INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

ISSN (ONLINE): 2321-3051

Vol.3 Issue 11,

November 2015

Pgs: 91-99

A REVIEW ON EFFECT OF HEAT TREATMENT ON STEEL

Devnath khunte[1], Gopal Sahu[2], Prakash Kumar Sen[3], Ritesh Sharma[4], Shailendra Bohidar[5]

[1]*Student, Mechanical Engineering, Kirodimal Institute of Technology, Raigarh (C.G.)*

[2,3,4,5]*Lecturer, Mechanical Engineering, Kirodimal Institute of Technology, Raigarh (C.G.)*

Abstract

In this paper, Author studies about the mechanical properties like Tensile strength, yield stress and elongation for different steels such as low carbon steel and stai nless steel an various heat treatment like d find out the effect of annealing, quenching and normalizing on material properties through testing on using Universal Testing Machine UTM.Effect of various types of heat treatment on fracture toughness and hardness is also analyzed.Optimum heat treatment strategy for commercial steel appears to be tempering in the 900ºC temperature range, to get the best combination of high toughness and high hardness.After that heat treated samples are used for testing of differen t material properties. Result shows which heat treatment will be better for improving material properties of mild steel and stainless steel.

Keywords: stainless steel, tensile strength, yield stress, toughness, hardness.

1. Introduction

Steel is an alloy of iron with definite percentage of carbon ranges from 0.15-1.5%, plain carbon steels are those containing 0.1-0.25%. There are two main reasons for the popular use of steel: It is abundant in the earth's crust in form of Fe2O3 and little energy is required to convert it to Fe.Steels are normally hardened and tempered to improve their mechanical properties, particularly their strength and wear resistance. Although the number of steel specifications runs into thousands, plain carbon steel accounts for more than 90% of the total steel output. The reason for its importance is that it is a tough, ductile and cheap material with reasonable casting, working and machining properties, which is also amenable to simple heat treatments to produce a wide range of properties [1] The current paper describes standard heat treatment practices followed in the industry for hot-work tool steels, and their effect on toughness and hardness. AISI H13 (DIN 1.2344) steel is widely used to make both hot and cold forming dies. Its popularity depends on its high hot hardness (resistance to thermal fatigue cracking) and high toughness. An exhaustive survey has been conducted to pool together information about mechanical properties of H13 steels, both from published literature and from tool steel manufacturers. A number of in-house experiments have also been conducted to supplement and corroborate the published data. Tool steel samples have been subjected to different heat treatment routines, and tested for relevant mechanical properties. Various graphs have been plotted to show the variation of mechanical properties, and the variation patterns have been analyzed. [2]

2. Material specification

Selection of steel types and grades and appropriate heat treatment methods are very important to produce components of reliable quality. The control of a given alloy's chemical composition and the inclusion content of steel have an impact upon and can create variance in an alloy's properties. Other contributing factors impacting the quality and reliability of final components include refining, casting, rolling and cooling methods. Further, strength, toughness, fatigue strength and wear properties result largely from the microstructure and hardness results created by heat treatment condition and methods applied. As a result, it is quite important to be cognizant of these factors and to ensure that appropriate methods are applied[4]Standard heat treatment procedures were adapted to heat treat the medium carbon steel. Five different samples were prepared for each of the operation and the average values were calculated based on the analysis was made. [3] We purchased the First steel samples from local steel trader. The sample was Mild steel rod Grade Fe 415D (IS 1786:2008). It is one of the Indian standard specifications of the mild steel or soft steel. The second material purchased from market was stainless steel rod SS 304. This steel contains nickel and chromium with iron and carbon. It is rust proof and has high hardness with moderate ductility. We can say that it is basically an austenitic matrix. The materials have following properties [1].

Table1Chemical composition of steels

Steel designation	C	MN	Si	S	p	Cr	Ni	Fe
Mild steal Fe 415D	0.23	0.60	0.30	0.040	0.040	-	-	Rest
SS 304	0.08	2	1	0.03	0.045	18	8	Rest

Table 2 Mechanical material properties of raw

S .No.	Material	Density (×1000 kg/m^3)	Poission Ratio	Elastic modulus (GPa)	Tensile strength (MPa)	Yield Strength (MPa)
1.	Mild steel rod (Fe 415 D,IS 1786:2008)	7.7-8.03	0.27-0.30	190-210	400-550	300-450
2.	Stainless steel rod (SS304)	8.03	0.27-0.30	190-210	500-827	207-552

3. Specimen preparation

The first and foremost job for the experiment is the specimen preparation. The specimen size should be compatible to the machine specifications: We got the sample from mild steel trader. The sample that we got was Mild steel. AISI8620:It is one of the American standard specifications of the mild steel having the paralytic matrix (up to70%) with relatively less amount of ferrite (30-40%). And so it has high hardness with moderate ductility and high strength as specified below. So we can also say that it is basically a paralytic/ferrite matrix.[5]

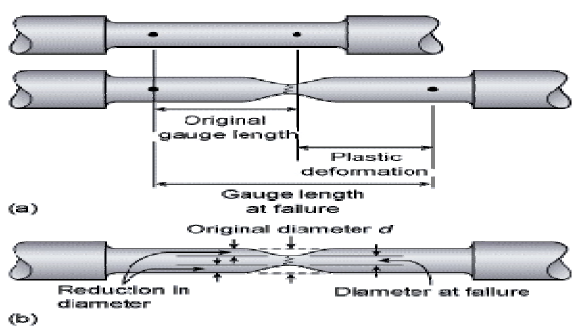


Figure1. Testing specimen

4. Heat Treatment

Treatment and surface modification technologies are utilized to optimize properties of virtually all types of metallic components with durability featuring prominently in a great number of applications. Beginning with raw metal products leading all the way to final component assembly, various types of heat treatment and surface engineering processes are applied in the manufacture of automotive components. Heat treatment processes impart the required strength or hardness properties as dictated by the given component application. Other processes involved in metal processing may include forming, machining as well as quench and tempering, carburizing and hardening and nitriding during production. Surface modification, when properly applied, yields optimum surface properties enhancing corrosion and wear resistance while improving frictional properties.[4]

5. Annealing

a) The specimen was heated to a temperature of 900 deg Celsius.

b) At 900 deg Celsius the specimen was held for 2 hour.

c) Then the furnace was switched off so that the specimen temperature will decrease with the same rate as that of the furnace.

The objective of keeping the specimen at 900 deg Celsius for 2 hrs is to homogenize the specimen. The temperature 900 deg Celsius lies above Ac1 temperature. So that the specimen at that temperature gets sufficient time to get properly homogenized .The specimen was taken out of the furnace after 2 days when the furnace temperature had already reached the room temperature

Figure2. Electric muffle furnace

6. Normalizing

a) At the very beginning the specimen was heated to the temperature of 900 deg Celsius. b) There the specimen was kept for 2 hour. c) Then the furnace was switched off and the specimen was taken out. d) Now the specimen is allowed to cool in the ordinary environment. i.e. the specimen is air cooled to room temperature. The process of air cooling of specimen heated above Ac1 is called normalizing [5]

7. Quenching

The specimen was heated to the temp of around 900 deg Celsius and was allowed to homogenize at that temp for 2 hour. An water/oil bath was maintained at a constant temperature in which the specimen had to be put. After 2 hour the specimen was taken out of the furnace and directly quenched in the bath. After around half an hour the specimen was taken out of the bath and cleaned properly. Now the specimen attains the liquid bath temp within few minutes. But the rate of cooling is very fast because the liquid doesn't release heat readily [1]

8. Hardening Process

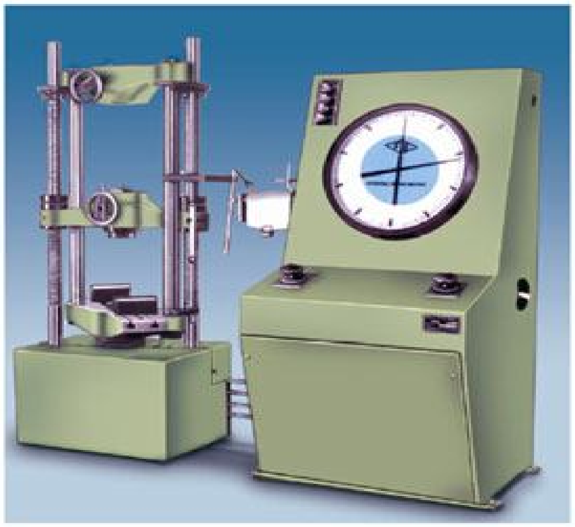
The specimens to be hardened were placed inside the furnace and heated to a temperature of 9000C. The samples were retained at this temperature for a period of one hour (because of its mass) during which the transformation must have been completed. The hardening operation was carried out on five medium carbon steel samples having the same dimensions.

9. Tempering Process

Tempering, consists of reheating quenched steel to a suitable temperature below the transformation temperature for an appropriate time and cooling back to room temperature. This process allows microstructure modifications to reduce the hardness to the desired level while increasing the ductility. Tempering results in a desired combination of hardness, ductility, toughness, strength and structural stability. The desired properties and structures depend on tempering temperature and time .The tempering of the quenched specimens was also carried out in a muffle furnace for one hour. Experimental heat treatment cycles for selective alloy is hardening and followed by tempering are done at 2500C increased by 1000C to 5500C for each tempering time interval(3)

10. Testing of Specimen on UTM

Tensile testing, also known as tension testing, is a fundamental materials science test in which a sample is subjected to a controlled tension until failure. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and yield strength. Uniaxial tensile testing is the most commonly used for obtaining the mechanical characteristics of isotropic materials. For anisotropic materials, such as composite materials and textiles, biaxial tensile testing is re**qui**red [1]



.

Figure3. Universal testing machine

11. Discussion

From the various experiments carried out following observations and inferences were made. It was seen that the various tensile properties followed a particular sequence [5]

1. Tensile strength of mild steel for Normalizing heat treated specimen is larger than other heat treated or without heat treated specimens. Tensile strength for stainless steel specimen is more in without heat treated than heat treated specimen.
2. Tensile strength of mild steel for Normalizing heat treated specimen is larger than other heat treated or without heat treated specimens. Tensile strength for stainless steel specimen is more in without heat treated than heat treated specimen
3. Elongation in Tensile test of mild steel for Normalizing heat treated specimen is larger than other heat treated or without heat treated specimens. Elongation in Tensile test for stainless steel specimen is more in normalizing heat treated specimen is larger than other heat treated without heat treated(1)
4. More is the tempering temperature, less is the hardness or more is the softness (ductility) induced in the quenched specimen. (Ductility) induced in the quenched specimen (5)

Result

Normalizing heat treated specimen of mild steel tensile strength is increases and stainless steel is decreases. Elongation in both mild & stainless is larger in normaling heat treatment.

Figure.4 Results of Tensile strength

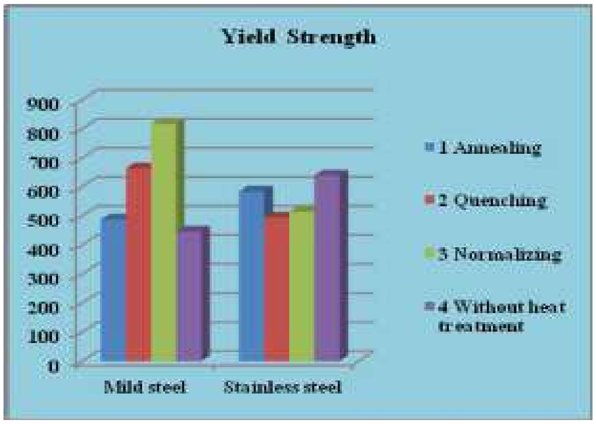


Figure.5 Results of Yield strength

Conclusion

From the various results obtained during the project work it can be concluded that the mechanical properties vary depending upon the various heat treatment processes. Hence depending upon the properties and applications required we should go for a suitable heat treatment processes. The optimum heat treatment for the tested maraging stainless steel is at

1050 C for 1 h at 70 C for 8h at 535 C for 4 h. By this treatment, the yield stress of the steel could reach1774 MPa and 1932 MPa. In the holding temperature range of 850 to 1150C, increasing holding time could result in slight increase in prior austenite grain size until at 1050 C for 1 h. Whereas, abnormal grain growth was seen at 1050 C for 3 h or longer holding time hardness of steel increases with austenitizing temperature and the lowest and highest hardness were obtained at 970oC and 1000oC respectively. The hardness of the steel decreases with increase of tempering temperature.

The tempered samples gave an increase in tensile strength and hardness than untreated samples. Comparing the mechanical properties of tempering sample with hardened sample, it was found that there was decrease in toughness and percentage of elongation. The quench and subsequent tempering of the steel in the temperature range 2500C to 5500C resulted in a corresponding decrease in tensile strength. In the above tempering temperature range, toughness of the steel gradually increased with increase in temperature. The result for yield strength receives more value at 3500C compared to the corresponding tempering temperature. The percentage of elongation is received at lower value in 4500C compared to the other tempering temperature.

References

1. American International Journal of Research in Science, Technology, Engineering & Mathematics ISSN (Print): 2328-3491, ISSN (Online): 2328-3580, ISSN (CD-ROM): 2328-3629 Effect of Various Heat Treatment Processes on Mechanical Properties of Mild Steel and Stainless Steel.

2. International Scientific Journal published monthly as the organ of the Committee of Materials Science of the Polish Academy of Sciences Volume 28 Issue 8 August 2007 Pages 503-508 Heat treatment of a hot-work die steel.

3. International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 4, April 2013 Effect of Tempering Behavior on Heat Treated Medium Carbon (C 35 Mn 75) Steel.

4. Trans. Indian Inst. Met. Vol.57, No. 4, August 2004, pp. 381-396 heat treatment of automotive components: current status and future trends.

5. Department of Mechanical Engineering National Institute of Technology Rourkela-769008 heat treatment of low carbon steel.