Editorial

Issues on the Surface Integrity of Case Hardened Steel Materials

In applications where the requirement is harder/wear resistant outer surface and tougher inner core, surface treatment process is used. Some of the prominent examples for such requirement are Rack and Pinion, Gears, Cam shaft, Valve Rocker shaft and axles. Such a combination of properties ensures that the component has sufficient wear resistance together with sufficient toughness to withstand shock loads.

Surface treatment processes fall into either thermal or thermo-chemical treatment processes. Induction hardening and Gas carburizing processes are the important examples for the above respectively. Gas carburizing is known as Thermo chemical treatment process because, the surface composition of the steel changes by diffusion of carbon and sometimes by other elements. Induction hardening involves, whereas, phase transformation by rapid heating and cooling of the outer surface. It falls under thermal treatment process.

Gas Carburizing is the most widely used process for surface hardening of low carbon steels with 0.1% to 0.25% of carbon. These steels also are known as Carburizing steels.

The most common application of Induction hardening process is in the hardening of low alloyed medium carbon steel with carbon content of 0.3% and 0.6%. These materials are widely used for critical automotive and machine applications such as Steering knuckles, propulsion shaft and Crank shaft which require high fatigue strength combined with wear resistant surface.

Surface engineering is a complex process as a number of variables affect the success of the process and quality of the components obtained. Further, Fatigue behavior of Gas carburized and Induction hardened components depends to a greater extent on the correct combination of Hardening depth and the magnitude and distribution of residual compressive stresses in the surface layer with minimal thermal damages. An industrial survey indicates that there is a rejection of 10-12% of case hardened components due to various defects like crack formation, over hardening, change in size and shape etc.

Many experimental studies reveal that Preheating temperature, Furnace Temperature, Carbon potential, Quenching time, Tempering Time and Tempering Temperature are the major influential parameters, which affect the obtainable characteristics on the Gas carburized components. In recent years, a number of investigations have been under taken in dealing with problems in Induction hardening. In this process, the obtainable characteristics of the components are affected by the parameters like, Power Potential, Scan Speed and quench flow rate.

Scientists have also investigated the distribution of compressive residual stresses in the surface layer and the resulting influence of it on the surface integrity of the case hardened components. Therefore, in both the surface treatment processes, if the process parameters are not controlled, it may lead to cracking after quenching, shape and size distortion, and excessive grain growth in the region below the hardened surface.

The main objectives of the present work, in respect of Gas carburizing and induction hardening, are to study:

i) Optimizing of process variables to control the hardness value and case depth.

ii) The Volume and Dimensional changes in case hardened components due to Thermal and Metallurgical effects.

iii) The Phase transformation and its effect in Induction hardening.

iv) The Residual stresses in case hardened materials.

For the objectives mentioned above, experiments have been conducted in Gas carburizing furnace for different Case carburizing steels by varying the Preheating Temperature, Furnace Temperature, Quenching Time, Tempering Temperature and Tempering time. All these experiments have been carried out by Repetition Method.

In Induction hardening furnace, trials have been carried out by Randomization Method for different low alloyed medium carbon steel materials by varying the Power Potential, Scan speed and Quench flow rate. Full Factorial Design of Experiment Method has been followed to optimize the process variables.

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Visual Inspection, Dimensional Inspection, Metallurgical Inspection, Material Flaw Inspection and the Residual Stress estimation and pattern of distribution have been carried out.

It is found that the Furnace temperature and Quenching time have equal influence on the surface integrity on the case hardened components in Gas carburizing. Further, under optimal conditions, the Gas carburizing products do not require any reworking process which may be required otherwise.

The investigations on Induction hardening shows that Power potential have more influence on the surface hardness and case depth of the Induction hardened components. Also, the controlling equations developed thorough the Regression analysis are useful in fixing the parameters at the required level.

Residual stress analysis indicates that the stress formed on the surface and beneath the surface upto, the surface hardened regions are compressive in nature and it improves the fatigue strength of the material.

N. Alagumurthi
(*Guest Editor*)
Department of Mechanical Engineering
Pondicherry Engineering College
Pondicherry-605014,
India
E-mail: alagumurthi@pec.edu