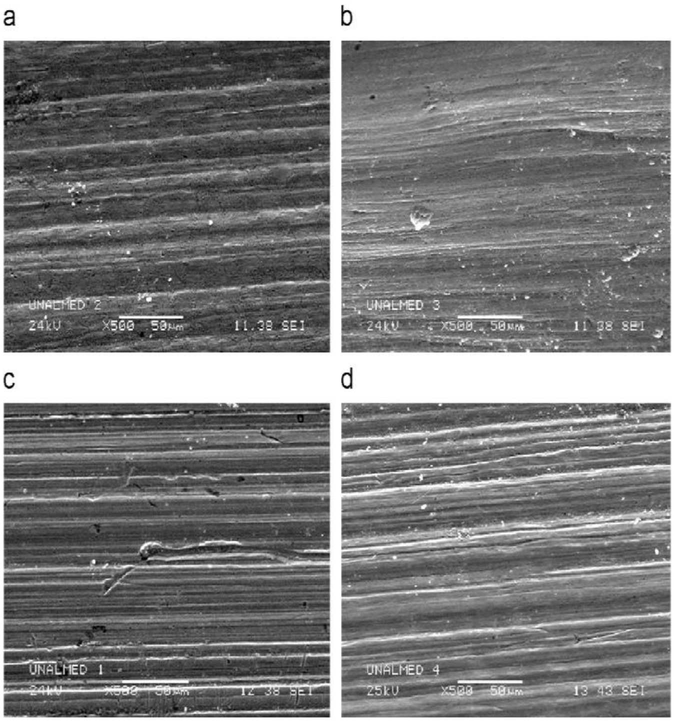

Fig-1: Abrasive wear mechanisms; (a) and (b) microcutting, (c) microploughing, (d) wedge formation.

2. ABRASIVE WEAR IN AGRICULTURAL EQUIPMENTS

The problem of wear has mainly been concentrated on industrial related to large industries, but the interaction between agricultural tillage equipment and soil constitutes a complicated tribological problem [10]. In addition the optimizing tillage is one of the major objectives in mechanized farming to achieve economically viable crop production system [11]. Farmers and equipment operators often complain about high wear rate of ground engaging tools in some dry land agricultural areas. The problems faced with recurring labour, downtime and replacement costs of exchanging the worn out ground engaging components like ploughshares [12]. Worn out tools results in poor tillage or seeding efficiency, poor weed control and higher fuel penalties. Carbon or low alloy steels are generally preferred to make tillage tool under low stress abrasive wear [13]. Tillage having composites with alumina ceramics and boron, medium and high carbon heat treated steels offers great potential the severity of abrasive wear in soil-engaging components [14]. Hardness of tillage tool, grain structure and its chemical composition are also the influential factors in determination of wear rate. Wear due to highly abrasive soils have surface damage characterized by scoring, cutting, deep grooving and gauging, and micro machining caused by soil constituents moving on a metal surface [15].

The wear of tillage implements in most soils is caused by the stones and gravel content. In addition wear on parts of a plough body, more systematically, depends on the wear resistance of the plough parts which in term is dependent on their thermal processing and shape, the tillage conditions, as plough area (or time), plough speed and tillage depth, the normal forces between the soil and the surfaces of the plough area, the proportion, hardness, sharpness and shape of soil particles, the moisture content of the soil, the density and mechanical properties of the soil (hardness, shear strength and brittleness) and environmental effects and weather changes [16]. Wear resistance of plough is mainly associated with their surface hardness and shape of ploughshare, which in turns related to the soil type and the cutting edge thickness. The wear and wear rate determination of tillage tool is necessary because it seriously affects production planning, tillage quality, repair cost of tillage component, energy consumption for tillage process each time performed and finally the production cost of agricultural product [17]. Several studies on the evaluation of abrasive wear resistance have found that using hard deposits in welding processes is a good alternative to recover parts under abrasive wear [18].

3. GROUND ENGAGING TOOLS

The mouldboard plough is the most widespread tillage tool in the world and the biggest consumer of energy in agriculture [19]. For the design of an energy efficient mouldboard plough in different operating conditions, an understanding of the interactions of different ploughs, soils and operational parameters is essential [20]. The ploughshare and the mouldboard are the main soil engaging parts of the mouldboard plough and the ploughshare is the part with the highest wear rate [21]. The ploughshare wear not only effects its working life but directly changes its initial shape, which is one of the most important factors influencing ploughing quality. The comparison between a new and a worn out ploughshare with changes in initial shape is shown in Fig. 2. The wear of the ploughshares also lead to frequent work stoppages for replacement, downtime and results in direct costs through the important effects of higher fuel consumption and lower rates of work [22].

4. REMEDIAL MEASURES

Wear is considered a genuine problem with engineering material globally, for instance, it has been reported that there is total losses in agricultural sector due to wear is about $940 million every year in Canada[23] the similar losses costing about $4.4 million in Turkey every year [24]. Research is going on over the years to reduce the wear either in the form of using a new wear resistance material or by improving the wear resistance of the existing material by addition of any wear resistance alloying element etc.

Fig-2: A new and a worn out ploughshare parts

In order to combat with problem of wear several attempts have been made, and surface treatment has been considered as the most appropriate method [25].In this various surface modification processes has been found so far, such as carborizing, boriding, nitridng, cryogenic treatment, heat treatment processes, coating and hardfacing. Hardfacing and coating are generally preferred for abrasion wear as cryotreatment found its application in the high-cycle fatigue fields [26]. Hardfacing process is considered as the effective and economical method to reduce wear problem by increasing hardness of the component [27]. Hardfacing is commonly employed method for functionalizing surfaces subjected to severe wear, corrosion or oxidation, which has transformed itself into a field of broad application and development, both in manufacturing of new components and in the repair and extension of useful life across a vast range of industries [28]. The hardfacing not only has a high wear and impact resistance, anti-corrosive behavior of deposited metal, but also can restore the dimensions of worn out components. In addition, the hardfacing may produce a thick deposited layer with a high deposition rate and resulting hardened layer has a high bonding strength with the matrix [29].

Hardfacing can be deposited by various welding methods:-

- Shield Metal Arc Welding (SMAW)
- Gas Metal Arc Welding (GMAW)
- Tungsten Inert Gas Welding (TIG)
- Metal Inert Gas Welding (MIG)
- Oxyfuel Welding (OFW)
- Electrslag Welding (ESW)
- Plasma Transfer Arc Welding (PTAW)
- Thermal Spraying

The systematic study of various consumable and welding processes applied to hardfacing, is of great interest for the optimization of the design of the consumables and for the evaluation of fine tuning of the welding procedures. The working life of equipment or of a mechanical component exposed to mechanical wear on its surface has been prolonged through the use of wear resistance alloys. Greater benefits can be and of the deposition process. The selection of deposition process is as important as the selection of the alloy to be deposited, i.e it must be based on various factors such as the operating conditions, characteristics of the base material, the geometry and dimensions of the part, the cost/benefit ratio of the component to be coated and processing cost.

The wear resistance of tillage tools depends mainly upon surface hardness. The increase in material hardness results in decrease in wear rate. Certainly, there has to be a relationship between tool hardness and hardness of particles in order to keep effective wear resistance but also to be borne in mind is the fact that high hardness implies brittleness [30]. Studies on the wear resistance of the materials subjected to the impact of abrasive particles are usually carried out at many research centres. The research determined the wear resistance of material under laboratory conditions and includes selection of adequate grades of steel [31]. On the other hand, determination of effect different implement designs and different working conditions on the wear and its distribution on a given element requires field testing. This is due to the difficulties in laboratory simulation of changes in load, which occur during work in soil [32]. In laboratory conditions several methods are employed to determine the wear resistance of materials like dry sand rubber wheel test, pin on disc test etc. When comparison is made between the laboratory and in field experiments, it can be concluded that the actual field environment, in which the impacts or contacts to the tillage tool components occurs due to factors such as hard soil particles as the stones, gravels, rocks and roots during working in field could not be achieved satisfactorily in the laboratory merely through wear test machine [33].

5. CONCLUSION

Wear is considered as the major problem in engineering and agricultural components. To combat with wear problem, hardfacing is the most versatile process among many alternatives to improve the life of the worn out components and reducing the cost of replacement. Hardfacing reduces the downtime because parts last longer and fewer shutdowns are required to replace them. To determine wear in agricultural sector, in-field tests are necessary due to the difficulties in laboratory simulation of changes in load, which occur during work in soil. The performance of the components in accordance to the variations in conditions in actual environment could not be achieved through laboratory tests.

6. REFERENCES

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