The effects of different types of heat-treatment on the wear of Shovel

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Abstract: Wear is known to be as the degradation of material under service conditions and is considered as one of the major issue of the material used in agricultural field. The wear of shovel is a major source of economic constraints to local farmers. Abrasive wear probably the most significant cause of the mechanical damage of equipment component coming in contact with abrasive bodies. The main reason for replacing agricultural equipment including upgraded old equipment and substituting them because of wear. The wear of the component depends on its surface characteristics like microstructure, toughness and hardness. The abrasive wear in agricultural equipment is the most common problem. This work states laboratory and field work results of the wear property of agricultural equipment (shovel). We evaluated wear resistance of shovel after providing heat-treatment as per composition by engaging the part in the field work wear resistance is analyzed The life of shovel under service condition can be increased along with reducing the replacement cost of worn out parts via wear property of the tools. Wear behavior effects non heat-treated and heat-treated parts in different ways. Heat treatment is the versatile process which reduces the downtime because parts last longer and fewer shutdowns are required to replace them. Our work indicates to the result that wear behavior of flame hardened agricultural equipment (shovel) is superior than non-heat treated agricultural equipment.

INTRODUCTION

Metal is integral part of human being mostly Iron and Steel. Iron is most important metal used in Agricultural field. India is an agricultural country so studying the problem of agriculture equipment made of metal is responsibility of Metallurgists.Common problem with agricultural equipment is that they are always in contact with soil. Physical and chemical reaction of the metal surface with agricultural environment e.g. soil, water, dust. Chemical reaction like corrosion of metal and physical reaction like wear of it.

For the most of agricultural equipment we need a sharp edge to cut either for land tillage or cutting of agricultural products e.g. wood, sugar-cane etc. These cutting tools most of the time are made of Iron alloys (steel). So what do we need for a sharp edge tool to work fast and for long time as we know the edge degrade during working. As being metallurgy student a rough idea comes into mind that as much as a metal is hard it is going to be to more wear resistant. So we decided to check the validity of that idea.

Most widely used agricultural tool is the Shovel of cultivator, used in tilling of soil. Two problems with that tool are: wear due to friction during work and corrosion because due to moisture in the soil.

Fig.1 Fresh Reversible Shovel

Fig.2 Worn out Reversible Shovel

Shovel is used for tillage, tilling is the very first step for any crop. Tilling requires very hard metal to cut the soil. Soil can be hard and soft depending upon constitutes of it e.g. sand, moisture etc. Mostly ploughshares are being used as tilling equipment. These days tilling is done by cultivators forced by tractors. Reversible shovel is main part of Cultivator responsible for tilling which comes into direct contact with soil during tilling

This Shovel is manufactured locally using *kamaani*of railway as raw material; this *kammani*is scrap for the railway. So local entrepreneurs use this spring steel as raw material and convert this into Shovel of cultivator by hot rolling and cutting into rectangular shape then bending it and grinding its edges.

So we cannot control its properties during casting .We need wear resistance so surface hardening treatments will be applied to component. Application of flame hardening, conventional hardening, hardening with tempering is done on Shovels to increase hardness value. Overlay materials of wear resistance metals improve wear property of Shovels We can also search for new metals which should be economic. Economics of component depends upon: its initial cost, maintenance cost and life of component. Few branded steels like TATA ABRAZO® are very good in manure of wear resistance but their initial cost is high which can be a negative factor for the Rural Economy.

Flame hardening, conventional hardening, hardening with tempering is applied on Shovels. To check the wear property samples are given to farmers for field work. The wear behavior 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. The complex nature of wearhas delayed itsinvestigations 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.[1] Wear also depends upon nature of land, its composition, moisture content, bonding force between soil particles. Our work aims on enhancing properties (hardness, toughness) of Shovel.

After field work the flame hardened sample showed improved properties. Only hardened and tempered shovels breakdown. Flame hardened sample has good wear resistance.

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 problem. In addition the optimizing tillage is one of the major objectives in mechanized farming to achieve economically viable crop production system. 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. 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. 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. Hardness of tillage tool, grain structure and its chemical composition are also the influential factors in determination of wear rate. The wear of tillage implements in most soils is caused by the stones and gravel content. Wear resistance of plough is mainly associated with their surface hardness.

In order to combat with problem of wear several attempts have been made, and surface treatment has been considered as the most appropriate method. In this various surface modification processes has been found so far, such as carborizing, boriding, nitridng, cryogenic treatment, heat treatment processes, coating and hardfacing. 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. 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.

All the influential factors associated with field working condition seem to suggest that wear must be more than a simple process that can be such hardness. Process that increase wearing resistance are listed below-

- Improving the basic material features by heat-treatment.
- Improving the strong materials against wearing.
- Coating the materials which are exposed to wearing

Alloy steel is mainly used to overcome abrasive wear-related problems due to their high strength and toughness. Various efforts are going on to reduce abrasive wear rate by changing the chemical composition, microstructure, and mechanical properties. Many researchers suggested heat treatment process as a suitable technique for obtaining combination of properties to resist the abrasive wear. Abrasion wear is one of the most dominant types of wear, and abrasion wear resistance is very important in many applications. It is well known that hardness of commercially pure metals influence on its abrasive wear resistance and that higher hardness imply a higher wear resistance.

Chahar (2009) studied the effect of different heat treatment process on abrasive wear behavior of medium carbon alloy steel for enhancing the service life of soil working components of agricultural machineries. They found that the increase of the wear resistance depends on the way in which the metal is being hardened (alloying, heat treatment or work-hardening) and that in some cases wear resistance decreases with increase of hardness. The aim of the present work is to study the effect of heat treatments with quenching media water on the microstructure, hardness, toughness, and abrasive wear resistance of agricultural tillage equipments steel type (34Cr4) with soil texture and compared with steel which was nottreated. [2]

MATERIAL AND METHOD

CHEMICAL COMPOSITION:

We purchased reversible shovels available in market. Before applying to heat-treatment, the composition of the shovels should be known. Chemical composition of shovel is determined using spectroscopy. For spectroscopy it was given to a private consultancy company SPECTRO RESEARCH LAB VENTURES (P) LTD. The chemical composition including main contents, as per test report is as follow:

Element	Iron	Carbon	Silicon	Manganese	Sulphur	Phosphorus

%	98.03	0.675	0.182	0.988	0.013	0.032

As from the composition it is clear that steel is austenitic steel. So the temperature for heating should be around 750-800^0 C.

HEAT TREATMENTS:

(a) Conventional Quenching

The object was heated to 800^o C for full austenization with a heating rate~ 6^o C min^{-1} , and held at this temperature for 3:00 hours for uniform transformation .After soaking time the object was water quenched.

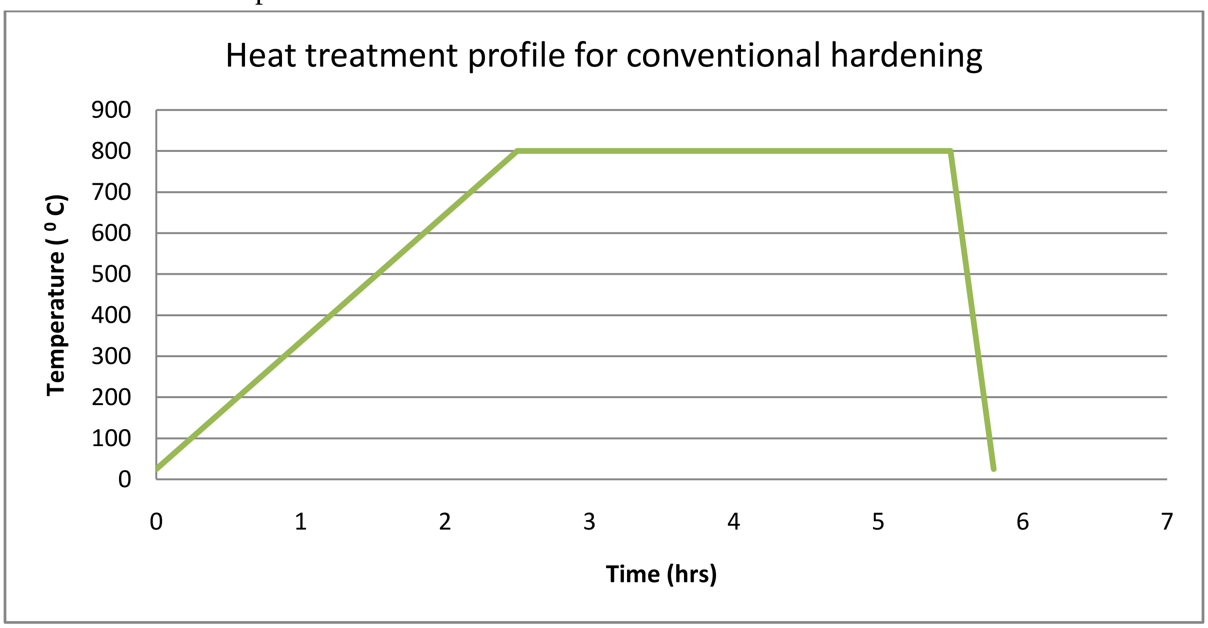

Fig. 3 Conventional Quenching Profile

Heat treatment parameters for Quenching:

Parameter	Heating Temperature	Heating time	Heating rate	Holding time	Type of Cooling
Value	800^o C	2:30 hours	~5.79^o C min^{-1}	3 hours	Water cooling (100^O C sec^{-1})

(b) Tempering

The object was heated to 200^{o} C for relieving internal stresses with a heating rate ~ 3.33^{o} C min^{-1} , and held at this temperature for 01:00 hours. .After soaking time the object was air cooled .

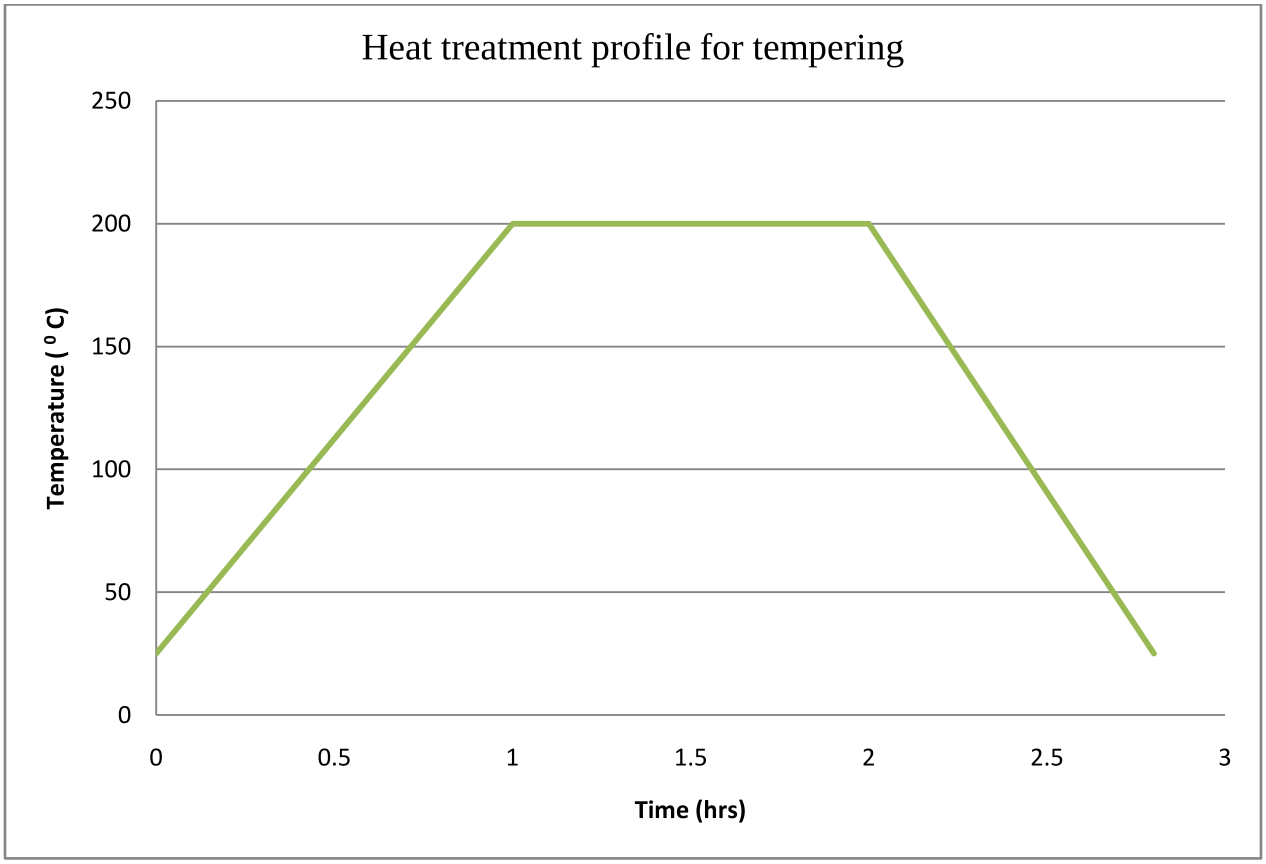

Fig. 4 Tempering profile

Heat treatment parameters for tempering:

Parameter	Heating Temperature	Heating time	Heating rate	Holding time	Type of Cooling
Value	200 ^{o} C	1 hour	3.33 ^{o} C min^{-1}	1 hour	Air cooling

(c) Flame Hardening

The object was heated with oxyacetylene flame at a temperature about 1000^o C for 10 minute, and hold about 3 minute. After soaking at this temperature the object was quenched by water jet.

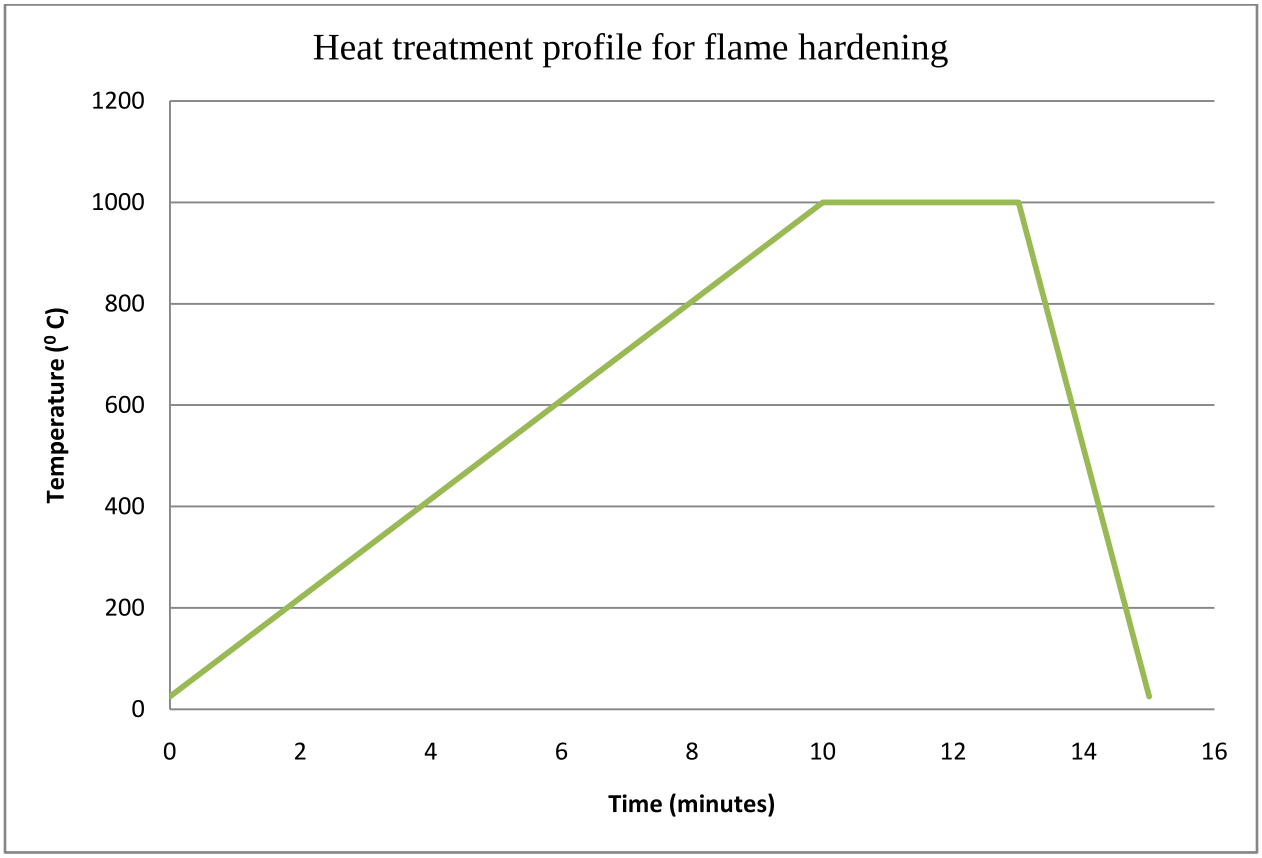

Fig.5 Flame hardening profile

Heat treatment parameters for flame hardening:

Parameter	Heating Temperature	Heating time	Heating rate	Holding time	Type of Cooling
Value	1000^o C	10 minute	100 ^{o} C min^{-1}	~3 minute	Water Jet Quenching

Hardness test:

The hardness of non heat-treated and different heat-treated object was determined by MACRO HARDNESS TESTER which is shown in the figure below.

Fig.6 Macro Hardness Tester

Determined hardness value for different heat-treated objects:

Sample	Non heat-treated	Quenched	Quenched and Tempered	Flame Hardening
Value	46HRC	71HRC	78HRC	85HRC

CALCULATIONS

Area of tillage is 258.7 *bigha* (43.11hectare).

SN	Type of Sample	Weight before tilling (gram)	Weight after tilling (gram)	Weight loss (gram)	% Weight loss
1	Non Heat-treated	920	800	120	13.043
2	Flame hardened	920	820	100	10.869

Shovel mass loss percent

Formula of weight loss =

[(mass of shovel before using –mass of shovel after use)/mass of shovel before use]*100

For non heat-treated

Weight loss percent = [(920-800)/920]*100= 13.043%

For flame hardened

Weight loss percent= [(920-820)/920]*100=10.86%

Shovel Wear rate

Formula of wear rate= loss of mass/area of tilling (gram/meter^2)

Non heat-treated

Wear rate =120/431100 g-m^{-2} =0.0002783 g-m^{-2}

Flame hardened

Wear rate=100/431100 g-m^{-2} = 0.0002319 g-m^{-2}

RESULTS

We concluded with the help of spectroscopy result that objects are austenitic steel because of 0.988% of Manganese is an alloying element which austenite stabilizer. The chemical composition of austenitic steel is as:

98.03% Fe, 0.67% C, 0.18% Si, 0.98% Mn, 0.01% S,0.03% P.

The laboratory experiment results showed different hardness values for different heat treated objects. The hardness value of tempered object is greater than that of only quenched object, because of formation of martensite along with carbides. The following determined hardness values by macro hardness tester are given below:

- The hardness value of quenched steel is 71 HRC
- The hardness value of tempered steel is 75 HRC
- The hardness value of flame hardened steel is 85 HRC

Wear is considered as the major problem in engineering and agricultural components. The wear is a essential characteristic in the agricultural production owing to the loss of the function of a given part caused by the change of the mechanical property, which is significant in this object during field work. To combat with wear problem, heat treatment is the most versatile process among many alternatives, to improve the life of worn out components. By applying the heat-treatment process the mechanical property (mainly wear resistance) increases, so the life of the reversible shovel could be increases with decreasing the downtime and replacement cost.

We are going through improving the basic material features by heat-treatment, because we only need increased hardness which can be enhanced easily by heat-treatment method and also heat treatment is less expensive than other methods.

Weight loss of flame hardened shovel is 10.8695 % and that is 13.043 % for non heat-treated.

Wear rate of flame hardened shovel is 2.3196 x 10^{-4} g-m^{-2} and that of non heat-treated shovel is 2.7835 x 10^{-4} g-m^{-2}.Wear rate of flame hardened Shovel is 16 % less than non heat treated Shovel.

As above mentioned number show that weight loss of flame hardened shovel is less, therefore wear resistance of this sample is more than non heat-treated. Hardness in flame hardened steel is due to martensitic and lower bainitic structure. Flame hardening is also economically feasible for rural economy, because low cost of workshop.

REFERENCE

1. [Parvinkal Singh Mann, Navjeet Kaur Brar; International Research Journal of Engineering and Technology (IRJET); vol 2; page 1704-1708; June 2015]
2. [Alwan S Abbas; Engineering & Technological Journal; vol 32; page 2205-2215; 2014]
3. [A. TufanPalali, Muammer NALBANT; TarimMakialaBilimiDergisi (Journal of Agricultural Machinery Science); vol 4(2) page 187-192; 2008]
4. [Aysel YAZIKI; Turk J Agric For Research article; vol 35; page 461-468; 2011]
5. [Singh jahtar, Singh Lakhwinder Pal, Kaushik Ankur; Friction and Wear research; Vol 1; page 22-27; July 2013]
6. [JercyNapiorkowski, Karol Kotakowski; Technical Sciences; Vol 14; page 101-108; 2011]