Investigation of Mechanical Properties of Austenitic stainless steels Quenched in Water, Mineral Oil and Air

P.Mahesh Boopathi[1] , L. Arul Sabarish[1], J. Allen Ignatious[1],

P. Sudharasan[1], G. Saravanan[1]btech, Mechanical Final Year

Tamilselvan , Assistant Professor, Prist University, Vallam Thanjavur

Abstract :

Austenitic stainless steels (SS304,SS310) have been investigated with respect to their mechanical properties after heat treatment. For heat treatment solutionizing temperature of 855°C with a soaking period of 60 min was used. Thereafter quenching was carried out in three media, viz., Step water, Air and Mineral oil separately. The quenched samples were step tempered at 575°C and at 220°C sequentially for 60 min each. Hardness, tensile strength, Charpy impact strength and metallographic were carried out on the untreated and heat treated specimens. The heat treated specimens showed higher hardness (40%), higher strength (45%) and higher impact energy (25%). The specimens quenched in Air exhibited the best mechanical properties. The heat treated specimens had a structure of fine tempered martensite with small amount of bainite.

Keywords: EN steels; Heat treatment; Polymer quenching; Forged steels; Impact energy, MWCNT

I.Introduction

Steel of SS304 and SS310 have choosen which have an wide range of application in Construction sector. In order to reduce the cost of the material we subjected to heat treatment for various quenching medium of lesser risk of cracking and less distortion, resulting in better mechanical properties compared to water, oil and Air.
Steel properties range of strength compositions. The mechanical properties of micro alloyed steel result, however, from more than just the mere presence of micro alloying elements. Austenite conditioning, which depends on the complex effects of alloy design and rolling techniques, is also an important factor in the grain refinement of hot-rolled steels. Grain refinement by austenite conditioning with controlled rolling methods has resulted in improved toughness and high yield strengths in the range of 345 to 620 MPa (50 to 90 ksi). The present study is aimed at determining a comparative evaluation of mechanical properties achieved in MCLA steels. With different quenching media with standard step tempering procedure.

Materials and Methods

Two steels of SS304 and SS310 in the normalized condition were procured from Chennai market. The compositions were analysed for confirmation and Table 1 gives the results of the composition check. Mineral oil (SAE 320 gear oil) [where n represent the average number of oxyethylene groups] from Bangalore market to serve as quenchant.

Test specimen preparation

A set of specimens was prepared for Tensile, Impact, Hardness and Microstructural analyses. The standards used for samples to carry out the various tests are listed out in Table 2.

II. Proposed Method -Heat treatment/quenching and step tempering

An electric furnace with maximum temperature of 1200°C was used for both solutionizing and step tempering. The heat treat temperatures were kept same for all four steels studied, as shown in Table 3. After solutionizing, the samples were directly quenched in water, oil

ANNEALING

Annealing is a very broad term used to describe a variety of heat treatments, but it is a process customarily applied to remove stresses or work hardening. For the purpose of the heat treatment used on carbon steels in the material specifications, the more specific term full annealing better describes the process. Full annealing is defined as "annealing a steel object by austenitizing it and then cooling it slowly through the transformation range" the result is that the maximum transformation to ferrite and to coarse pearlite is achieved, which corresponds to the lowest hardness and strength.

NORMALIZING

Normalizing is a specific term defined as "heating a steel object to a suitable temperature above the transformation range and then cooling it in air to a temperature substantially below the transformation range" for many of the carbon steels discussed in this report, the cooling rate in air is not rapid enough to prevent significant transformation from austenite into ferrite and a pearlitic microstructure. Higher alloy, air-harden able materials can be significantly hardened by normalizing. The normalizing temperature is typically 100ºF (55ºC) above the upper critical temperature.

Element	SS304	SS308	SS309	SS310
C	0.07	0.08	0.2	0.25
Mn	2	2	2	2.0
P	0.045	0.045	0.045	0.045
S	0.030	0.03	0.03	0.030
Si	0.75	1	1	1.5
Ni	8-10.5	11	14	19-22
Cr	17.5-19.5	20	23	24-26
Mo	-	-	-	-
N	0.1	-	-	-
Fe	bal	bal	bal	Bal

Table 1: Chemical Composition of steels studied (%)

Test	Standard used
Hardness Test	ASTM 92
Tensile Test	ASTM E-8
Charpy Test	IS: 1499

Table 2: Standards used [3]

Process	Temp ₒC	Soaking time
Hardening	855	60 min
Tempering I	575	60 min
Tempering II	220	60 min

Table 3: Temperature and soaking ftime [4].

The microstructural investigation was performed using a Carl Zeiss optical microscope. In sequence, the steps include sectioning, mounting, coarse grinding, fine grinding, polishing, etching

EN Series	Sample uenching medium	Yield Strength 0.2% Proof (MPa) min	Tensile Hardness Strength (MPa) min	Elongation (% in 50mm) min	Rock well B (HR B) max	Brinell (HB)
SS304	As-received	205	515	40	92	201
	Water	205	520	40	92	201
	Oil	208	525	45	92	205
	Air	220	530	42	98	245
SS310	As-received	205	515	40	95	217
	Water	205	520	40	95	201
	Oil	208	525	45	95	205
	Air	223	532	42	96	246

Table 4: Shows the Mechanical properties of as-received and quenched steel samples.

Element	SS304	SS310
C	0.07	0.25
Mn	2	2.0
P	0.045	0.045
S	0.030	0.030
Si	0.75	1.5
Ni	8-10.5	19-22
Cr	17.5-19.5	24-26
Mo	-	-
N	0.1	-
Fe	Bal	Bal

Table 5: Shows the properties of steel

Mechanical tests

A standard Brinell Hardness Tester was used for measurement of indentation hardness. The tests were conducted using a 10 mm diameter steel ball and 3000-kg load. The tensile tests were carried out using an electrically powered Hounsfield tensometer with a capacity of 20 KN. Impact energy to failure was found using a Charpy impact tester.

III. Results and Discussions

Table 4 shows the mechanical properties of the as–received and heat treated steel samples with the three quenchants. Figures 1-4 are plots of variations of mechanical properties when different quenchants are used. Figure 1 shows the variation of hardness for the four EN steels when the quenchant is changed from water to oil and then polymer. It is observed that the maximum hardness value of 362 BHN is obtained in EN 25 with water quenching in general, water quenching has the maximum impact on hardness followed by oil quenching and polymer quenching as the least defect [10-12]. However, in case of EN 19 polymer quenching resulted in highest hardness of 286 BHN. Figure 2 depicts the defect of varying the quenchant on the UTS of EN steels. The variation of the UTS generally follows the same behaviour as the variation of hardness. It is observed that once again the highest UTS value is obtained in water quenched EN 25 steel (1280 MPa) which is more than twice the value (580 MPa) for the as received steel. Figure 3 depicts the change of impact energy of the four EN steels considered. Once again it is evident that step tempering after quenching for hardening has improved impact energy of steels except in case of water quenching of EN18 and EN19. This may appear as in congruent with Figure 4 where the percentage of elongation of the forged steels is highest in the as received condition in the lower in the heat treated conditions (except for oil quenching).

The explanation for higher impact energy (and therefore higher toughness) of the heat treated steels lies in 20-50% increase strength values while the elongation is reduced by maximum 20% only.
microscopic examination, and the general procedure followed by earlier investigators was employed. The samples were polished using a series of emery papers of grit size varying from 1000 μm to 1500 μm. The samples were etched with nital solution, 100 mL ethanol and 1-10 mL nitric acid for about 10-20 seconds before observation in the optical microscope.

The mechanical properties of microalloyed steels result, however, from more than just the mere presence of microalloying elements. Austenite conditioning, which depends on the complex effects of alloy design and rolling techniques, is also an important factor in the grain refinement of hot-rolled steels. Grain refinement by austenite conditioning with controlled rolling methods has resulted in improved toughness and high yield strengths in the range of 345 to 620 MPa (50 to 90 ksi).

IV. Conclusion

It has been established that polymer can also be used as a quenching medium for MCLA forged steels. The study has shown that using of water, oil and polymer as quenchants improves the mechanical properties when compared to the untreated steels. Air quenching improves the ductility of the steel because of its lower and uniform cooling rate compared with water and oil; also there is lesser risk of cracking and distortion in the parts. The uniform low cooling rates also result in better mechanical properties for the polymer quenched steels. Microstructural analysis corroborates the changes in mechanical properties observed.

V. References

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