Quench Hardening and Tempering Behaviour of A Low Carbon Steel

Tehreem Kanwal, Rabia Nazir, Saba Zulqernain, A. Salam, Javaid Ahmad

Abstract

A 0.2%C steel was subjected to quenching and tempering heat treatment in this work. During both oil and water quenching hardness of the as received material reasonably increased, reaching a maximum from 53.75-68.65 HRA during water quenching. Ultimate tensile strength also increased to a maximum of 1096.38MPa from 853.89MPa corresponding to the as received material. Tempering of the quenched specimen resulted in a decrease in both the hardness and tensile strength over the entire temperature range studies. Also the effect of tempering on ductility of the quenched steel was not very clear.

Key words: Plain carbon steel, Quenching (oil & water), Tempering, Tempering temperature, Mechanical properties.

Introduction

Plain carbon steels in which %age of carbon is upto 0.3% are termed as low carbon steels. These steels do not respond to heat treatments in which the strength and hardness is increased by formation of martensite. These steels posses low strength but high ductility and are cold formable. Therefore, instead of heat treatments, such as quench hardening, their strength and hardness may be increased by cold working. The typical applications of low carbon steels include: Automobile component, structural shapes/sections and sheets which are used in pipe lines, buildings, bridges, tin cans etc. [1, 2, 4]

Although low carbon steels do not respond to quench hardening. An attempt was made in present work to improve strength and hardness of a 0.20% C steel by quenching it in cold water and oil. The present work was further extended to the study of tempering behaviour of these quenched steels. However, tempering of such steels is usually not required because of a very high Ms (about 400◦C) and Mf temperatures, which allow these steels to undergo self tempering during quenching [3].

Experimental Work

Specimen for heat treatment and subsequent hardness and tensile testing were obtained from ½" diameter bar of a 0.20%C low carbon steel. A muffle furnace was used, for austenitizing the specimens at 960◦C for 1hr and then quenched in cold water and oil. After quenching the hardness and tensile properties were evaluated and then the specimens were subjected to tempering heat treatments, in the temperature range of 150-550◦C. After which the hardness and tensile properties were again determined. For hardness testing Rockwell & Vickers hardness testing

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

machines and for tensile testing a universal testing machine were used respectively. Specimens for microscopic examination were prepared using standard metallographic procedures.

Results And Dicussions

Hardness testing results of as received, as quenched and tempered specimens are given in Table 1. It may be seen that the hardness of as received specimen increased from 53.75 HRA to 55.5HRA and 68.55 HRA during oil and water quenching respectively. However, the hardness value somewhat decreased during tempering in the entire temperature range. Similar observations can be made from vicker hardness testing results. Tensile testing results are given in Table 2 . Once again it may be seen from table 2 that UTS of as received specimen increased to a higher value 872.75MPa during oil quenching and a much higher water quenching. However, a decrease in UTS values is observed during tempering at all temperatures. Results of %age elongation which are given in Table 2 , show some decrease in %age elongation during both oil and water quenching. But no increase in elongation has been seen during tempering.

HARDNESS TESTING				
	ROCKWELL(HRA)		VICKER	
As received	53.75		173.5	
	Oil	Water	Oil	Water
As quenched	55.5	68.55	232.33	476
Tempering temperature ºC				
150	49.35	56	190.5	245
250	47	49.5	187	228
350	46.4	49	186	208
450	46.2	47.4	180	200
550	44	45.4	175.5	181.66

The results which are reported above indicate that the strength and hardness of this particular mild steel may be successfully increased by quenching it in both oil and water quenching media. As mentioned earlier that these steels can undergo self-tempering during quenching and therefore do not perhaps require a second tempering, appear to be true in present work as well, because the results of second tempering did not show any improvement in ductility with decrease in strength and hardness.

Table 2

TENSILE TESTING					
UTS(N/mm^2)			%Age elongation		
As received	853.89				
Oil			Water		
	UTS(N/mm^2)	%Age elongation		UTS(N/mm^2)	%Age elongation
As quenched	872.75	20.1	As quenched	1096.38	23.6
Tempering temperature		Tempering temperature			
150 °C	629.91	23.7	150 °C	732.83	23.6
350 °C	618.48	25.7	450 °C	656.44	25.5
550 °C	579.02	32.2	550 °C	636.51	28.4

Table 1

Conclusion:

Following conclusions may be drawn from above work.

1. The 0.2% C low carbon steels which were heat treated in this work showed a reasonable increase in both hardness and strength during oil and water quenching.
2. The hardness of as received specimens increased from 53.75HRA to a maximum of 68.65HRA during water quenching.
3. The UTS of as received specimen increased from 853.89MPa to maximum of 1096.38MPa during water quenching.
4. Tempering of both oil and water quench specimen resulted in a decrease in both hardness and strength in the entire range of tempering temperatures. Effect of tempering on ductility was not very clear.
5. The microstructures corresponding as received, oil and water quenched specimens shows a transformation of two phase ferrite+pearlite structure to a partially martensitic structure, during the quenching process.

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