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Induction Hardening Process Using AISI 1040 Steel Material on Samples of ASTM a 370-97(E18) and E70-97(E10) Standard and Its Benefits

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Abstract—***A Induction Heating Is One Of A Wide Range Of Electrical Heat Used In Industry And Household Today. The Main Applications Of The Process Are In The Steel And Metal-Working Industries induction Heating Provides A Heat Source Which Is Very Easily Controllable, Can Be Limited To Partial Heating Zones And Creates Reproducible Heat-Up Processes. This Provides The Opportunity To Build Heating Equipment With A High Level Of Automation Which Allows To Be Integrated In A Production Line, Such As Machine Tools.***

Index Terms—**Induction Hardening, Induction Heating, Electromagnetic Field, AISI Io40 Steel.**

Main Objectives are

1. To Know About induction Heat Treatment
2. To Study Induction Heat Treatment by Aisi 1040 Steel
3. To Know About Benefits Of Induction Hardening Process By Taking Samples Of ASTM A 370-97 (E18) And ASTM A 370-97 (E10) Standard.

I. INTRODUCTION

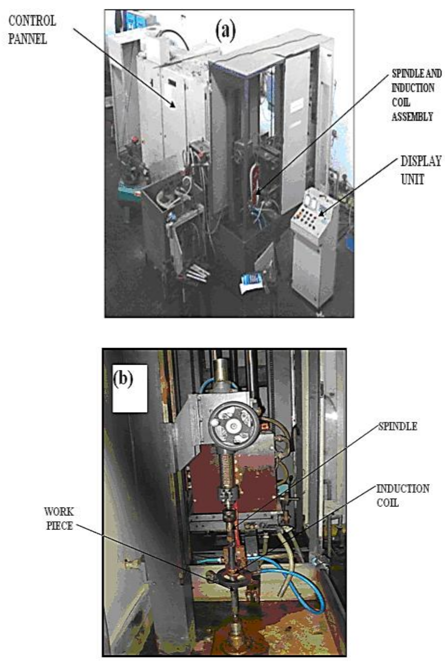
In Induction hardening Uniform heating of the parts of the component to be hardened.Short heating times and as a result thereof the formation of a minimum amount of scale. In many cases no subsequent work is necessary. Due to short-time heating the formation of coarse grain as a result of overtimes and overheating is avoided. Safe control of heat input. The temperatures required are kept. The distortion is generally low. In comparison with case hardening, expensive alloyed case hardening steels can be replaced by cheap heat-treatable steels. Partial hardening is mostly possible even on most difficult work piece shapes. The hardening machines and generators can be directly integrated in the production lines. The space requirement is low, easy and clean operation with no health hazards.

II. USE OF MATERIAL AISI 1040 STEEL IN BAR FORM

The material used for induction hardening for the present work was AISI 1040 steel in bar form (Length: 304.8 mm {distance between two spindles}, Diameter: 25 mm) having composition 0.45% Carbon, 0.75% Manganese, 0.2% Silicon, 0.05% Sulphur, 0.07% Phosphorus and 0.12% Chromium, as assessed through spectrometer test. Three batches of samples were prepared at different conditions of the material viz as-rolled, normalized(raw material in rolled condition is heated at 900^0 C for one hour and then cooling is done in air at 25º C), and hardened tempered(raw material in rolled condition is heated at 860º C for one hour and then water quenching is done for 3 minutes; again material is heated at tempering temperature of 560º C for 3 hours and then air cooling is done at 25º C).The length of the work-piece has further been divided into three parts of 75 mm each. This material is suitable for a wide variety of automotive components like spline shafts, axle shafts, excavator bucket pins, steering components, power tool shafts and drive shafts, and for edge components, such as paper knives, leather knives, and hacksaw blades (Oberg 1996.

III. MODULES OF PROJECT

A medium frequency induction hardening machine as shown in Figure 1 having frequency 10 kHz, spindle speed 400 r.p.m and of "Unit herm" make has been used for conducting the experiments.



(Experimental set up of 1(a) Induction Hardening Machine 1(b) detailed view of Spindle and Induction Coil Assembly)

A source of high frequency electricity was used to drive a large alternating current through a copper coil. The passage of current through this coil generates a very intense and rapidly changing magnetic field in the space

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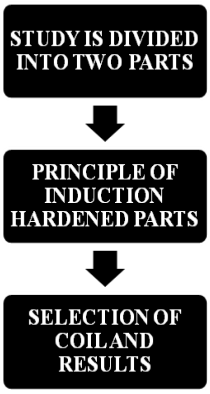
within the work coil. The work piece to be heated was placed within this intense alternating magnetic field where eddy currents were generated within the work piece and resistance led to Joule heating of the metal . After the part had been heated properly, it was passed through a quench ring, which cooled it to a temperature of 950^0C to form a martensite case. The core of the component remains unaffected by this treatment (Jacobs and Kilduff 1994).



IV. PRINCIPLE OF INDUCTION HARDENED COILS

According to the physical law of induction an alternating magnetic field is generated around each electrical conductor through which an alternating current is flowing. By conside-rably increasing these magnetic fields, metals brought into close proximity will be heated by eddy currents produced within the metal. Heating by induction makes use of the ca-pability of the magnetic field to transmit energy without direct contact. This means heating is not done by contact trans-mission such as known in resistance heating in light bulbs, heating plates or electrical furnaces where the direct current flow causes resistance wires to glow Induction heating provides a heat source which is very easily controllable, can be limited to partial heating zones and creates reproducible heat-up processes. This provides the opportunity to build heating equipment with a high level of automation which allows to be integrated in a production line, such as machine tools.

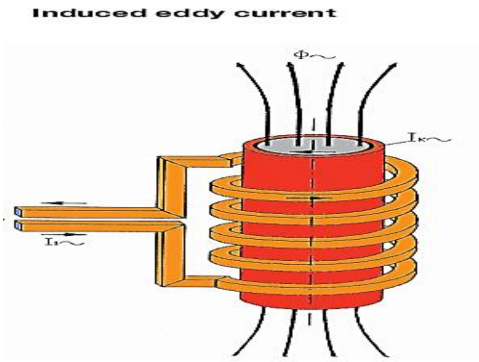
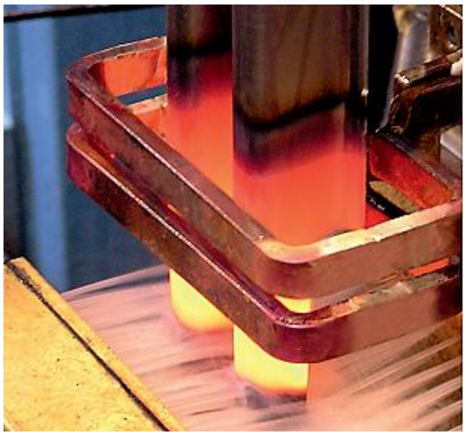
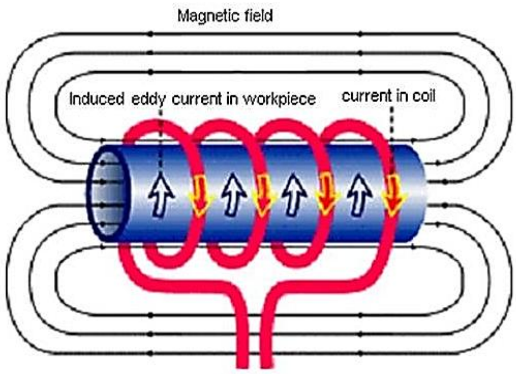


FIGURE 2





(Figure 3 and Figure 4 Shows the Principle of Induction Hardened Parts)

V. SELECTION OF COIL

According to Gupton (Gupton 1986, pp 171), commercial tubing may be used for coils. The tubing must be large to permit an adequate flow of water for cooling. The number of turns of work coil is calculated by the formula (Han et al. 2008):

$$N = \left[\frac{1_w}{(d_c + C_p)} \right]$$

Where,

l_w = length of the work-piece to be hardened

d_c= core (inner diameter) of the work-piece to be hardened

C_p = pitch of coil winding or coupling distance

In the present study, l_w = 75 mm, d_c = 29 mm and C_p= 8 mm

Putting the values in Eq. 3.1, we get

$$N = \left[\frac{75}{(29+8)} \right] = 2\ (approx.)$$

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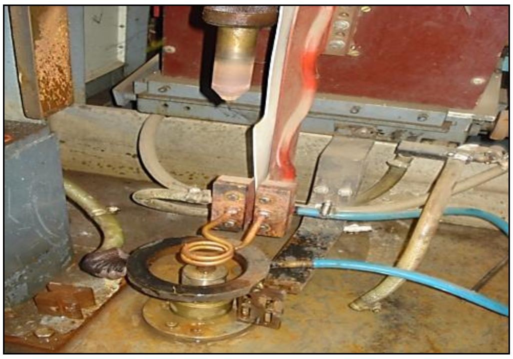
The number of turns of work coil taken in the study is shown in Figure 5 and figure 6.



VI. RESULTS AND ANALYSIS OFOF PILOT EXPERIMENTS

The experimental studies were performed on induction hardening machine. Various input parameters varied during the experimentation are feed rate or feed speed or scanning time (speed with which induction coil moves), dwell time or delay in quenching (time interval taken by water to flow), current, and gap between the induction coil and work piece. The effects of these input parameters were studied on hardness, total case depth and mean effective case depth of the material using one factor at a time approach, After subjecting the specimens to induction hardening, the samples were then prepared for hardness testing and depth measurement by cutting the specimens into smaller sizes in a direction perpendicular to the hardening runs with an abrasive cutter and mounting in acrylic to facilitate polishing. The specimens were etched using a 2% Nital solution (mixture of 98% methanol and 2% pure concentrated nitric acid). The specimen having coding is shown in Figure 7 (a) and that after etching is shown in Figure 7 (b).

Hardness has typically been defined as the resistance of a material to permanent penetration by the one that is harder. This can be achieved by using an indenter with hardness similar to that of the diamond. In the present study, the hardness was measured by Rockwell hardness testing machine for C scale at 150 kg load, having diamond indenter at 120 degree, using ASTM A 370-97 (E18) standard and Brinell's hardness testing machine at 3000 kg load, using ASTM A 370-97 (E10) standard.

(Rockwell hardness tester)

The average hardness was obtained taking observations at five different spots of the samples.

Total case depth is defined as the distance from the surface of the hardened case to a point where difference in chemical or physical properties of the case and core can no longer be distinguished. For its measurement, reading from external surface of the specimen to a selected line of a darkened zone as seen in Figure 7(b) was ascertained under metallurgical microscope of magnification 50 X. Mean effective case depth is the perpendicular distance from the surface of a hardened case to the furthest point where a specified level of hardness is maintained. The hardness criterion is HRC 50 normally. The hardness begins to decrease drastically below mean effective case depth. For its measurement,

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step grinding method is used. The hardness readings are taken on steps of about 0.5 mm below the free surface and mean effective case depth is measured up to which the hardness starts dropping below HRC 50 (SAE 1998).

VII ADVANTAGES OF INDUCTION HEAT TREATMENT

VII. CONCLUSION

1. Induction hardening process is highly energy efficient
2. The space requirement is low, easy and clean operation with no health hazards
3. There is safe control of heat input
4. It is an additional hardening process which is used for those applications where there is a benefit, both in technical and economic respect.

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