A Review on Effect of Carburizing on Hardness of Low Carbon Steel

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***Abstract*: Steel is the most versatile material in engineering. The processes of heat treatment affects the mechanical and structural properties of steel either by allotropic modification or by changing relative solubility of elements in the base metal. A suitable method of heat treatment is adopted depending upon the properties and the applications required for any design purpose. It is evident that the mechanical and structural properties of steel can be altered by heat treatment processes and the type of treatment depends on the composition of the steel. Low carbon steel is soft and hardly any martensite is formed on quenching due to less carbon content. Thus to improve the surface hardness of low carbon steel, carburizing is done by different methods. The carburizing treatment develops a hard and wear resistant case on steel surface with a tough core. Many researchers worked on different approaches of carburization to analyze the effect on mechanical properties of steel. This review paper is trying to analyze the different approach of carburizing which results in good mechanical properties.**

***Keywords*: Steel, Carburizing**

Literature Review

B. Selc [1] in his work concluded that various types of surface treatments like carburizing, nitriding, boronizing and induction hardening are used for improving the surface hardness of low carbon steel. From all of those methods, carburizing process provides a deeper case depth in case of AISI 1020 and AISI 5115 as compared to the other methods.

Shewmon [2] observed that the major influencing parameters in carburization treatment are the holding time, carburizing temperature, carbon potential and the quench time. Also Schimizu N [3] investigated that surface hardening processes are influenced by heat treatment temperature, rate of heating and cooling, heat treatment period, quenching media and temperature. He also observed that post heat treatment and pre-heat treatment processes are the major influential parameters, which affect the quality of the part surface hardened.

Fitzgerald [4] defined carburizing as a diffusion controlled process, so the longer the steel is held in the carbon-rich environment, the greater the carbon penetration will be and the higher the carbon content results higher value of hardness. The carburized section will have carbon content high enough so that it can be hardened again through flame or induction hardening which will produce a hard and wear-resistant case.

According to Prime et al. [5] carburizing is one of the most commonly used surface treatment method for steels. He also investigated that carburizing process results in the addition of carbon to the surface of low carbon steels at temperatures generally between 850 °C and 950 °C at which austenite with its high solubility for carbon is stable in the crystal structure.

Enver Atık [6] worked on two different type of steel SAE 1010 and SAE 1040. After carburizing at 930 °C for 3 hours the maximum layer thickness of 300 µm is obtained for SAE 1010 and layer thicknesses lies in the range of 25 µm and 290 µm for SAE 1040. The best abrasive wear strengths is obtained by boronizing for 8 hours at 900 °C for SAE 1010 and SAE 1040 steels, 4 hours at 900 °C for D2 steel and 6 hours at 900% for 304 steel. Case depth of carburized steel is a function of carburizing time and available carbon potential at the surface. Demirkol (1999) found that the thickness of carburized layer varies when AISI 8620 was quenched and tempered followed by carburizing at 900 °C for different time periods, The maximum thickness of 1.1mm was obtained for the steel carburized for a maximum period of 7.5hours. When prolong carburizing time was used for deep case depths, a high carbon potential produced a high surface carbon content which resulted in to excessive retained austenite or free carbide. These two microstructural phases have adverse effects on the distribution of residual stress in casehardened part. Consequently, a high carbon potential may be suitable for short carburizing time.

Fatai Olufemi Aramide [7] observed that controlling of parameters in carburizing process is a very complex problem. After experimenting on mild steel carburized at three different temperatures 850, 900 and 950 °C soaking for 15 minutes and 30 minutes he observed that during the process of carburizing initially the core and the case hardness increased to 65.85 RHA and 62.7 RHA with rise in carburizing temperature up to 900 °C for 15 minutes. But at 900 °C, the case hardness reduced to 61.5 RHA while the core hardness increased to 67.5 RHA. With further increase in temperature to 950 °C the case hardness increased to 63.6 RHA and the core hardness reduced to 65.8 RHA. Furthermore when the steel carburized at the same temperatures and soaked for 30 minutes, the same pattern continued but higher case hardness of 66.1 RHA and higher core hardness of 68.6 were obtained. He studied the effect of carburizing time and temperature on mechanical properties of mild steel and observed that the mechanical properties of mild steel were strongly influenced by the process of carburizing, soaking time and temperature.

Sandor [8] simulated carburized layer after carburizing on the samples made of grade SAE 43XX. According to the varying content of carbon from 0.20% to 1.00% specimens were copper layer electroplated, and then, they were heat treated in a cycle of carburizing, quenching, and tempering at five different temperatures to expose them to the thermal effects without diffusion of carbon. The results of the micro hardness of the steels and for the analyzed conditions were presented in the table. The curve of micro hardness has the same profile of a carburized layer for the SAE 4320 heat treated under similar conditions. The crack growth rates as a function of delta K for three tempering temperatures are plotted. In Fig. it shows that when the hardness is high at 200 °C tempering temperature, there is a scattering of the curves and for the case of lower hardness at 600 °C tempering temperature, the curves are closer. With increase in tempering temperature there is a decreasing in hardness and a significant effect on the metallurgical properties has been observed. Further, with decrease in carbon content there is significant increase in the resistance to the fatigue crack growth. As a result of that, in case of carburized layer there is an increase in fatigue crack growth resistance when the crack grows from the surface to the core of the steel samples.

K. Palaniradja [9] experimented on EN29 and EN34 grades of steel and observed that furnace temperature and quenching time have equal influence on better surface integrity of the case hardened components in gas carburizing. Preheating before gas carburizing further enhanced the surface hardness and the depth of hardness. In the case of induction hardening process, power potential played a vital role in optimizing the surface hardness and the depth of hardness.

According to Shristee Singh [10], carburizing treatment not only improves hardness, but also improves tensile strength and wears resistance. Higher hardness value and higher tensile strength were obtained when mild steel was carburized at 860 °C with 3 hours soaking time. The carburizing process was carried out in an electric furnace followed by hardening& tempering.

P. Tamil Arasu [11] found that carburizing is an effective process for improving the hardness of steel of grade EN- 353.High value of hardness was obtained when carburized it for 120 minutes at 920 °C followed by air cooling. The case hardness after carburizing improved from 193.7 VHN to 684.5 VHN and on the other hand the core hardness improved from 201.8 VHN to 387.8 VHN. From XRD analysis, it is clear that the carburizing process does not harden the steel; it only increases the carbon content on the case. The pictorial view of the microstructure on case after carburizing indicated martensite formed on the surface after carburizing treatment which is the main reason for the improved hardness property.

Rashmi Ranjan Panda [12] found the highest hardness value for mild steel as 57 RHC when carburized at 950 °C for 3 hours and the lowest hardness value of 51 RHC when carburized at 850 °C for 3 hours. The carburized samples were tempered at 200 °C for 2 hours followed by air cooling.

Conclusion and Future Scope

Heat treatment process is a very critical process as any of the parameter can be varied to get different value of hardness for low carbon steel. Hence there is a wide scope of research in the area of enhancement of hardness and also the other mechanical properties like tensile strength of low carbon steel by carburizing process. The best result on hardness occurs when the low carbon steel is carburized at the temperature range between 800 °C and 950 °C.

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