International Journal of Materials Research in Science & Technology
Volume 1 | Issue 1

Research Article Open Access

Evaluation of Mechanical Properties of Medium Carbon Low Alloy Steels

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Citation: Chandan BR, Ramesha CM (2020) Evaluation of Mechanical Properties of Medium Carbon Low Alloy Steels. Int J Mater Res Sci Tech 1(1): 21-24.
https://doi.org/10.47890/IJMRST/2020/CMRamesha/14205433

Received Date: May 21, 2020; **Accepted Date:** June 19, 2020; **Published Date:** July 10, 2020

Abstract

Medium carbon low alloy steel is being used in the forged condition in the automobile, aerospace and transport industry. Reliability of critical components made of EN Series is directly based on the fatigue strength of this steel, which in turn is dependent on forging process. A review of literature shows that substantial information is available relating to structure and mechanical properties of medium carbon low alloys forged steels. Some information is available regarding the evaluation of mechanical properties of steels. In the light of the above, the present investigation was taken up to study the effect of variables on the chemical composition of EN Steels. Mechanical properties such as UTS, percentage of elongation, Percentage of reduction (%RA) and hardness,of the alloy was assessed. The aim of the study is to evaluate the possibility of replacement of this steel with lower Ni content.

Keywords: EN series; elongation; Hardness; Medium carbon steel; reduction; Ultimate Tensile strength (UTS);

Introduction

Medium-carbon steels are similar to low-carbon steels except that the carbon ranges from 0.30 to 0.60% and the manganese from 0.60 to 1.65% [1]. Increasing the carbon content to approximately 0.5% with an accompanying increase in manganese allows medium carbon steels to be used in the quenched and tempered condition. The uses of medium carbon steels include shafts, axles, gears, crankshafts, couplings and forgings. Steels in the 0.40 to 0.60% C range are also used for rails, railway wheels and rail axles.EN18 (AISI 4140) EN19 (AISI 4142) EN24 (AISI 4340) are medium carbon low alloy steels under High strength Low alloy [HSLA] categories. EN 19 is nickel free steel and EN 24(low nickel) steels. The mechanical strength of medium carbon low alloy steels can be improved by forging and heat treatment. The primary source of information for heat treatment of steels is ASM Metals Handbook Vol-4 [2]. Various other textbooks and standards are available for determining the temperatures of homogenization, quench media, tempering temperatures and procedures thereof.

Materials and Methods

Chemical composition Test

The chemical composition test of medium carbon low alloy steel samples for this investigation is given in (Table 1).

Table 1: Chemical Compositions of selected Steels

Steel	Element	Wt %							
		C	Mn	P	S	Si	Ni	Cr	Mo
EN18	Min	0.35	0.65	0.040	0.040	0.10	--	0.85	--
	Max	0.45	0.95	0.040	0.040	0.35	--	1.15	--
EN19	Max	0.43	1.10	0.035	0.040	0.30	--	1.10	0.25
	Max	0.43	1.10	0.035	0.040	0.30	--	1.10	0.25
EN24	Min	0.37	0.60	0	0	0.15	1.65	0.70	0.20
	Max	0.43	8.80	0.035	0.040	0.30	2.00	0.90	0.30
EN25	Min	0.27	0.45	0	0	0.10	2.30	0.50	0.45
	Max	0.35	0.70	0.04	0.04	0.40	2.80	0.80	0.65

Heat Treatment

Heat treatment of steels is based on three diagrams (i) the Iron Carbon Diagram for the specific composition, (ii) The Time-Temperature-Transformation (TTT) diagram and (iii) the Continuous Cooling Transformation (CCT) Diagram. These are well explained in ASM Metals Handbook and various other handbooks [3].

The prepared tensile test samples and other samples were heated to different tempering temperatures and soaked for 45 minutes using muffle furnace. Taken Test samples were quickly taken out of the furnace after each of the heat treatment temperatures. Surface morphologies of the heat-treated samples the hardness and tensile test were carried out

Mechanical Test

Tensile Testing

The tensile strengths of the steels under various heat-treated conditions were determined using a Hounsfield Tensometer (shown in Figure 2.1), according to ASTM E8 standard.

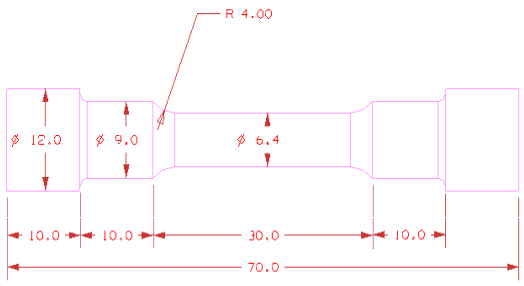

Figure: 2.1 Tensile Test Specimen as per ASTM E8 Standard

Hardness Test

Vickers pyramid method was used for the determination of the hardness of the heat-treated samples. Each of the test specimens was flatten after heating and then mounted on the anvil. The specimens were brought in contact with the pyramid indenter and allowed to rest for a dwell time. The hardness of the specimen is indicated by the penetration of the indenter on the test specimen and average values are recorded after repeating the test for each of the test specimens.

Results and Discussion

Mechanical tests were carried out as a part of quality confirmation of forging and heat treatment process as per customer specifications. Tension, hardness was carried out for each batch of components.

The measured values of ultimate strength, yield strength, % elongation and % reduction in area, and BHN for selected steel tempered at different temperatures are tabulated in Table 2 to 4.

Table 2: Mechanical Properties of EN19 steel for various Tempering Temperatures

Sl. NO	Temp	YS	UTS	% EL	%RA	BHN
1	670	679	849	29.4	68	232
2	650	647	824	19.6	58.6	232
3	640	590	913	28.8	59	258
4	620	596	736	26.80	62	258

Table 3: Mechanical Properties of EN24 steel

Sl. NO	Temp	YS	UTS	% EL	%RA	BHN
1	600	755	925	16	60	290
2	600	960	1140	24	56	330
3	640	796	990	28	58	309
4	670	818	964	29	60	298

Table 4: Mechanical Properties of EN25 steel forVarious Tempering Temperatures

Sl. NO	Temp	YS	UTS	% EL	%RA	BHN
1	620	945	1099	19.8	60.15	318
2	600	803	1003	14	56.4	316
3	600	878	1088	26	59	333
4	620	893	1084	19.6	61.5	320

1) Ultimate strength and yield strength of the EN19 steel decrease with increase in tempering temperature.

2) % Elongation and % reduction in area increase with increasing tempering temperature.

3) Hardness decreases with increasing tempering temperature.

The following observations can be made from the Figure 3.1 to 3.6.

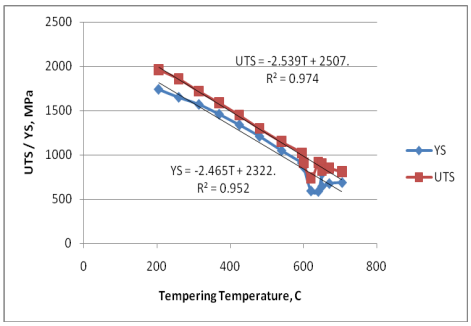

Figure: 3.1 Variation in UTS & YS with Tempering Temperature for EN19

% Elongation and % reduction in area increase with increasing tempering temperature.

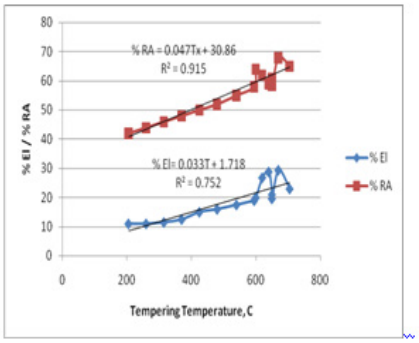

Figure: 3.2 Variation in %EL and %RA with Tempering Temperature for EN19

Hardness decreases with increasing tempering temperature

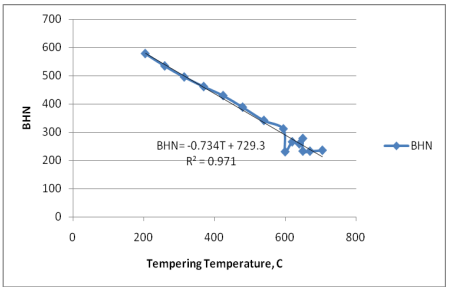

Figure: 3.3 Variation in BHN with Tempering Temperature for EN19

Ultimate tensile strength and yield strength of the EN24 steel decrease with increase in tempering temperature.

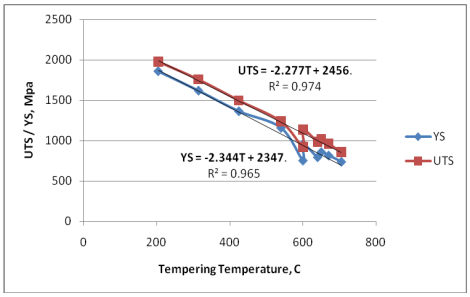

Figure: 3.4 Variation in UTS & YS with Tempering Temperature for EN24

% Elongation and % reduction in area increase with increasing tempering temperature.

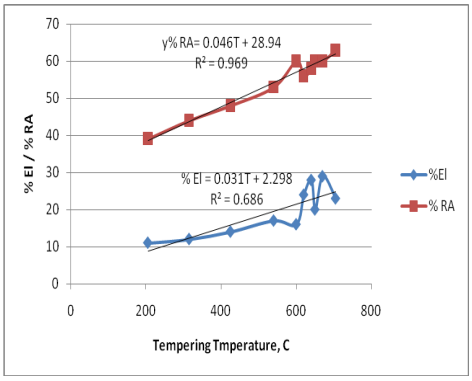

Figure: 3. 5Variation in UTS and YS with Tempering Temperature for EN24

Hardness decreases with increasing tempering temperature

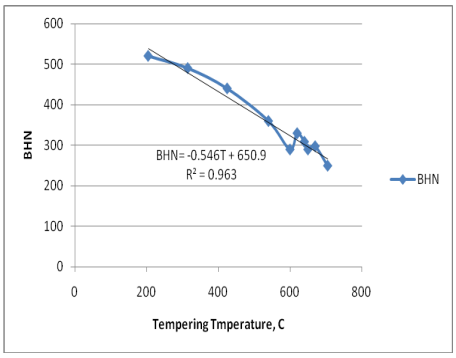

Figure: 3.6 Variation in %El and %RA with **Tempering Temperature for EN24**

4) Ultimate tensile strength and yield strength of the EN24 steel decrease with increase in tempering temperature.

5) % Elongation and % reduction in area increase with increasing tempering temperature.

6) Hardness decreases with increasing tempering temperature

The behavior of EN24 almost duplicates that of EN19.

Since the industrial test values are compared with the values specified by customers and not with standard values, no correlation is attempted for the mechanical properties of EN25 steel.

Conclusions

From the different heat treatment results we can conclude EN 24 steel have good mechanical properties than EN 19 steel, so we can recommend EN 24 steel for some critical and semi critical applications. Mechanical test revealed that EN19 and EN24 can be used in place of EN25 for some critical and sub critical applications.

Acknowledgement

The authors express heartfelt thanks to Management of Gokula Education Foundation (GEF) and Department of Mechanical Engineering, MSRIT Bangalore-560054 to provide all facility to carry out this research work.

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