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# Surface Modification of HSS by Induction Boriding

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**ABSTRACT-** In this present investigation, the surface modification of high speed steel of M2 grade was attempted. The aim of this work is to combine the process of induction hardening and conventional boriding without affecting ductility and toughness. Cross section was examined by optical microscope and Vickers microhardness test.

**KEY WORDS—**Induction hardening, Boriding, Vickers hardness, Optical microstructure, permeability, sawtooth structure, Diffussion

## I. INTRODUCTION

Induction hardening is an extremely versatile heating method that can perform uniform surface hardening, localized surface hardening, through hardening, and tempering of hardened pieces. Heating is accomplished by placing a steel part in the magnetic field generated by high-frequency alternating current passing through an inductor, usually a water-cooled copper coil. The depth of heating produced by induction is related to the frequency of the alternating current: the higher the frequency is, the thinner or more shallow the heating. Therefore, deeper case depths and even through hardening are produced by using lower frequencies.

The electrical considerations involve the phenomena of hysteresis and eddy currents. Because secondary and radiant heat are eliminated, the process is suited for production line areas. compares the flame- and induction-hardening processes. In this process of heating an electrically conducting object by electromagnetic induction, where eddy currents (also called Foucault currents) are generated within the metal and resistance leads to Joule heating of the metal. An induction heater (for any process) consists of an electromagnet, through which a high-frequency alternating current (AC) is passed. Heat may also be generated by magnetic hysteresis losses in materials that will have significant relative permeability. The frequency of AC used depends on the object size, material type, coupling (between the work coil and the object to be heated) and the penetration depth. Induction heating allows the targeted heating of an applicable item for applications including surface hardening, melting, brazing and soldering and heating to get fit in properly. Iron and its alloys responds best to induction heating,

The main use of high-speed steels continues to be in the manufacture of various cutting tools: drills, taps, milling cutters, tool bits, gear cutters, saw blades, etc.. although usage for punches and dies is increasing.High speed steels also found a market in fine hand tools where their relatively good toughness at high hardness.

The main objective of the project is to obtain the High speed steels with maximum hardness on surface. This should also ensure the ductility and toughness of steels without compromising the hardeness. It is because of the reason that product so formed after the conventional method (Pack boriding), surface of steels are affected with sawtooth structures which makes it anisotropic in nature. Inorder to obtain the required result, various tests has to be carried out. In the first phase, selection of appropriate materials and study of various testing and experimental methodshas has to be carried out.

## II. EXPERIMENTAL

### 2.1 Test specimen and equipments

Various variety of materials are available in the industries today. Steels are considered one of the best material available for the purpose of surface hardening so that the best results can be obtained easily. Out of available steel materials HSS (high speed steel), are considered as the finest of them for the experiments.

High speed steels are also available in various types with respect to the materials used for their furnishing which has already discussed earlier. Out of M grade and T grade HSS steels, M grade are considered for the purpose of testing as they are easily available and at affordable rates. Most industries are working on the M grade steels only for best cost effective output. Hence "M 2"grade HSS is considered here for whole experiments.

Dimension of the material should be properly selected so that the experiment can be carried out cost effectively.As per the requirement of industry setup, HSS steel has been selected for a particular dimension. Sample has a length of 50mm and diameter of 20mm. Fig.1 shows the sample of high speed steel that is to be treated.

Fig. 1: high speed steel of M2 grade.

### 2.2 Testing method

Paste should be gently applied over the material. Care must be given while applying the paste over the material as it should be applied uniformly throughout the sample. Only uniform material shows the unique characteristics through out the sample which is must for testing purposes.

The process of drying the paste over the material is done with the help of high temperature furnace which is shown below.

Fig.2: Diagram shows the high temperature furnace.

As the paste which is applied over the material is in wet condition, it has to be dried off before it is taken for Induction boriding.

Fig. 3: Picture shows the dried sample

Following shows the equipment that represents the experimental setup to carryout induction boriding. The setup is usually used for conducting induction hardening processes.

Fig. 4 : Experimental setup for Induction Boriding

Borided sample should be taken for Microhardeness test using Vicker-Hardeness test which makes a micro point impression on the material. Further the sample impression was thoroughly analysed for better results. The Vickers test is easier to use than other hardness tests since the required calculations are independent of the size of the indenter, and the indenter can be used for all materials irrespective of hardness. The basic principle, as with all common measures of hardness, is to observe the questioned material's ability to resist plastic deformation from a standard source.

The Vickers test can be used for all metals and has one of the widest scales among hardness tests. The unit of hardness given by the test is known as the Vickers Pyramid Number (HV) or Diamond Pyramid Hardness (DPH). Here The results so obtained must be compared with that of results obtained by conventional method.

The optical microscope, often referred to as the "light microscope", is a type of microscope which uses visible light and a system of lenses to magnify images of small samples. Basic optical microscopes can be very simple, although there are many complex designs which aim to improve resolutionand sample contrast.The image from an optical microscope can be captured by normal light-sensitive cameras to generate a micrograph. It is one of the finest method using which the user an study and analyse the sawtooth structure of borided layer easily. It provides detailed structure of borided layers in pictorial representation. Hence the results obtained from optical microscopy has to be compared with results of conventional methods.

## III.RESULTS AND DISCUSSION

a. Induction Boriding

Induction boriding was carried out and the high speed steel is changed into the following form. Two trials of Induction were conducted and was carried out at various intervals of time. Voltage was kept constant throughout the process which was 230 Volts. Time intervals were kept at constant intervals such as 5 minutes and 10 minutes. As a result of the induction process following products were obtained.

Dwell time can be defined as the time duration in which the workpiece has to be kept inside the heating coils while boriding is carried out. Dwell time can be increased or decreased based on the impregnating time required for the Boron atoms to penetrate inside the steel material. “distance between the work metal and heating coil” and “frequency of current” were also kept constant.

Fig. 5: Treated sample A

Fig. 6: Treated sample B

b. Vickers hardness test

Vickers hardeness test were conducted on both samples A & B. Remarkable improvement in the hardeness was obtained as a result of induction boriding.

Sample A and sample B shows the hardeness value of 1500 HV and 1550 HV respectively.

3.3 Optical Microstruture

In this test the study and analysis were carried out through the cross section of the samples where borides are available. Borided layers were found to be improved when compared with that of conventional boriding. Conventional boriding induce the formation of sawtooth structures and it will be distributed from the top surface layer to some millimetres to the inside.

Following shows the image of microstructure that was formed as a result of pack boriding. We can also see the crack propagation through the material.

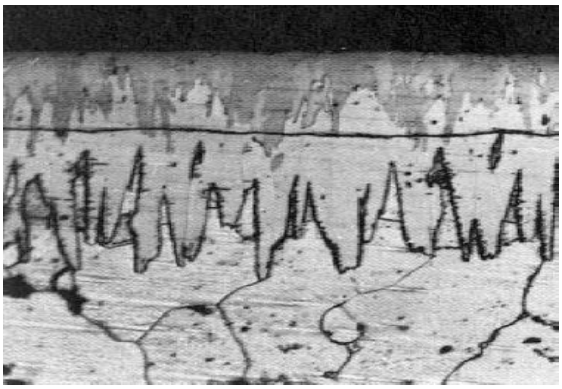

Fig. 7: Sawtooth structure

Sawtooth structures makes the material anisotropic in nature and hence the material loses its properties. It weakens the ductility and toughness of high speed steel.
Following is the image of microstructure formed as a result of induction boriding.

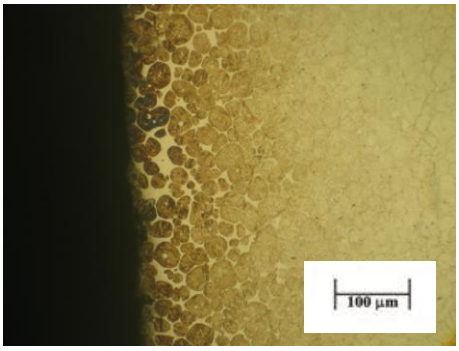


Diagram A & B clearly shows the formation of borides over the high speed steel. We can also concludes the diffusion of Boron instead of coating.

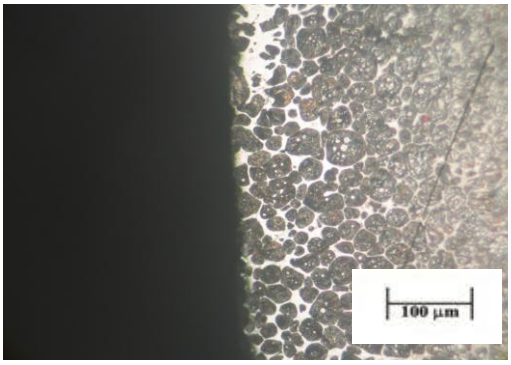


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Fig. 9: Microstructure of sample B

Above images clearly shows the formation of borides without the formation of any sawtooth structure and crack propagations. It shows the improvement of samples in terms of ductility and toughness.

## IV.CONCLUSION

Thus the study and analysis on various methods of conventional and modern surface hardening processes had been completed, expecially on boriding process. Various demerits associated with the above methods have been thoroughly analysed and hence a new method called "Induction boriding" have been founded out. Experimental setup required for the induction boriding has been arranged and tests were carriedout.

Various types of testing methods have also been carriedout and confirmed the diffusion of Borons into the samples. Hence this method can offer high surface hardness. Also it can be considered as an energy efficient and ultra fast process. So components can be processed for hardening rapidly. Hence this process could offer sufficient hardness, toughness and high temperature resistance to the tools and dies.

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