Relationthip Between Case Depth and Hardness in an Induction Hardened Medium Carbon Steel

Tauseef Ahmad, Omar Yousaf, A.Salam and J.Ahmad

Abstract

Surface hardening behaviour of a medium carbon steel (AISI 1045) was studied achieved by using induction hardening technique. Surface hardening of the specimens with different case depths was successfully achieved by using this technique. Case depths were produced on the specimens ranging from 0.80 mm to 2.50 mm. In all specimens the hardness of the case was significantly higher than the core. The hardness of the case slightly increased with increase in case depth for all specimens.

Introduction

Induction hardening is perhaps one of the most commonly used method for surface hardening. In this method, principle of electromagnetic induction is utilized i.e. when an electric current passes through a conductor generating an electromagnetic field around itself, a current is induced in another conductor placed within that field. When high-frequency alternating current flows through the inductor a highly concentrated, rapidly alternating magnetic field is developed within the coil. The magnetic field which is developed here induces an electric potential in the part to be heated, and because the part represents a closed circuit, the induced voltage becomes the cause of flow of current. The resistance of the part to the flow of induced current causes heating [1,2,3].

Medium- carbon steels containing from 0.3 to 0.5 % C are most commonly induction hardened materials. Due to a high heating rate in induction hardening, the transformation of pearlite into austenite is shifted towards higher temperatures. The steels are normally quenched in water or oil. In certain cases, the alloy steels may be cooled by means of an oil emulsion. The steels should preferably be hardened and tempered before subjecting them to induction hardening because their response to induction hardening has been seen to be better as compared to annealed ones. When lower hardness is required induction hardened steels may also be tempered at low temperatures. [1,2,3].

Present work was aimed at studying surface hardening behaviour of a medium carbon steel, AISI 1045 using induction hardening technique, in order to improve its surface hardness and strength which are often required in many applications and to study the relationship between case depths obtained and hardness.

Experimental Procedure

Specimens were prepared from AISI 1045 steel rods having dimensions 6 in. in length and 1 in. in diameter. Six specimens were prepared having these dimensions. The specimens were then hardened by induction furnace using parameters as mentioned in Table-1. These parameters have also been discussed else where (1,2,3). The induction furnace used for hardening had frequency range of electric supply ranging

**Faculty of Engineering & Technology, University of the Punjab, Lahore*

from 30-40 KHz. The inductor coil used in induction equipment was a medium to high frequency coil. The efficiency of the equipment was between 75 to 95%. The temperature for heating the specimens in furnace was about 8700C to 9000C.

Table1: Induction Hardening Parameters

Material used for induction hardening	Medium carbon steel
Type of Power Source Used for Induction Hardening	Solid State Inductor
Power of Source used for Induction Hardening	40-50 KW
Frequency Range of Induction Heating equipment	30-40 KHz
Efficiency of the Induction heating Equipment	75-90 %
Type of inductor Coil used in Heating Equipment	Medium to High frequency coil
Temperature of heating	870-900 °C
Medium used for coil cooling	Water
Temperature of Heating	Few seconds
Rotational speed	7-10 mm/min

The heating time for specimens was few seconds. Induction hardening was carried out at different case depths ranging from 0.80mm to 2.50 mm. The induction hardened specimens were then cut into small specimens for metallography and hardness testing purposes. The specimens were cut into a size of 1 x1 inch. by cut-off machine. The specimens for microscopic examination were prepared using standard procedures. Hardness testing of the specimens was carried out by using Rock well hardness testing machine.

Results & Discussion

Surface hardening of the specimens was obtained by induction hardening technique. Induction hardening parameters used are given in Table 1. Different case depths were obtained ranging from 0.80 mm to 2.50 mm by varying the power of the induction heating equipment and time of heating. Altogether six specimens were induction hardened having case depths approximately equal to 0.80, 1.00, 1.50 2.00, 2.25 and 2.50 mm. Hardness values of both core and the case were also determined and are given in Table 2. It may be seen from this table that hardness of the case is considerably higher as compared to the core in case of all specimens which shows that hardening method used in this work has been very successfully. For example the hardness of case of specimen having the case depth of 0.80 mm increased from 32.33 HRC to 57.00 HRC. Similarly specimen having case depth 1.00 mm shows increase in hardness from 32.66 HRC to 57.33 HRC.

Table 2: Hardness values at different case depths

Sr. No.	Case Depth (mm)	Core Hardness (HRC)	Case Hardness (HRC)
1	0.80	32.66	57.00
2	1.00	32.66	57.33
3	1.50	33.00	57.33
4	2.00	32.66	57.00
5	2.25	32.33	58.33
6	2.50	33.00	61.33

Specimen of case depth 1.50mm shows increased in hardness from 33.00 HRC to 57.33 HRC. Similarly hardness increases from 32.66 to 57.33 HRC for the specimen having case depth 2.00mm. The hardness value change from 32.33 to 58.33 HRC for the 2.25 mm case depth specimen. This may also be noticed that the hardness of the case increase slightly with increase in case depth. This may be explained on the basis of incomplete martensitic transformation in case of smaller case depth, due to less heating time.

Conclusions

Following conclusions may be drawn from this work:

1. Surface hardening of a medium carbon steel (AISI 1045) Specimen was successfully done by using induction hardening technique.
2. Case depths were produced on the specimens ranging 0.80 mm to 2.50 mm.
3. In all specimens the hardness of the case was significantly higher than the core.
4. The hardness of the case also slightly increases with increase of case depth for all specimens.

References

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