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Heat Treatment of EN-8 Steel Casting Samples

Heat treatment and microstructure studies have always been a wide area of research for mechanical engineers. The use of different quenchants for cooling process has further widened the scope of quenching operation. This research mainly concentrates on the study of microstructure of EN-8 medium carbon steel cast samples when heat treated at different temperatures and quenched into different quenchants. The properties, of medium carbon steel EN-8, gets affected due to sudden quenching. The microstructure of the steel was analyzed and it was subjected to Rockwell's hardness test. Thus the increase in hardness values was determined. The change in microstructure is also studied. Heat treatment is a cost effective process, economically viable and have great scope in industrial sector.

Introduction

We come across steel in our life on an everyday basis. We can find its influence in our life in almost everything we do, we use or we look at. The steel used for this research however is a medium carbon EN-8 steel AISI 1040.it is unalloyed and it is used to make things like shafts, keys, stressed pins. The steel with its immense practical applications are an important component in everybody's life. The steel as per the content of carbon in it is divided into three categories mainly. They are low, medium and high carbon steels. The EN-8 steel can be used, where higher strength is required than the low carbon steel, in many engineering applications. The steel with the addition of carbon becomes more hard but at the cost of being brittle. As a result of the increase in hardness it becomes stronger but becomes more brittle. The medium carbon steel's carbon content is .45 % - .80 %. As it is not brittle and not ductile at the same time, its material properties are apt for many engineering applications. Thus the steel material is used in many purposes. To do heat treatment of medium plain carbon EN-8 steel and then use different quenchants for cooling. The purpose of this research was to see the variation in microstructure in EN-8 steel and to do heat treatment at different temperatures and quenching in different mediums thereby knowing about the effect of different quenchants on hardness of medium carbon steel.

Lijun Hou and etal in their paper have discussed the details of the cooling capacity of nitrogen-spray water, nitrogen, clear water, quench oil, through the effective comparison of temperature difference and velocity of cooling of the specimen. [1]. In his research paper T.S. Prasanna Kumar have speculated about the equipment development, which, in concurrence with mathematical models, and how it can be used for obtaining cooling curves for a particular steel/quenchant permutation[2] . Yuichiro Koizumi and etal in their paper have speculated about Microstructures seen and the hardness values of a Fe-1.4%Cr-1%C pearlitic steel processed and subjected to super-rapid induction heating and then quenching (SRIHQ)under different conditions.

Research Methodology

Heat Treatment

The heat treatment of steel was done at different temperatures of 950°c, 975°c, 1000°c, 1025°c by using muffle furnace. The EN-8 steel rod was cut into pieces of 30 mm lengths and had a diameter of 30 mm. At each temperature 6 samples were kept to be heated.

Quenching

The steel samples were then quenched into different quenchants which included water, air, and salt solution with varying compositions of 2.5%, 5%, 7.5%, and 10%. For the preparation of salt solution, into 250 ml of water common salt or NaCl was added in the required weight percentages. Thus the samples were properly quenched and cooled.

Microstructure Studies

The effect of each quenchant on the hardness of steel was studied. The microstructures were observed and analysed to know about the changes happening in the steel. The microscope used for this purpose was optical microscope. The microstructures of the steel quenched in water and air at each temperature was seen. The steel was polished with sand papers of grades 100W, 320W, 400W, 600W, and then diamond polishing was done. Then etching was done with ethanol and nitric acid

Hardness Test

The steel samples were subjected to hardness test and was carried out using Rockwell's hardness testing machine.

Results and Discussion

There was a Variation in the hardness of steel after the heat treatment and quenching. The hardness of the steel used was found to increase as the sudden quenching is done. Effect of different quenchants on Steel properties was studied and then a conclusion was reached based on the results obtained. The various microstructures obtained and the hardness values are listed below :

The steel samples quenched in water and air were found to have significant variation from themselves in hardness, as the water quenched specimen at all the temperatures found to have more hardness values than the air quenched specimens. Whereas the salt quenched specimens always seem to have the highest hardness values. The salt solution must have a higher cooling rate than the water and the air quenchants. As the samples quenched in air seem to have much lesser hardness values than those in salt solutions. The samples quenched in 10% salt solution seem to have the highest amount of hardness as the martensite is formed much faster in this rapid cooling of the samples. The samples quenched in air has a much lesser cooling rate as a result less martensite can only be seen in the microstructure.

Fig. 1 : Microstructure of Air Quenched Sample at 950°c

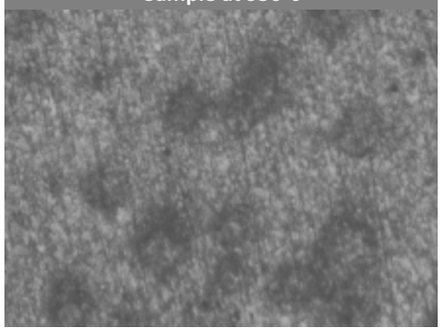
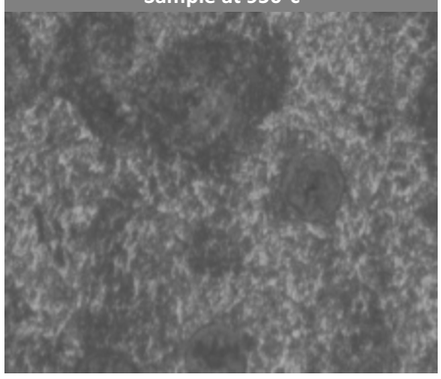


Fig. 2. : Microstructure of Water Quenched Sample at 950°c

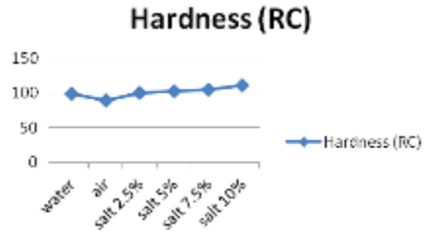


The EN-8 sample was initially heated in the muffle furnace at 950°C, 975°C, 1000°C,1025°C and then was quenched in 6 different quenchants. The six different quenchants each having different cooling rates than the other contribute much to the hardness value variation occurring in the sample.

The samples quenched in solutions as shown in the above charts does not show a considerable increase in

TABLE I : HARDNESS VALUES OF SAMPLES AT 950°C						
Quenchants	Water	Air	Salt 2.5%	Salt 5%	Salt 7.5%	Salt 10%
Hardness (RC)	98.5	89	100	102.33	105.33	111.33

Fig. 3. : Variation of Hardness Values in Samples Quenched at 950°c



hardness but shows only a slight increase in the hardness properties. The microstructure indicates the presence of more pearlite and some amount of martensite in the water quenched sample giving it more hardness. Whereas the ones quenched in air took more time to cool as a result of which it became softer due to presence of bainite and pearlite.

Fig 4. : Microstructure of Air Quenched Samples at 975°c

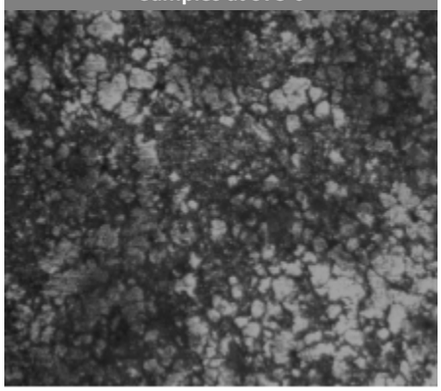


Fig 4. : Microstructure of Air Quenched Samples at 975°c

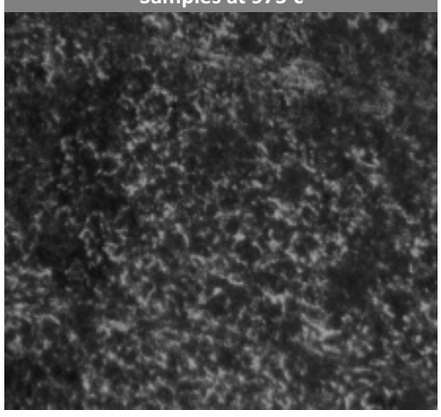


Fig. 6 : Variation of Hardness Values in Samples Quenched at 975°c

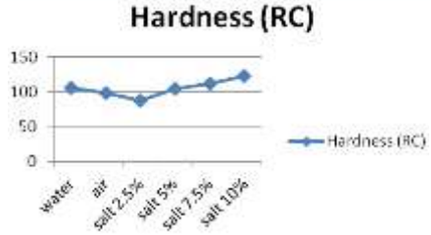


Fig 7 : Microstructure of Air Quenched Sample at 1000°c

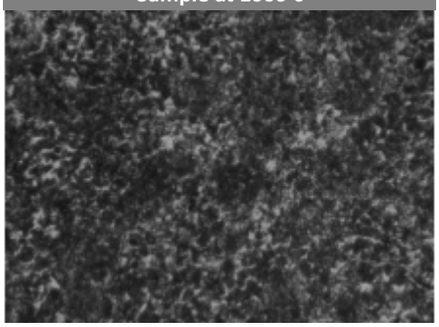


Fig 8 : Microstructure of Water Quenched Samples at 1000°c

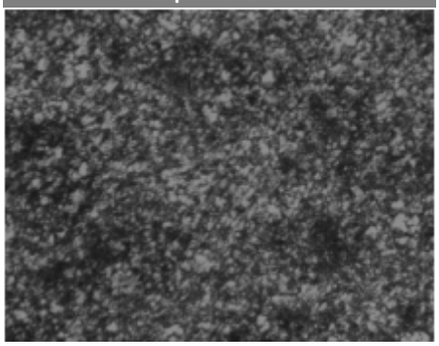


Fig. 9 : Variation of Hardness Values of Samples Quenched at 1000°c

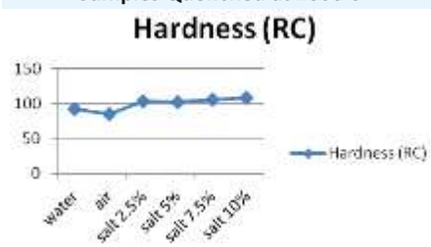


TABLE II : HARDNESS VALUES OF SAMPLES AT 975°C						
Quenchants	Water	Air	Salt 2.5%	Salt 5%	Salt 7.5%	Salt 10%
Hardness (RC)	105.33	98.33	87.83	105.17	111.83	123

Fig 10 : Microstructure of Air Quenched Sample at 1025°c

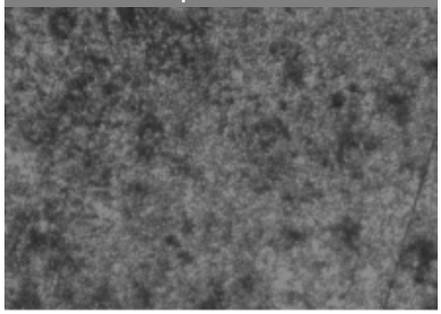


Fig 11 : Microstructure of Water Quenched Sample at 1025°c

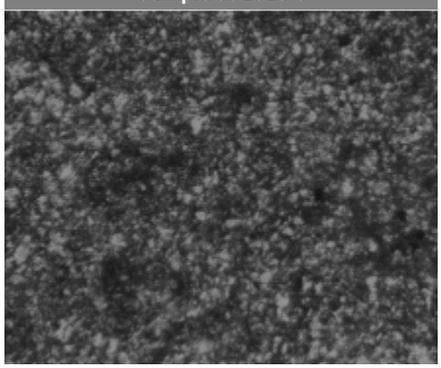


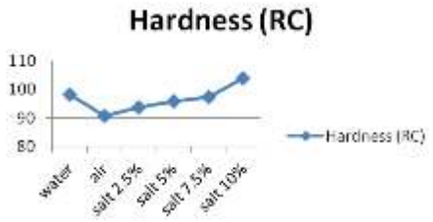
TABLE III : TABLE I. HARDNESS VALUES OF SAMPLES AT 1000°C						
Quenchants	Water	Air	Salt 2.5%	Salt 5%	Salt 7.5%	Salt 10%
Hardness (RC)	92.17	85.83	103.17	102.33	105.33	108.33

Conclusion

The microstructure of EN-8 steel after quenching in water and air was seen. The hardness tests were carried out on the whole 24 samples. From the graphs it is evident that the hardness values increases with the increase in salt percentage and the specimens heat treated at higher temperatures were found to have more hardness than the others. The steel samples quenched in salt solution were found to have more hardness than others. The cooling rate of salt solution must be higher leading

TABLE IV : TABLE I. HARDNESS VALUES OF SAMPLES AT 1025°C						
Quenchants	Water	Air	Salt 2.5%	Salt 5%	Salt 7.5%	Salt 10%
Hardness (RC)	98.33	90.83	93.83	95.83	97.33	103.83

Fig. 12 : Variation of Hardness Values of Samples Quenched at 1025°c



to the formation of more martensite in the samples which provide the hardness to the steel. Thus the samples quenched in salt 10 % have the maximum hardness values and this is attributed to the high cooling rate of salt solution.

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