Synopsis of

Wear Characteristics of Surface Treated Structural Materials

A Thesis

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Wear characteristics of surface treated structural materials

All mechanical components that undergo sliding or rolling contact are subject to some degree of wear. Wear is probably the most important factor in the deterioration of machinery with moving components , often limiting both the life and performance of such equipment . Therefore , the economic consequences of wear induced failure are of major concern and this makes the selection of proper material and treatment very important .

In selection and design of automotive components and structural material for tribological applications, least surface deterioration is the prime concern. Wear characteristics of automotive components vary based on their applications and the surface treatment carried out to enhance the mechanical properties. Surface fatigue or pitting, fretting, spalling and scuffing are few of the common wear types encountered in heat treated automotive components.

There is a need for designers and Material scientists to have an estimate of the wear characteristics for various materials with variety of Heat-treatment and case hardening operations. The study is to support that need by experimentation & creating an empirical relationship of commonly used structural materials which are treated with various surface treatments like Sursulf, Nitrocarburising, Carburising, Induction hardening, cladding to achieve the desired mechanical properties.

Properties of various material subjected to different case hardening mechanisms, resulting in various combination of hardness , case depth / compound layer achieved and the microstructural changes will be studied in details , along with comparison of their abrasive wear property. The aim will be to establish an empirical relationship between the various materials , surface treatment carried out and the wear characteristics to facilitate the selection of steels for automotive components with tribological applications. This work is intended to provide a guideline for material selection for Designers and Material Engineers with respect to wear characteristics .

Chapter 1: Introduction

An introductory overview on various wear types , manifestations, and methods of prevention of wear are given . Abrasive wear is found to be mostly responsible for intensive degradation of machine parts or tools. Methods of increasing the lifetime are discussed , which are based on application of abrasion resistant materials or creation of hard, wear resistant surface layers or coatings on the surface of the moving part or sliding part of the machine or tool . The scope of research is to have a relative abrasive index , to facilitate designers and material scientists for proper and optimised material selection. This study does not include study of wear behaviour , as lot of study is already done in this area . Mostly the commonly used Low and Medium alloy steels , used for ground engaging tools and transmission parts for construction equipment .

Chapter 2: Literature Review

This Chapter explains the important literature reviews done through various published papers , journals and books and the learnings .

From various literature review, it has been found , that improvement for various surface treatments is the best effective way to improve service life of components and many researchers have reported various work in this area . Dry Sand abrasion testing : ASTM G 65 is found to be the standard test method for measuring 3-body Abrasive Wear , using Dry Sand/ Rubber Wheel Apparatus. It has been found that Steels and cast irons with a martensitic matrix have a higher abrasion resistance than pearlitic steels and cast irons with a similar chemical composition. The higher content of carbon and alloy elements leads to a marked enhancement of abrasion resistance. The presence of carbides in the martensitic matrix results in a further increase of abrasive wear by particles. It has also been observed that improvement in the abrasion resistance of the order of ~50% can be achieved by subjecting the steel to

suitable heat-treatment cycles. It has been found that Abrasion Resistance of carburized low alloy steels is on the same level as in high carbon structural or Tool Steels !!

Chapter 3: Research Objective

This Chapter explains why this work is needed and the major research objectives intended with this work .

Analysing the extensive information of research results of the other authors, mostly working on studying wear resistance of pure metals , various coatings, wear resistance plates, hard-facing alloys – there is still a lot of work left for studying and comparing the wear characteristics of various materials with variety of Heat-treatment and case hardening operations.

The study is to support that need by experimentation & creating a **relative abrasion index** of commonly used structural materials for Earth Moving Machinery is selected, combined with suitable Heat Treatment and case hardening operations and subjected to abrasion Resistance and hardness test along with material characterization.

This will serve as a **ready reckoner** for Designers and Material Scientists in selection of material and facilitate them to optimize material selection and treatment for specific abrasion resistance need.

Chapter 4: Methodology

This chapter deals with a planned roadmap and methodology.

Abrasion resistance is decided based on Dry Sand Abrasion test result, along with co-relation with Surface hardness and UTS. The Aim of this work is to establish a correlation between various materials with different combinations of case hardening/surface treatment and their wear characteristics , thereby

ranking the materials as per their resistance to abrasive wear, along with material Characterization and study of effect of alloying element in abrasion behaviour of readily available materials.

This chapter also discusses about the Selection of materials, their heat-treatments , the specimen preparation method, and the various testing methods , including wear tests.

Chapter 5: Instruments and Test Facilities

This Chapter describes about the various Instruments like Spectrometer , Microscope, Micro-hardness testing machine, wear testing machines , as well as the various other facilities like Sealed Quench furnace , Nitrocarburising furnace , Induction Hardening machine etc.

Chapter 6: Selection of Materials

In this chapter , we have described the selection of 22 various combinations of materials (which are widely used in earth moving machinery as transmission parts of ground engaging tools, based on Application Based Material Index), which include plate and bar, which are processed through normalizing, TMCP, Q&T, Carburising, Nitrocarburising, surface cladding to study the wear characteristics of materials with varying mechanical and wear properties. Also , we have detailed the various surface treatments given to them with the Heat-treatment cycle applied .

Chapter 7: Observations

In this chapter , we have described the results of the various tests for chemical composition, Mechanical tests for Hardness and UTS and also done the microstructure with phase analysis for metallographic confirmation.

Chapter 8: Results and Discussion

We have analysed the wear loss data , for correlation with material composition, Hardness , UTS with Wear behaviour analysis also did mathematical modelling with Best Fit Curve equation, for materials where wear loss data is not readily available.

Strong correlation has been found between Hardness and Wear resistance for the selected materials.

By assessing the correlation between volume loss and hardness, we have derived best fit curve for the materials matrix. This will enable to assess the wear resistance of a material, for a known hardness and assist in material selection.

For correlation of mechanical properties with wear loss we have tried to understand the trend of wear loss with Ultimate tensile strength of individual materials. We could not find any direct correlation of the UTS with wear loss,

We have also taken consideration for alloying materials viz. specially Nickel, Chromium, Molybdenum, Vanadium & Boron with material characterization and tried to correlate the wear behaviour with microstructure study.

Then , as a final output of the experimentation , the relative abrasive wear resistance index of the selected materials with various heat-treatments / Surface treatments is obtained through their average volume loss and calculated based on the average mass loss obtained in metal abrasive wear tests conducted in accordance to ASTM G65.

This **Relative Abrasive Index** provides a basic guideline and can be used as a **ready reckoner** for Designers and Material Scientists in selection of material and facilitate them to optimize material selection and treatment for specific abrasion resistance need. Cost reduction activities for material cost , with cheaper material substitution can be taken up , without resorting to costly field trials.

Chapter 9: Overall conclusion and future scope

In this chapter all the major findings and conclusions of this thesis work and future scope of work has been discussed.

Overall Conclusion

1. The objective of this study is to establish a correlation between various materials with different combinations of case hardening / surface treatment and their wear characteristics.

2. By experimentation, a comparative index of resistance to wear of commonly used structural materials is prepared.

3. This is a Ready reference guide for designers for material selection with relative ranking of material.

4. Wear behaviour of various materials studied with material characterization and effect of alloying elements . Although hardness is the most important factor in the resistance to abrasion, other properties such as alloying elements, Heat-treatment, and microstructure also play an important role.

5. Mathematical modelling for generation of correlation factor - best fit curve for wear resistance established with hardness for selecting suitable material in absence of wear loss value.

Future Scope of work

1. We can further extend this study with HSS and other Tool Steels for tool life estimation.

2. Study can be carried out for some more advanced material like Dual Phase steel, Hadfield Steel and various other coated materials like weld hardfacing coatings, Ceramic or cermet thermal spray materials deposited by plasma spraying, hard coatings by vapour deposition, for example TiN.

3. We can further study the effect of impact toughness along with abrasion on different material grades, with various surface treatments.

4. Application based study can be done (Quarry application, Earthwork or Stone application) for getting wear pattern and further optimise material selection based on application.