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"COMPARISON AND TESTING OF TENSILE STRENGTH FOR LOW & MEDIUM CARBON STEEL"

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ABSTRACT

In this research work investigations were carried out to study the effects of heat treatment on the Tensile strength (mechanical properties) of low carbon steel and medium carbon steel and on Dual phase steel development from low carbon steel and medium carbon steel. Dual phase steel is developed by intercritical annealing in order to improve the tensile strength. Low carbon steel of 0.26% carbon content and Medium carbon steel of 0.46% carbon content is first inter critically heated in furnace and then rapid cooling in water is done to obtain the martensite steels and named as Dual phase steel. Dual Phase steels are prepared by the intercritical annealing process at 840°C temperature and for holding time of 6 minutes. Dual phase steel so obtained is now tested and properties of the Dual Phase steel are evaluated. Tensile test for each Dual phase steel specimen which is developed from low carbon steel and medium carbon steel is conducted to compare its tensile strength with untreated low carbon steel and untreated medium carbon steel. The result indicates that the specimen increased tensile strength decreased elongation percentage with the heating temperature and holding time.

KEYWORDS: Dual Phase Steel, Intercritical Annealing, Martensite, Tensile Strength, Water Quenching

INTRODUCTION

Low carbon steel (LCS) and medium carbon steel (MCS) is the most common form of steel. Due to its relatively low price and superior mechanical properties such as tensile strength and toughness, it is acceptable for many engineering application. Low and Medium carbon steel is used extensively for construction of buildings and bridges. They are also use for making diesel pump injection parts and automated packing machinery parts; other application includes railroad tracks, pressure vessels and ships. Steels whose structures consist of mixtures of ferrite and martensite are often referred as Dual phase steel. Ferrite is soft and provides good ductility whereas martensite is hard and is responsible for high strength [Das et al, (2009)]. The desire to produce high strength steels with formability greater than micro alloyed steel led to the development of DP steel in 1970s. The properties which make DP steels most popular include good combination of strength and ductility, absence of yield point phenomena, low yielding, high initial work hardening rate, high uniform and total elongation, high strength to weight ratio and good formability [Bag et al, (1999); El-Sesy et al, (2002)]. Low and Medium carbon steel may be heat treated by austenitizing, quenching and then tempering to improve their mechanical properties, on strength to cost basis, medium carbon steel provide tremendous load carrying ability. Such heat treatments of the steels for the purpose of improvement in mechanical properties have been studied previously by many workers. Evin (2013) present the basic concepts of advanced high strength dual phase steels for automotive applications, including the design of chemical composition, microstructure and mechanical properties development during thermo-mechanical processing as well as characterization production technology and the potential applications of in-service performance. Dual-phase steel sheets have very good ability of absorption of kinetic energy on impact and higher strength properties. A good combination of strength and ductile properties of dual phase steels can reduce weight and improve safety (strength, stiffness, absorption energy) of an auto body. Manoranjan et al (2014), Mechanical properties and fracture behavior of Medium Carbon Dual Phase Steels. Dual phase steels have been developed from plain medium carbon steel containing 0.42 % carbon. Intercritical austenitisation (ICA) treatment was carried out at 740°C for different (ICA) time followed by water quenching to obtain different martensite volume fraction (MVF) in DP steels. DP steels have been characterized by optical and scanning electron microscopy, Vickers hardness measurements and tensile properties determination. The effect of MVF on various mechanical properties and fracture behavior of MC dual phase steels have been explained in this work. Vishnu Pratap Singh et al (2014) develop dual phase steel from low carbon steel and its mechanical properties have been tested and studied. Dual phase steel is developed by intercritical annealing in order to improve the hardness and impact toughness. Low carbon steel of 0.21% carbon content is first intercritical heated in furnace and then rapid cooling in water is done to obtain the martensite steels. Different samples of DP steels are prepared by the intercritical annealing process temperature ranging from740°C to 840°C. The heating temperature and different time of heating of the steel is used to make different percentage of Martensite steel. Dual phase steel so obtained is now tested and properties of the DP steel are evaluated. Hardness, Charpy, microstructure test for each specimen is conducted to compare its hardness and toughness with low carbon steel. The mechanical properties of heat treated and non heat treated specimens are obtained and compared. The result indicates that the specimen hardness and toughness are proportional to amount of martensite and amount of martensite depends on intercritical annealing temperature.

Quenching: Carbon steel with at least 0.4 wt% C is heated to normalizing temperatures and then rapidly cooled (quenched) in water, brine, or oil to the critical temperature. The critical temperature is dependent on the carbon content, but as a general rule is lower as the carbon content increases. This results in a martensitic structure; a form of steel that possesses a super-saturated carbon content in a deformed body-centered cubic (BCC) crystalline structure, properly termed body-centered tetragonal (BCT), with much internal stress. Thus quenched steel is extremely hard but brittle, usually too brittle for practical purposes. These internal stresses cause stress cracks on the surface. Quenched steel is approximately three to four (with more carbon) fold harder than normalized steel.

MATERIALS AND METHOD

The dimensions of the specimen used in the present work is 203×10×10 mm square rod of low carbon steel and medium carbon steel prepared from 610×10×10 mm square rod. The main chemical composition of the material is shown in the table.

Table 1: Chemical Composition of Low Carbon Steel and Medium Carbon Steel

Element	C	Si	Mn	S	P	Ni	Cr	Mo	Al	Cu	Ti	Co
LCS Wt%	0.26	0.058	0.785	0.050	0.045	0.081	0.112	0.005	0.001	0.024	0.001	0.001
MCS Wt%	0.46	0.34	1.00	0.31	0.03	0.035	0.042	0.001	0.03	0.17	0.005	0.001

The material studied in this work was low carbon steel of 0.26% and medium carbon steel of 0.46% carbon. Specimens are made for heat treatment and subsequent mechanical testing, were obtained and machined from the bar material in standard dimension. Two specimens from each square rod of LCS and MCS is prepared. One specimen of both LCS and MCS were heated first at 840°C temperature for holding time of 6 minutes in the austenite and ferrite region in a muffle furnace and then quenched in water. These specimens are termed as heat treated. The tensile testing of the specimen was carried out by using an Ultimate tensile testing machine.

Development of Dual Phase Steel

Dual phase steels are developed by heating low carbon steel of 0.26% carbon content and medium carbon steel of 0.46% carbon content into two phase ferrite-austenite (α + ϒ) region of Fe-C phase diagram, followed by rapid cooling to transform austenite (ϒ) into martensite, resulting in a structure of ferrite and martensite that is known as dual phase steel. Method mainly used for developing dual phase microstructure in steels, namely intercritical hardening.

Process for Intercritical Annealing

Step 1: Switch ON the furnace and set 840 °C temperature in the controller which controls the voltage, current and the temperature inside the furnace.

Step 2: Gradually the temperature of the furnace reaches 840 °C in 45 min approximately.

Step 3: Temperature will fluctuate between 838°c to 842°C due to error in the thermocouple used so wait for the stable value.

Step 4: Now put the work piece on ceramic plate.

Step 5: Set timer in the mobile for required time (Holding Time).

Step 6: In the end of set time, open the lid of the furnace Remove the material and drop the work piece in the water pool.

Step 7: Use asbestos plate to cover the furnace to avoid heat loss.

Step 8: Remove the material and repeat steps for other material.

The production route for intercritical annealed Dual Phase steels is schematically shown in Figure 1, where, Ac1 and Ac3 are the start and finish temperatures of austenite formation during heating.

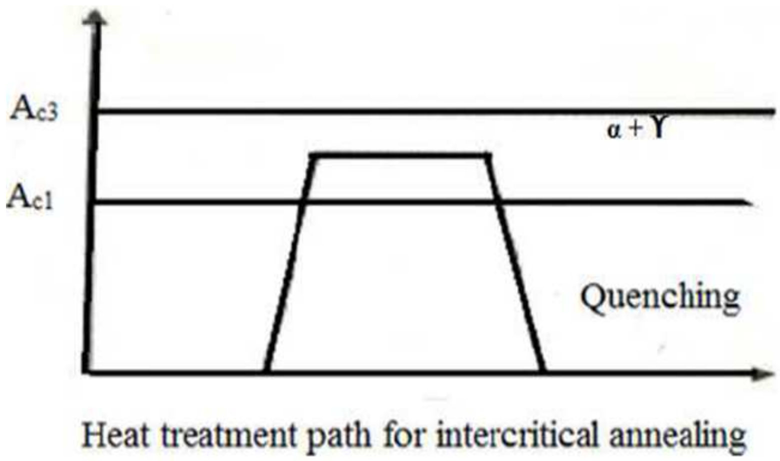


Figure 1

Table 3: Heating Temperature and Holding Time Selected as Shown

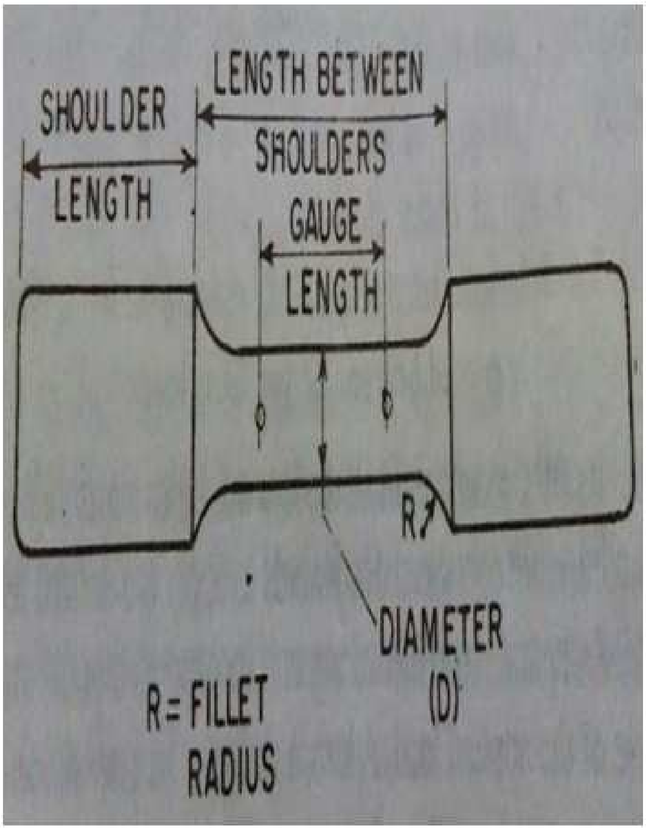
Specimen	Low Carbon Steel		Medium Carbon Steel	
	1	2	1	2
Temperature (^{0}C)	0	840	0	840
Holding time(min)	0	6	0	6

Sample Description

Tensile Test Parameters	Dimensions
Total Length (mm)	203
Shoulder Length (mm)	70
Length between Shoulders (mm)	63
Diameter (mm)	6.03
Area (mm^2)	28.56
Fillet Radius (mm)	12
Gauge length (mm)	30

Tensile Test

It is very commonly used test, performed to determine different tensile properties, viz., ultimate tensile strength, yield strength elastic limit, proportional limit, breaking strength, % elongation, % reduction in area, modulus of elasticity, etc. This test can be performed either on an exclusive tensile testing machine or on a universal testing machine. The tensile test sample has (10 × 10 × 203) mm dimensions and gauge length 30 mm.



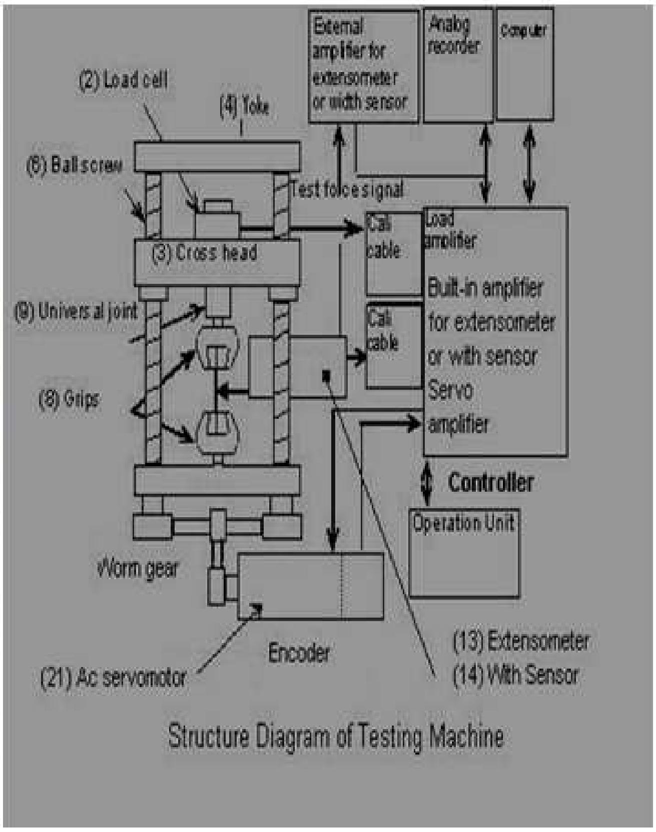


Figure 2: Tensile Test Specimen **Figure 3: Universal Testing Machine**

Procedure for Tensile Test on Universal Testing Machine

For performing the test one end of the specimen is gripped in the upper *cross-head* of the machine, which is a fixed head. The other end of the specimen is gripped in the *adjustable (movable) cross-head.* This set-up is schematically shown in fig. Tensile load is gradually applied to the specimen by means of the loading unit of the machine. In all modern machines a *hydraulic drive* is used to move the adjustable crosshead downwards to apply the desired tensile load on the test piece. A separate load measuring unit incorporated in the machine shows the magnitude of the applied load. A *strain* *gauge* is attached to the test piece to show the elongation. With increase in load there is a corresponding increase in length between the two extremities of the gauge length, i.e., there is elongation in length of the test piece. It is therefore; clear that elongation is obtained as a function of load.

As the load is increased further a point is arrived after which the stress-strain proportionally is lost but elastic elongation continues up to another point (elastic limit). Further loading of the test piece leads the material to another specific point (yield point) from where plastic deformation starts. With further addition of load the point of maximum stress (ultimate stress) is reached. Hereform the test piece starts developing the neck. Further deformation of the metal is concentrated on his neck and its area goes on reducing till such time when the specimen breaks.

Figure 4: Sample before Testing

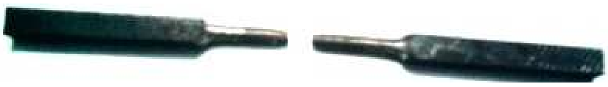


Figure 5: Sample after Testing

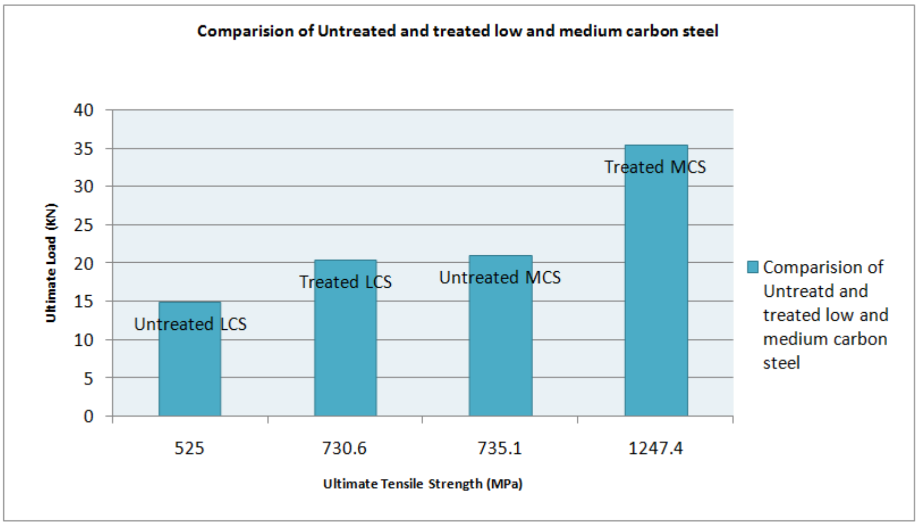
RESULT AND DISCUSSIONS

The experimental results show that dual phase steels have excellent mechanical properties in terms of tensile strength.

Table 4: Mechanical (Tensile) Properties of Heat Treated and Untreated Steel

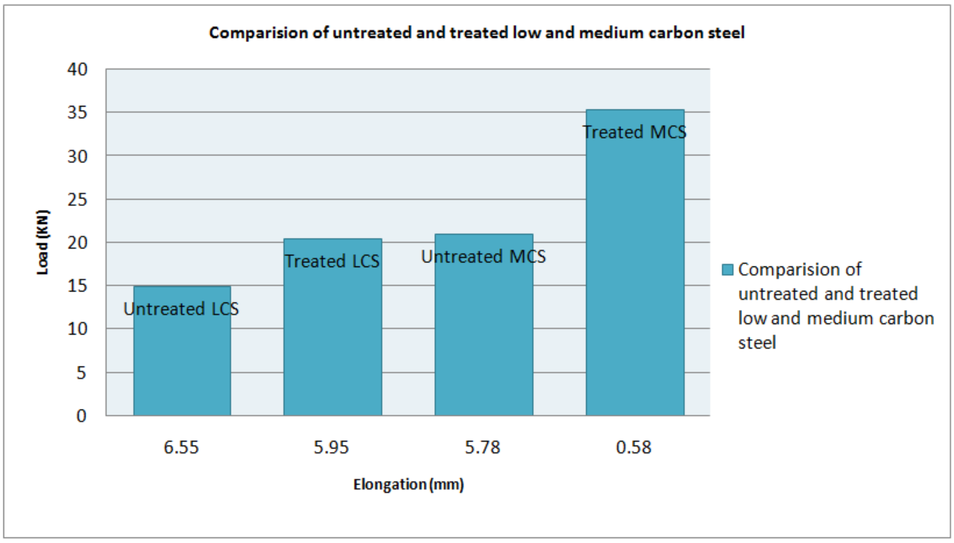
	Untreated Low Carbon Steel	Untreated Medium Carbon Steel	Treated Low Carbon Steel	Treated Medium Carbon Steel
Temperature ^{0}C	0		840	
Holding time (min)	0		6	
Ultimate Load (KN)	15	21	20.46	35.40
Ultimate tensile strength (MPa)	525.0	735.1	730.6	1247.4
Elongation (%)	21.83	19.27	19.83	1.93
Final gauge length (mm)	36.55	35.78	35.95	30.58

Strength vs Load



Graph 1: Shows Increase in Strength after Treated

Elongation vs Load



Graph 2: Shows Decrease in Elongation after Treated

CONCLUSIONS

Dual phase steel can be developed from low carbon steel and medium carbon steel by intercritical annealing process. The investigations are carried out on various samples to study the effect of temperature and time in the martensite phase of dual phase steel. The percentage elongation of untreated LCS is 21.80%, treated LCS is 19.26 %, untreated MCS is 19.13% and treated MCS is 1.93 %. It is clear that tensile strength of dual phase steels are higher than the untreated low carbon steel and medium carbon steel. The result obtained confirmed that improvement in the mechanical properties that can be obtained by subjecting low and medium carbon steel to intercritical annealing heat treatment. Dual Phase steels have better mechanical properties as it consists of ferrite and martensite structure. By simple heat treatment of steel, the mechanical properties are improved and cost adding costly material is saved.

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