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Analysis of Effect of High Temperature on Micro Structure of Low Carbon Steel Bars Using Hot Rolling Process

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Abstract:
Low carbon steel is easily available and cheep having all mechanical properties that are acceptable for many application. High temperature on low carbon steel is to improve ductility, to improve toughness, Strength hardness and tensile strength and to relieve stress developed in the material. Hence basically the experiment of hardness and ultimate tensile strength and to determine the microstructure and invariable the mechanical properties is done to get idea about high temperature on low carbon steel, which has extensive uses in all industrial and scientific fields.

Key words*: Rolling, high temperature, microstructure, steel, strength, hardness, toughness, ductility tensile strength*

1. Introduction

The TMT bars can be produced by hot working process. The raw material billets are heated in to the furnace at a temperature 1145^0 to 1200^0C and passed from the last rolling mill stand and it can be obtained by the length is increased & thickness is decreased. In hot rolling of steel temperature is to dominant parameter controlling the kinetics of metallurgical phenomena such as flow stress, strain-rate and recrystallization (both static and dynamic). The mechanical properties of the final product are determined by a complex sequence of microstructure changes conferred by thermal variations. Temperature also aids the softening mechanism by which rolling stocks (billet) are prevented from brittle fracture due to work hardening effect of the rolling forces.

In low-temperature controlled rolling, grain refinement is achieved by designing a schedule so that the ferrite is produced from an recrystallized austenite. Columbium is often used as an alloying element since it is very effective in delaying recrystallization. It was therefore of interest to determine whether columbium coulduse in this way for steels finished at higher temperature. However in high temperature rolling the ferrite is more likely to be formed by the transformation of a recrystallized austenite. Thus the recrystallized austenite grain size will be the prime factor that influence ferrite grain size. The possibility of obtaining fine grain size by a suitable dispersion of particles has been explored for both titanium and columbium steel. But the effect in this case was assumed to be due to a solute rather than a precipitate effect.

The finishing passes groves fro reinforcement bars are turned in the rolls to the size of the minor diameter of the cross section while the helical impressions on the surface of the groove are obtained by milling. An oval bar is entered into this round pass with helical impression. Thus die rolling of reinforcement bars differs from the rolling of plain rounds only in the grooves of the finishing pass and in the somewhat larger oval leader and square strand passes. The latter are increased in size so that the extra metal will be forced into the milled impressions of the finishing pass. Die-rolled reinforcement bars (commonly called deformed bars) in size from N0. 10 to 90 (U.S.S.R. Std.) find use in construction.

2. Experimental Procedure

2.1. Materials

The raw material billets (100 X 100 X 1600mm) of chemical composition were charged into the re-heat furnace and heated to the rolling temperature in the range of 1200 – 1220^0C. They can be removed from the furnace and put it into the rolling mill, then rolled into 12 mm diameter high-yield bars. Each billet were rolled in each of the seven rolling cycle monitored.

2.2. Procedure

The furnace is stared first and get at 900^0C temperature constant, mean while both surface of each specimen are ground and the hardness is measure on Rockwell hardness tester and recorded. Then the numbers are given to the samples by use of number punches. Then the sample kept in the furnace at 900^0C for 20 – 25 minutes. After holding the sample for 20 -25 minutes they are quenched in above quenching medium. After all the samples have been sufficiently cooled, they are removed. Then the hardness of each sample is checked on Rockwell hardness of each sample is checked on Rockwell hardness tester and tabulated as below. After this the sample are prepared for microstructure and then microstructure are observed under the optical microscope.

Sr. No	**Quenching Medium**	**Hardness (Rc)**
1	Brine	66 Rc
2	Water	62 Rc
3	Oil	58 Rc
4	Air	37 Rc
5	Furnace	21 Rc

Table 1: Hardness of billet in various quenching medium

Microstructure changes produced as a result of Ferrite, Pearlite, Bainite, Martensite and Austenite.

- Ferrite: In ferrite microstructure it is a α solid solution. It is an interstitial solid solution of a small amount of carbon dissolved in α (b.c.c) iron. The maximum solubility is 0.025% C at 1333^0F and it dissolves only 0.008% C at room temperature. It is the softest structure tht appears on the diagram. Average properties are tensile strength 40.000psi: elongation, 40 % in 2 in: hardness, less than Rockwell Co or less than Rockwell B 90.
- Pearlite: is the eutectoid mixture containing 0.80% C and is formed 1333^0F on very slow cooling. It is very fine plate like or lamellar mixture of ferrite and cementite. The fime fingerprint mixture carried pearlite. The white ferritic background or matrix which makes up most of the eutectoid mixture contains this plate of cementite. The same structure magnified 17,000 times with the electron microscope. Average properties are tensile strength 120,000psi: elongation 20% in 2 in: hardness Rockwell C 20, Rowkwell B-95-100, or B.H.N 250-300.
- Austenite: It is a solid solution of carbon in γ-iron having a maximum of about 2%C at 1130^0C. It is a coarse-grained structure. Higher amount of retained austenite after qauenching.Decarburization and oxidation at the surface. It gives increased distortion and danger of forming cracks in the specimen.
- Martensite: Ms represents the temperature at which the formation of martensite will start and Mf. The temperature at which the formation of martensite will finish during cooling austenite through this range. Mf is fairly low temperature martensite is formed by the diffusion less transformation of austenite on rapid cooling to a temperature below 465^0F (approximately) designated as Ms. Temperature. The martensite transformation differs from the other transformation in that it is not time dependent and occurs almost instantaneously, the proportion of austenite transformed to martensite depends only on the temperature to which it is cooled. For example the approximate temperatures at which 50% and 90% of the total austenite will, on quenching, transform to martensite are 330^0F & 240^0F respectively.

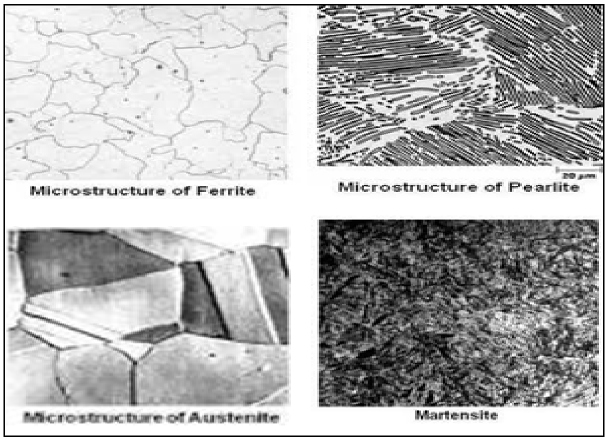


Figure 1

3. Microstructure Analysis

Test specimens were ground on a water-lubricated grinding machine using silicon carbide abrasive paper grade 240, 320, 400 and 600 grits. Final polishing of the specimen were affected with 0.5µm Chromic oxide powder. The surface so obtained were etched in 2% Nitial solution and left for 30s then, raised with water. The microstructure features of the specimens were examined under a metallurgical inverter microscope model FERO X PL at X 100 magnification.

3.1. Mechanical Properties

- Increase in Strength: of a metal with strain is charted for cold working (top) & hot working (two lower one). The upper curve relating to hot working reflects dynamic recovery, a dislocations softening mechanism that limits the increase in strength. The lower curve reflects dynamic recrystalization, wherein soft grains replace distorted grains.

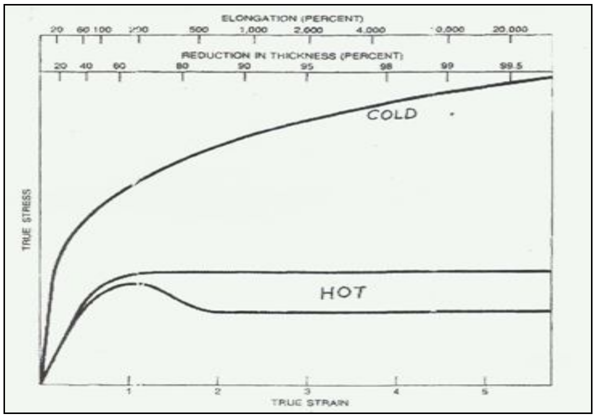
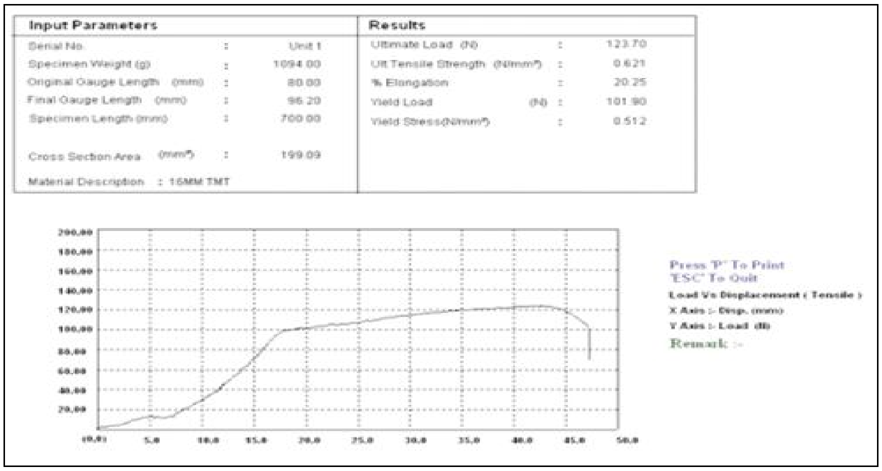


Figure 2

- Hardness Test: Is a measure of the difficulty of a scratching of a material can be said to be a measure of low resistant solid matter is to various kinds of permanent shape change when a force is applied. Microscopic hardness is generally characterized by strong intermolecular bonds, but the behavior of solid materials under force is complex, therefore there are different measurements of hardness scratch hardness indentation hardness and rebound hardness.
- Tensile Test: Room temperature unianial tension tests were performed on round tensile samples machined from the steel sample with dimensions of 5mm gauge diameter a d 40mm length. P2000 electronic tensiometer was used to conduct the test following standards test procedures in accordance with the ASTM E8M-91 Standards (1992). The samples were tested at a nominal strain rate $10^{-3/5}$ until failure. Multi test were performed for each test condition to ensure reliability of the data generated. The tensile properties evaluated from the tension test are –the ultimate tensile strength(µu), the yield strength(σy) & strain to fracture(ξf)

4. Result &Discussion

The hot rolled billets are carried out at 1100^{0}C to 1145^{0}C and it passes from the rolling mill, it gives the best result of fine grain microstructure, remove internal stress, remove surface defects, the hot rolled bars are cooled in the air and improve all the mechanical properties.



Input Parameters			Results		
Serial No.	:	Unit 1	Ultimate Load (N)	:	123.70
Specimen Weight (g)	:	1094.00	Ult Tensile Strength (N/mm²)	:	0.621
Original Gauge Length (mm)	:	80.00	% Elongation	:	20.25
Final Gauge Length (mm)	:	96.20	Yield Load (N)	:	101.90
Specimen Length (mm)	:	700.00	Yield Stress(N/mm²)	:	0.512
Cross Section Area (mm²)	:	199.09			
Material Description	:	16MM TMT			

Press 'P' To Print
'ESC' To Quit
Load Vs Displacement (Tensile)
X Axis :- Disp. (mm)
Y Axis :- Load (N)
Remark :-

Figure 3

S.A.Balogun, G.I Lawal.,O.I.Sekunowo and S.O. Adeosun.,"Influence of finishing temperature on the mechanical properties of conventional hot rolled steel bars"., Journal of Engineering and Technology Research Vol. 3(11), pp.307-313, October 2011.: Result of the temperature tracking experiment are the values of micro-hardness induced in the steel bars after air-cooling..Using the data obtained tensile test on specimens relevant tensile data are computed and presented in the microstructure features of test specimens. The micro structural features of test specimens are variations in the functional mechanical characteristics in terms of ultimate tensile strength, yield strength and hardness exhibited by test specimens in relation to the finishing temperature are the result of yield properly behavior with variation in carbon content are the variation of reheat temperature of billets used during the rolling cycle. The result gives the fine grain structure and improves the mechanical properties.[10]

J.M.Chilton and M.J.Roberts, "Microalloying effect in hot-rolled low-carbon steels finished at high temperature", Colum-bium and vanadium additions can improve the toughness of hot-rolled

Steels. Although this generalization is certainly true, our investigation brought out a point of practical importance for alloy design aimed at improving the properties of heavier-gage hot-rolled products, namely, that columbium and vanadium steels respond quite differently to variations in the finish rolling temperature. The somewhat complex interrelation of grain size, precipitation hardening, and processing the two steels. Finally, the key finding on the two steels will be compared.

5. Summary & Conclusion

From the various experiments carried out following observations and inferences were made. It was seen that the various tensile properties followed a particular sequence:

- More is the tempering temperature, less is the hardness or ore is the softness (ductility) induced in the quenched specimen. (Ductility) induced in the quenched specimen.
- Microstructure photographs taken by SEM and metallurgical inspections indicated that the surface of heat treated samples is martensitic.
- Case depth can be increased by longer cycle of carburization. Case depth can be increased exponentially by increasing carburization temperature.
- The samples having greater case depth an surface hardness are more wear resistant than that with low case depth and surface hardness are more wear resistant than that with low case depth and low surface hardness.
- More is the tempering time (keeping the tempering temperature constant), more is the ductility induced in the specimen.
- This clearly implies that the UTS and also to some extent the yield strength decreases with increase in tempering time where as the ductility (% elongation) increases.
- For a given tempering time, an increase in the tempering temperature decreases the UTS value and the yield strength of the specimen where as on the other hand increasing the % elongation and hence the ductility.
- Similar finding as also experienced by different scientist on their literate.
- From the various results obtained during the experiment work it can be concluded that the mechanical properties vary depending upon the various high temperature processes. Hence depending upon the properties and applications required we should go for a suitable high temperature processes. When ductility is the only criteria tempering at high temperature for the best result.

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