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Literature Review on Experimental Investigation and Optimization of Processing Parameters of Induction Hardening of AISI 1040 Steel

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Abstract—Medium carbon steel parts are induction hardened to obtain better mechanical properties in the automotive and aerospace industry sectors. The various factors such as power supplied, scan speed, frequency, distance between work piece and coil, dwell time, quenching pressure are considered as input parameters for induction hardening process. Response variables such as surface hardness, case depth and yield strength are considered for experimentation. In this study, data were taken by Taguchi method using L9, L18 or L27 experiment orthogonal arrays table. Analysis of Variance (ANOVA) was employed with the help of data taken and regression equation was determined. As a result of these experiments and analyses, the optimization of the process done by surface response methodology.

Keywords— ANOVA, Induction hardening, Orthogonal array, Regression analysis, Signal to noise ratio, Taguchi method, Surface response methodology.

I. INTRODUCTION

Numerous industrial applications such as cams, gears, crankshafts etc require a hard wear resistant surface called a case and a relatively soft, tough and shock resistant inside, called the core. Conventional hardening cannot possesses both the requirements. However both these requirements may be met by surface hardening treatments like carburising, nitriding cyaniding, flame hardening and induction hardening.

Induction hardening is a surface treatment method in which a medium carbon steel is heated by induction heating and then cooled in a quenchant, such as water. During induction hardening, the quenched metal undergoes a phase-transformation of austenite to martensite, and the hardness of the quenched part increases. The induction heating process uses the principle of electromagnetic induction to heat the surface layer of a work-piece. Induction hardening temperature should be 850 to 900 º C. Steels with carbon content in the range 0.40 to 0.5% are most suitable for this process. Some of the examples of applications of induction hardening components are crank-shafts, camshafts, axles, gears, rolls of rolling mills, boring bars, brake drums, over head travelling crane wheels, etc

Comparing with other surface heat treatment methods induction hardening has the advantages of easily controlled case depth, energy saving and low cost.

II. LITERATURE SURVEY

Amit Kohli et al. [1] investigated the process parameters such as feed rate, dwell time, current and gap between material and inductor coil on affect the hardness of steel. He worked on rolled and normalized AISI 1040 steel. Hardness is optimized by Response surface methodology.

Amit Kohli et al. [2] investigated the process parameters such as feed rate, dwell time, current and gap between material and inductor coil on affect the case depth of steel. He worked on rolled and normalized AISI 1040 steel. Case depth is optimized by Response surface methodology..

K. Palaniradja et al. [3] used regression analysis to optimize high hardness and Case depth. He worked on input variables Power potential, Scan speed, Quench flow rate. The test bar is of AISI 4340 and AISI 1055 steel.

Mert Onan et al. [4] worked on the material AISI 1040 steel with input variables Power supplied, scan rate and distance between work piece and coil. He concludes the selection of higher power ratio and lower scan rate affected micro structural transformation

during hardening process. As a result of applying higher power ratio or lower scan rate, induction hardening induces high surface hardness. He used Taguchi method and ANOVA technique to optimize Hardness.

P.G.Kochure et al. [5] worked on the material AISI 1040 D steel with input variables Power and heating time. Taguchi method of experimental design with L9 orthogonal array has been applied for selection of optimized process parameters of induction hardening of AISI 1040 D steel. Hardness and case depth is optimized by Taguchi method and ANOVA technique.

R. Palanivasan et al. [6] worked on the material SUH–3 steel with input variables Power, Heat time, Cooling media. He used single turn flat coil gives the consistent hardness as per requirement. He investigated induction hardened samples a constant biaxial residual stress state at the surface. The induction hardening gave rise to compressive and tensile normal residual stresses in the hardened zone and outside the zone.

Pankaj Kumar et al. [7] worked on the material IS:2004 CL-4 steel with input variables Induction coil, Operating frequency, Heating time and temperature, A.C power input. He investigated that induction hardening results in hardening and tempered case which is wear resistance and high strength. The case depth is of more than 4 mm which is adequate enough to give the gear a longer service life . The process capability and thus the repeatability of the induction hardening process has also been established. Hardness is optimized by trial and error method.

Manojkumar et al. [8] worked on the material TMT steel with input variables Water Pressure, Cooling Rate, Speed, Temperature. He says water pressure and cooling rate were having significant effect on the quality characters that is Yield strength. More ever water pressure was having the highest contribution of the order 66 % The effect of temperature drop can be controlled by controlling water pressure in quenching process, by keeping the speed of rolling constant. Yield strength is optimized by Taguchi method and ANOVA technique

III. CONCLUSION

Based on above literature references, we can conclude that

A. The induction hardening process is used for medium carbon steel.

B. AISI 1040 steel is used for shaft, axles, gears, camshafts, crankshafts etc.

C. The various input parameters like feed rate, dwell time, current, gap between material and inductor coil, heating time and temperature affects the output variables hardness and case depth.

D. Effect of water pressure, cooling rate, speed and temperature affects output variable yield strength.

E. From above literature survey we can experiment on AISI 1040 steel by controlling the process parameters Scan speed, Dwell time and Quenching time to get desired hardness and case depth in induction hardening process. In this study, data will be taken by Taguchi method using L9 experiment orthogonal arrays table. Analysis of Variance (ANOVA) can be employed with the help of signal to noise ratio of hardness and case depth obtained. Regression equation will be determined for both response parameters hardness and case depth. As a result of these experiments and analyse, the optimization of the process can be done by grey relational analysis technique.

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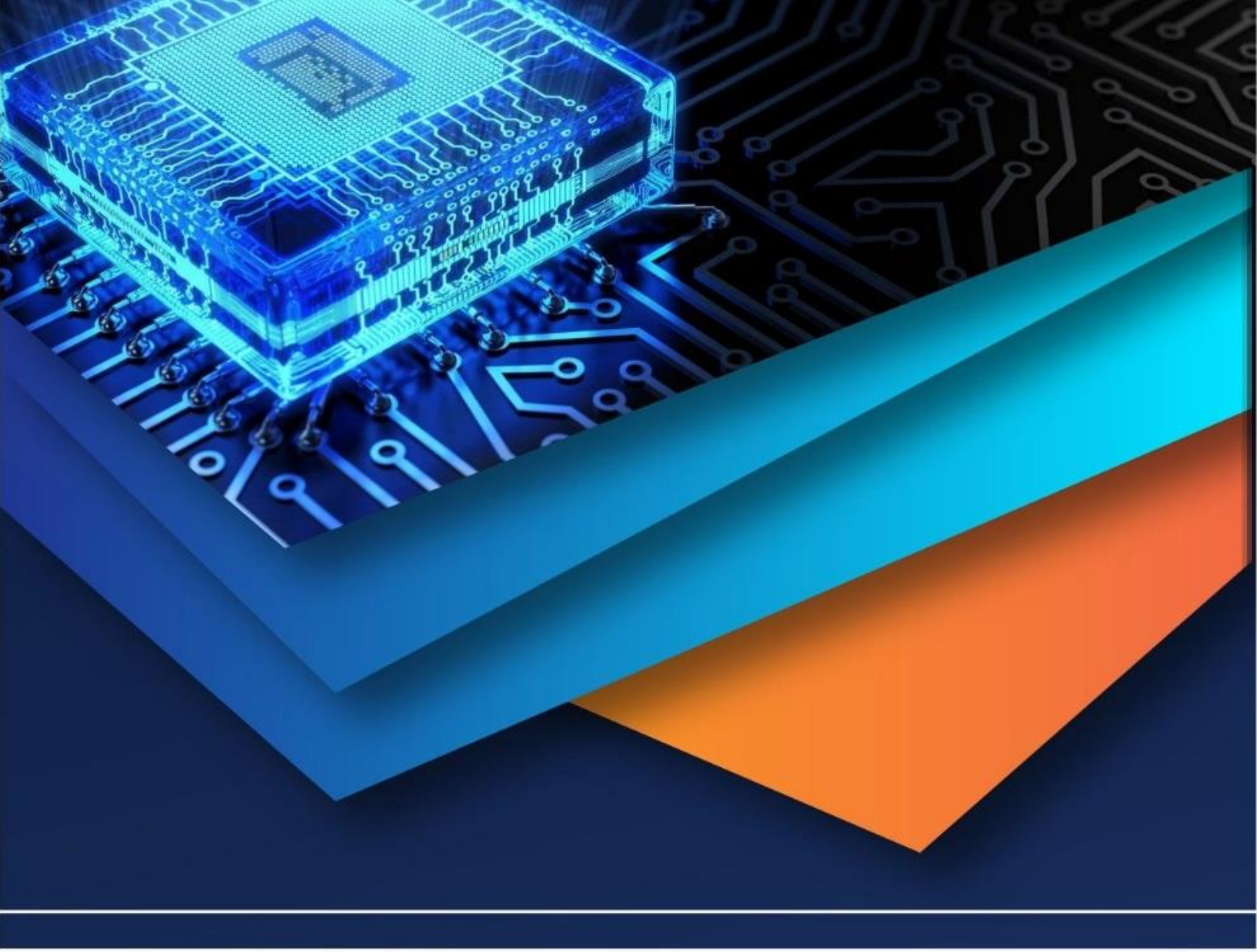

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