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THE INFLUENCE OF VARIOUS HEAT-TREATMENT METHODS ON THE WEAR OF THE SHOVEL

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Abstract: One of the main problems with the materials used in agricultural fields is wear, which is understood to be the degradation of material under service circumstances. The main source of financial hardship for nearby farms is shovel wear. The mechanical damage to equipment components coming into contact with abrasive bodies is most often caused by abrasive wear. Wear is the primary factor in replacing agricultural equipment, even enhanced versions of older models. The surface properties of the component, such as its microstructure, toughness, and hardness, affect how quickly it wears. The most frequent issue with agricultural equipment is abrasive wear. The findings of laboratory and field research on the wear property of agricultural equipment are presented in this study (shovel). By using the component in field operations and applying heat treatment according to composition, we examined the shovel's wear resistance. The wear characteristic of the tools may be used to extend the life of a shovel while also decreasing the cost of replacing damaged pieces. Heat-treated and non-heated components are affected by wear differently. Heat treatment is a flexible procedure that decreases downtime since heat treatment makes parts survive longer and necessitate fewer shutdowns to replace them. Our research points to the conclusion that agricultural equipment that has been flame-hardened exhibits better wear behaviour than agricultural equipment that has not been heat-treated.

Index Terms* – *Wear, Abrasion, Metallurgy

I. INTRODUCTION

Iron and steel, in particular, are an essential component of human beings. The most significant metal utilised in agriculture is iron. Since India is an agricultural nation, metallurgists are in charge of researching the issue of metal agricultural equipment. The fact that agricultural machinery comes into constant touch with the ground is a common concern. Metal surface's physical and chemical response to agricultural environment, such as soil, water, and dust. both physical and chemical reactions, such as metal corrosion and wear. For the majority of agricultural machinery, a sharp edge is required for cutting, either for ploughing of the soil or cutting of agricultural products, such as wood, sugarcane, etc. The majority of the time, these cutting instruments are built of iron alloys (steel). So, given that the edge degrades while being used, what do we need for a sharp edge tool to function quickly and for a long time? Being a student of metallurgy, the general assumption that a metal will be more resistant to wear the harder it is occurs to me. So we made the decision to examine that theory's viability. The cultivator's shovel, used to till the soil, is the most often used agricultural implement. Wear from friction during usage and corrosion from moisture in the soil are two issues with that tool.

Figure.1 Fresh Reversible Shovel

Figure.2 Worn out Reversible Shovel

Tilling is the very first stage in growing any crop and is done with a shovel. To cut the earth during tilling, very hard metal is needed. Depending on its components, such as sand, moisture, etc., soil can be either hard or soft. As tilling tools, ploughshares are mostly utilized. Nowadays, cultivators are driven by tractors to till the soil. The primary component of a cultivator that is directly in touch with the soil when tilling is a reversible shovel. Local labourers use railroad scrap as the primary raw material in the construction of this shovel. Local business owners utilise this spring steel as their raw material, hot roll it into a rectangular form, cut it, bent, and ground its edges into a shovel of cultivator Therefore, we are unable to regulate its characteristics when casting. Surface hardening treatments will be given to the component since we need wear resistance. Shovels are subjected to flame hardening, conventional hardening, and hardening with tempering to raise their hardness value. Shovels' wear properties are improved with overlays made of metals with high wear resistance. We can also look for new metals, which ought to be economically viable. The original cost, maintenance costs, and lifespan of a component all affect its economics. A few well-known steels, such as TATA ABRAZO®, are excellent at resisting wear, but their high initial costs might be detrimental to the rural economy. Shovels are subjected to flame hardening, conventional hardening, and hardening with tempering. Farmers are given samples to test in the field in order to determine the wear attribute. Along with service circumstances like load, sliding speed, environment, and temperature, the form, size, composition, and distribution of micro components are factors that affect how a material wears. The complexity of wear has slowed down research into it and led to solitary studies focused on certain wear mechanisms. The surface properties of the component, such as its hardness, microstructure, and roughness, affect how quickly it wears. In engineering practise, friction and material wear are typically regarded as important qualities. The type of the land, its composition, its level of wetness, and the strength of the bonds between soil particles all affect wear. Our effort is to improve the shovel's physical characteristics (hardness, toughness). The flame-hardened sample's characteristics improved during field testing. Only tempered and hardened shovels degrade. The sample with flame hardening exhibits high wear resistance

WEAR FROM ABRASION IN AGRICULTURAL EQUIPMENT

The interaction between agricultural tillage equipment and soil is a complex subject, however the issue of wear has primarily been focused on major companies. One of the main goals of mechanical farming is to optimise tillage in order to develop an economically feasible crop production system. In some dry land agricultural locations, farmers and equipment operators frequently lament the high rate of ground engaging tool wear. issues with repeated labour, downtime, and replacement costs for replacing worn-out ground-engaging parts like ploughshares. Poor weed management, ineffective tillage or sowing, and greater fuel penalty are all effects of worn-out equipment. Under low stress abrasive wear, carbon or low alloy steels are typically preferred to make tillage tools. The severity of abrasive wear in soil-engaging components can be greatly reduced by tillage using composites of alumina ceramics and boron, medium and high carbon heat treated steels. The hardness of the tillage tool, the grain's structure, and its chemical makeup are further important variables in determining wear rate. In the majority of soils, the presence of stones and gravel increases the wear on tillage equipment. Surface hardness of ploughs is mostly related to their wear resistance. Several attempts have been made to tackle the problem of wear, and surface treatment has been deemed the most effective approach. So far, a variety of surface modification techniques have been identified in this, including coating, hardfacing, cryogenic treatment, boriding, nitriding, and carborizing. Surface hardness is the primary factor that determines how long tillage implements last. The rate of wear decreases as material hardness increases. In order to maintain efficient wear resistance, there must undoubtedly be a link between tool hardness and particle hardness. However, it is important to keep in mind that high hardness also suggests brittleness. Numerous research centres often conduct studies on the wear resistance of the materials exposed to the impact of abrasive particles. Under laboratory circumstances, the wear resistance of the material was evaluated by the study, which also involved choosing the right steel grades.

All the significant aspects that are connected to field working conditions seem to imply that wear requires more than just a straightforward technique to be this severe. The following are methods that increase wearing resistance. by using heat, enhancing the fundamental properties of the material strengthening the durable materials to resist abrasion. protecting the materials from wear by coating them Due to its great strength and hardness, alloy steel is mostly utilised to solve abrasive wear-related problems. There are several initiatives underway to lower the rate of abrasive wear by altering the chemical composition, microstructure, and mechanical characteristics. Many scientists recommended heat treatment as an effective method for generating a mix of qualities to withstand abrasive wear. One of the most common forms of wear is abrasion wear, and in many applications, abrasion wear resistance is crucial. It is commonly known that the abrasive wear resistance of commercially pure metals is influenced by their hardness, and that harder metals have better wear resistance. Chahar (2009) investigated how different heat treatment processes affected the abrasive wear behaviour of medium carbon alloy steel to extend the lifespan of agricultural machinery parts that work the soil. They discovered that the method of hardening the metal—alloying, heat treatment, or work-hardening—determines the increase in wear resistance, and that in certain circumstances, wear resistance declines as hardness increases. The current study's objective is to compare steel that has not been treated to steel that has undergone heat treatments with quenching media water to determine the effects on microstructure, hardness, toughness, and abrasive wear resistance of agricultural tillage equipment steel type (34Cr4) with soil texture

CHEMICAL COMPOSITION OF THE MATERIAL AND METHOD:

I bought reversible shovels from the market. It is important to understand the shovels' composition before performing heat treatment. Utilizing spectroscopy, the chemical composition of the shovel is identified. It was handed to the private consulting firm SPECTRO RESEARCH LAB VENTURES (P) LTD for spectroscopy. According to the test report, the chemical makeup, including the principal ingredients, is as follows:

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 750-8000 C.

It is evident from the composition that the steel is an austenitic steel. Therefore, the recommended range for heating is between 750 and 800 °C

HEAT TREATMENTS:

Standard Quenching With a heating rate of 6ºC min^{-1}, the item was heated to 800ºC for complete austenitization and maintained at this temperature for three hours to ensure homogeneous transformation. The item was water quenched after soaking time

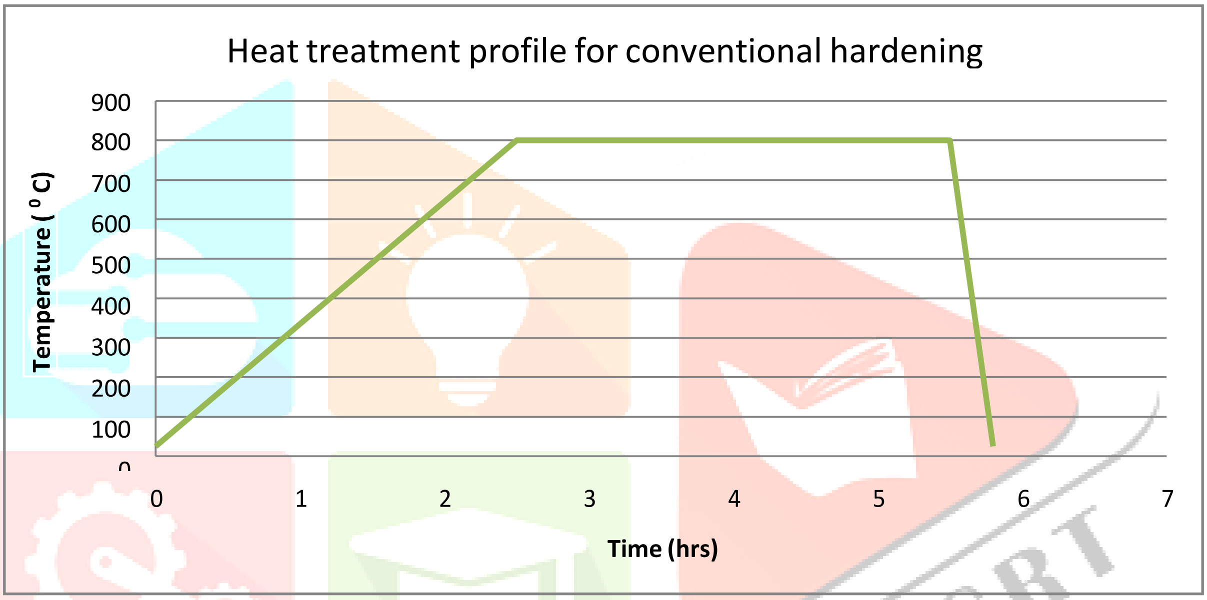

Figure.3 standard Quenching Profile

Heat treatment parameters for Quenching:

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

(b) Tempering

The item was heated to 200° C and maintained there to relieve internal tensions at a heating rate of 3.33° C min-1. temperature at 1:00 in the morning. After soaking, the item was air cooled

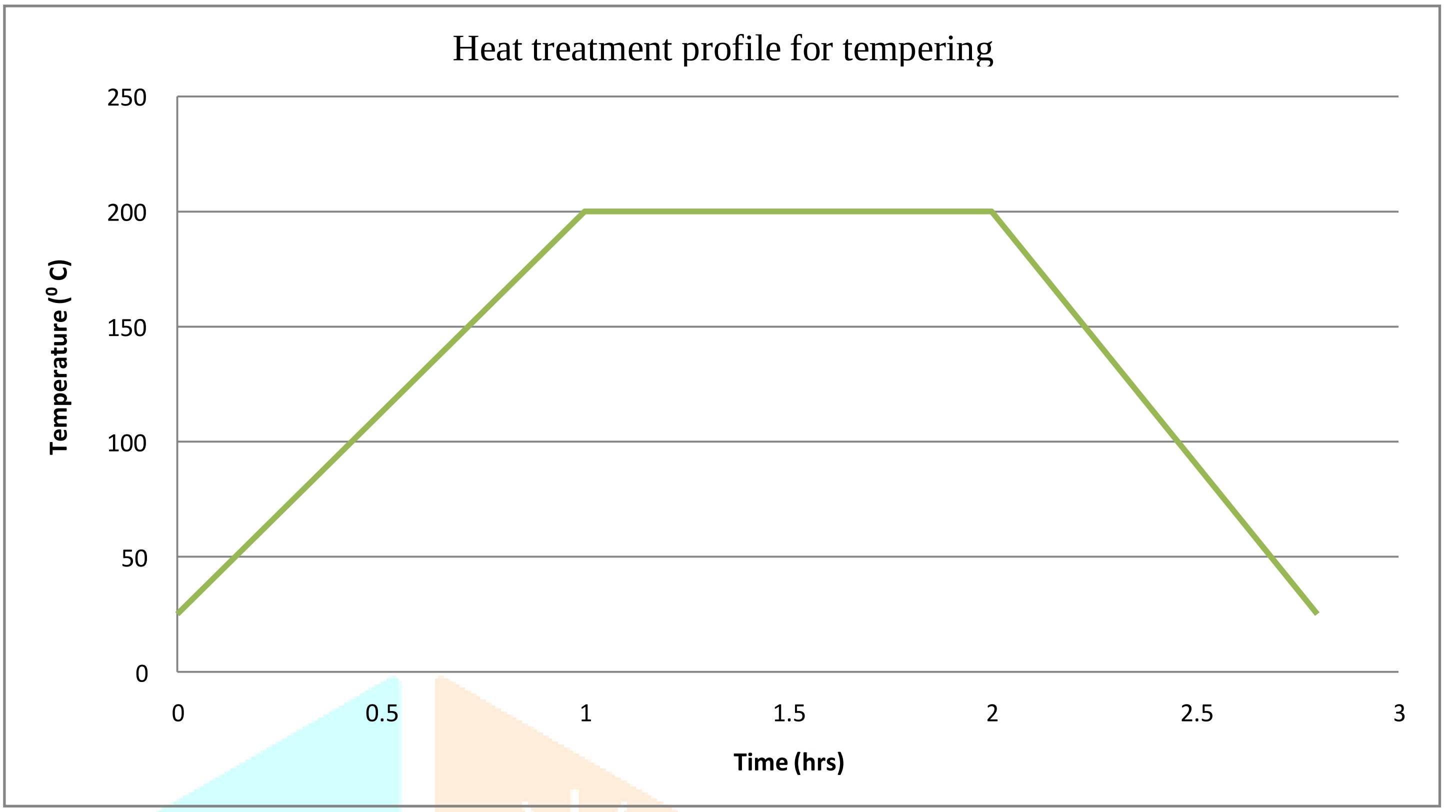

Figure.4 Tempering profile

Criteria For Heat Treatment During 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 item was heated for 10 minutes and held at a temperature of around 1000o C using an oxyacetylene flame. The item was quenched with a water jet after being submerged at this temperature.

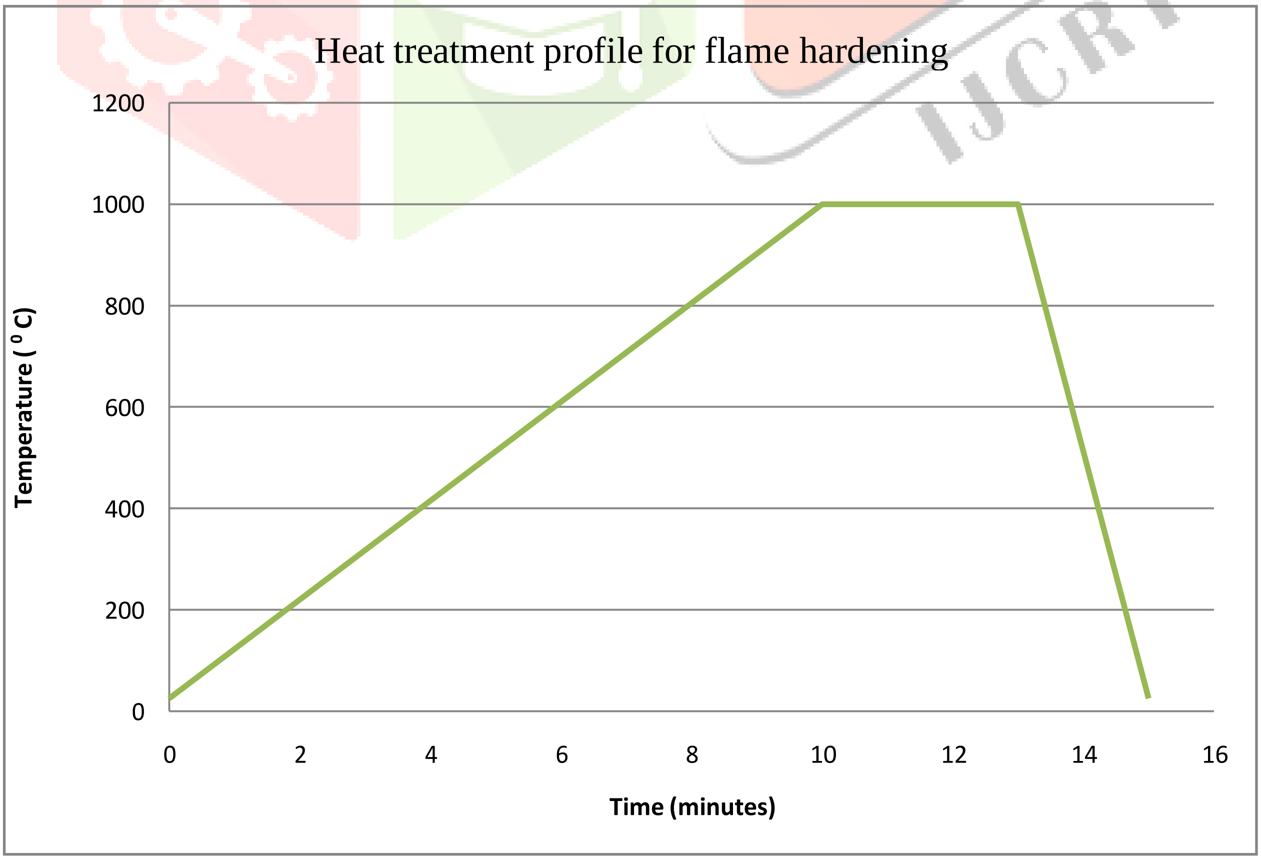

Figure.5 Flame hardening profile

Criteria For Heat Treatment During Flame Hardening:

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

Hardness test:

MACRO HARDNESS TESTER, which is seen in the picture below, was used to measure the hardness of various heat-treated and non-heated objects.

Figure.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

IV. RESULTS AND DISCUSSION

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	1000	880	120	12
2	Flame hardened	1000	900	100	10

Shovel mass loss percent

Formula of weight loss = $\frac{\text{mass of shovel before using} - \text{mass of shovel after use}}{\text{mass of shovel before use}}$ *100

For non heat-treated

Weight loss percent = [(1000-880)/1000]*100= 12%

For flame hardened

Weight loss percent= [(1000-900)/1000]*100=10%

Shovel Wear rate

Formula of wear rate= $\frac{\text{loss of mass}}{\text{area of tilling (gram/meter2)}}$

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}

With the aid of the spectroscopic results, we deduced that the items were made of austenitic steel since they included 0.988 percent manganese, an alloying component that stabilises austenite. Austenitic steel's chemical make-up is as follows: 98.03 percent Fe, 0.67 percent C, 0.18 percent Si, 0.98 percent Mn, 0.01 percent S, and 0.03 percent P.

The outcomes of the laboratory experiment revealed various heat-treated items to have varying hardness levels. Due to the development of martensite and carbides, tempered objects have a higher hardness value than only quenched ones. Below are the hardness values that the macro hardness tester determined:

- Quenched steel has a hardness rating of 71 HRC.
- Tempered steel has a hardness rating of 75 HRC.
- Flame-hardened steel has a hardness rating of 85 HRC.

Wear is seen as the main issue with agricultural and technical components. Due to the loss of functionality of a specific part brought on by a change in the mechanical property, wear is a crucial aspect of agricultural productivity during fieldwork, this item was noteworthy. Heat treatment is the most adaptable method among numerous possibilities for reducing wear and extending the life of worn-out components. The mechanical properties (primarily wear resistance) are improved by the heat-treatment procedure, extending the life of the reversible shovel while lowering downtime and replacement costs. We are using heat treatment to improve the fundamental properties of the material since we simply need to increase hardness, which can be done quickly with this technology, and because it is less expensive than alternative techniques.

Flame-hardened shovels lose weight by 10 %, compared to 12% for non-heat-treated shovels.

Flame-hardened shovels have a wear rate of 2.3196 x 10-4 g-m-2 whereas non-heated shovels have a wear rate of 2.7835 x 10-4 g-m-2.

Flame-hardened shovels wear out at a rate that is 16% lower than non-heated shovels. Since the weight loss of a flame-hardened shovel is smaller than that of a non-heat-treated shovel, this sample has greater wear resistance. The martensitic and lower bainitic structure of flame-hardened steel is what gives it its hardness. Due to the cheap cost of the workshop, flame hardening is also economically viable for rural economies.

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