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Study On the Effect of Heat Treatment on Medium Carbon Steel And Its Mechanical Properties

M. D. Harlapur[1,*], S. T. Vasan[2], Altaf Hussain M H[3]

[1*]Research Centre,Department of Mechanical Engineering, R.T.E.Society's, Rural Engineering College, Hulkoti, 582205, Karnataka, India,

[2] Department of Engineering Science, R.T.E.Society's,Rural Engineering College, Hulkoti, 582205, Karnataka, India,

[3]Department of Mechanical Engineering, R.T.E.Society's,Rural Engineering College, Hulkoti, 582205, Karnataka, India,

email: mdhrechulkoti@gmail.com*, email: vasan_rec@rediffmail.com
email: altaf.hussain867@gmail.com

Abstract

In the present work conventional heat treatment proceeds like annealing, normalizing and tempering of the material has been performed. The material used in this study is medium carbon steel. Two different grades of steel (one with copper and another without copper) have been used. In the current work reports and analyze result of mechanical testing performed on various heat treated samples of two grades of steel. The samples are tempered at 200°C, 400°C and 600°C for 1 hr. Heat treated samples were then mechanically tested for hardness (Rockwell) ,tensile properties (ultimate strength, ductility) and the microstructure, The comparison of mechanical properties and microstructure of two grades of steel has also been studied. The results revealed that steel with copper has high hardness, ultimate tensile strength and low ductility.

Keywords: Tempering, annealing, normalizing, hardening, tensile strength, ductility.

1. Introduction

The medium carbon steels (carbon 0.2-0.6%) in this range are used extensively in the manufacture of shafts, gears, railway wheels, axles and other applications. The performance of these components depends mainly on the mechanical properties of steel and these properties are very much important for the design for the above components. It has been

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found that customers have preference for medium carbon grades with wide range of carbon (0.2-0.6%) for specific end applications.

Heat treatment is a combination of heating and cooling applied to a particular metal in the solid state in such a way as to produce certain microstructure and desired mechanical properties (hardness, toughness, yield strength, ultimate tensile strength, Young’s modulus, percentage elongation and percentage reduction). Annealing, normalizing, hardening and tempering are the most important heat treatments often used to modify the microstructure and mechanical properties of engineering materials particularly steels. Hardening and Tempering are used to get better mechanical properties. Performance levels of the components can thus be improved.

EXPERIMENTAL DETAILS

4.1 Material selection

Medium carbon steel

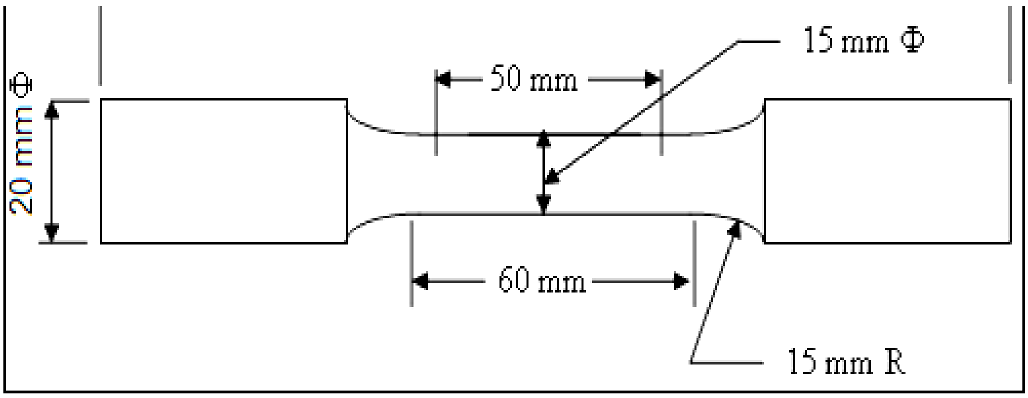
Table 4.1 Chemical composition of the steel.

Sr. No.	C %	Si %	Mn %	P%	S %
1.	0.206	0.062	0.770	0.023	0.030

4.2 Standard Tensile Specimen

The standard tensile specimen is prepared as per the shown drawing.

Fig. 4.1 Tensile test specimen (as per ASTM 8E)



4.3 Metallographic studies

Before the heat treatment, samples are prepared for metallographic examination. The surface preparations of the steel are done by usingdifferent sand papers of grade 4/0, 6/0 and then wet polishing is carried out using wet alumina paste of sub-micron grade. Specimens are etched with 2% Nital solution and analyzed under optical microscope.

Fig. 4.3 Microscope with phase analyze

4.4 Heat treatment

4.4.1 Heat Treatment of samples

1. Standard samples are kept inside hearth of furnace
2. Close the furnace door properly and then switch on the furnace.
3. Temperature is raised to 800’c (Austenitizing temperature) and waited for homogenizing.
4. Taken out heated samples from furnace and rapidly quenched into the water.
5. Waited for completely cooling of the sample to room temperature.

4.5 Hardness Test

Hardness is property of material that enables it to resist plastic deformation usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting.

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4.5.1 Hardness Test Methods

- RockwellHardness Test.
- RockwellsuperficialHardness Test.
- BrinellHardness Test
- VickersHardness Test.
- MicrohardnessTest.
- Moh'sHardness Test.
- Scleroscope and other Hardness Test.

4.5.1.1 Rockwell Hardness Test

The Rockwell hardness test method consists of indenting the test material with diamond cone or hardened steel ball indenter. The indenter is forced into the test material under preliminary minor load 10kgf. When equilibrium has been reached, an indicating device, which follows the movements of the indenter and so responds to changes in depth of the penetration of the indenter, is set to a datum position. While the preliminary minor load is still applied an additional major load is applied with resulting increase in penetration When equilibrium has again been reach, the additional major load is removed but the preliminary minor load is is still maintained. Removal of the additional major load allows a partial recovery, So reducing the depth of penetration. The permanent increase in depth of the penetration, resulting from the application and removal of the additional major load is used to calculate the Rockwell hardness number.

5. RESULTAND DISCUSSION

5.1 Mechanical Properties

5.1.1 Tensile Test Results

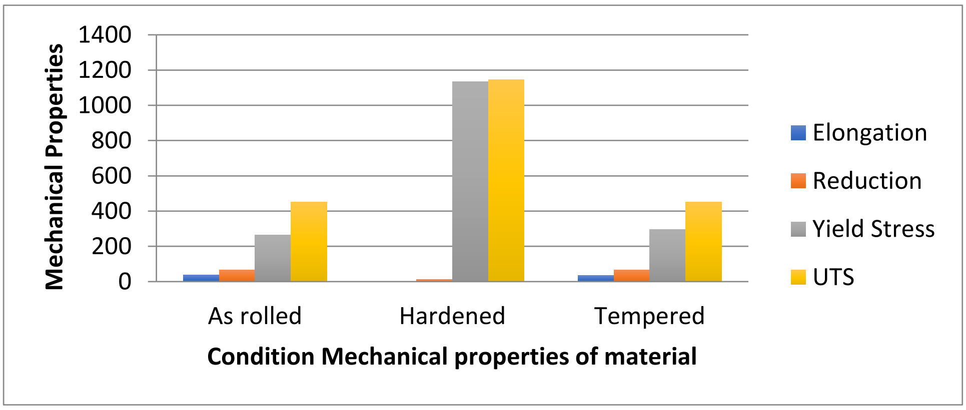


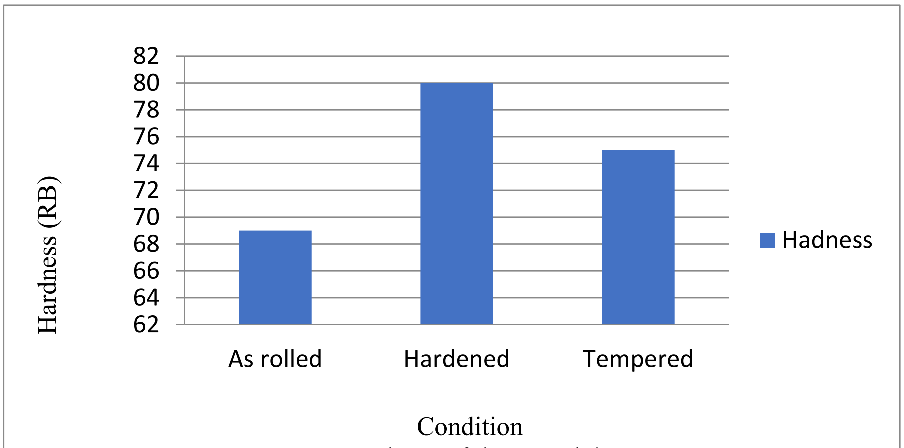
Fig. 5.1 Tensile test results

As seen from the Figure 5.1hardened structure shows maximum Ultimate tensile strength and the yield stress as compared to as rolled and tempered structure. This is due to martensitic formation from austenite.

Table. 5.1 Tensile test data

Material Condition	% Elongation	%Reduction	Yield Stress	UTS
Rolled steel	37.54	65.617	265.87	450.87
Hardened steel	0.763	11.79	1133.847	1144.599
Tempered steel	33.998	67.163	294.384	451.783

5.2.2 Hardness Test Results



Hardness of the material

As seen from the Figure 5.2.2 hardness is maximum in case of hardened steel due to the formation of martensitic structure. As rolled steel hardness is minimum because of more.

Table 5.2 Rockwell hardness test data

Material Condition	Hardness Number
As rolled steel	69
Hardened steel	80
Tempered steel	75

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5.3 Optical and SEM Microstructures

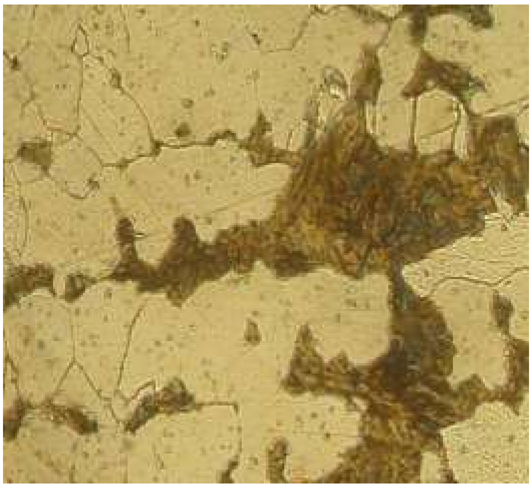

Fig 5.3 Rolled steel 400X,

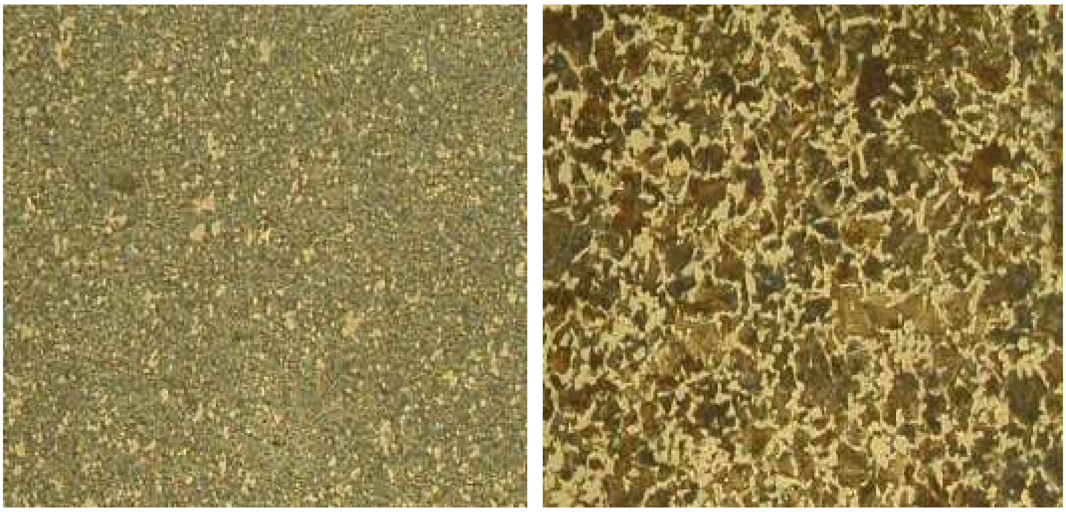

Fig 5.4 Martensite at 400 X (a) Hardened steel, (b) Tempered steel

As seen from Figure 5.3 shows the as received steel in rolled condition. It consists of coarse grains due to the annealing process and few traces of pearlite with ferrite as matrix. Fig 5.4(a) shows martensitic structure is formed after hardening the steel Fig 5.4(b) shows the effect of tempering due to which ferrite is precipitated along with the transformation of hard lath martensite into tempered martensite.

Conclusion

1. Hardening treatment on medium carbon steel (.2%C) increases the mechanical properties like hardness and tensile strength due martensite formation.
2. Alloying elements like Cr, Ni etc. can be added and heat treated for improvents of mechanical properties.

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