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TO STUDY EFFECT OF DIFFERENT HEAT TREATMENT PARAMETERS ON MECHANICAL PROPERTIES OF SHAFT AND SQUARE SHAPE STEEL SAMPLE: A COMPARATIVE STUDY

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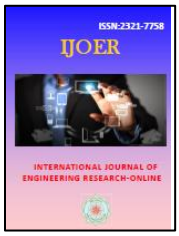

ABSTRACT
In this work we have analyzed the effect heat treatment on properties of two different shape steel specimens under various heat treatment processes. Specimens were subjected to heat treatment in electric muffle furnace. Heat treatment temperature, soaking time and cooling rate were selected as per phase diagram of specimen material. Specimens were tested for mechanical properties before and after heat treatment. Two processes annealing and normalizing compared with respect to their effect on properties of two different shape specimens.
Keywords: Heating, Cooling, Steel, metal parts, soaking.

Introduction

Heat treatment is a group of industrial and metalworking processes used to alter the physical, and sometimes chemical, properties of a material. The most common application is metallurgical.[1-15] Heat treatments are also used in the manufacture of many other materials, such as glass. In the other words heat treatment is an operation or combination of operations involving heating at a specific rate, soaking at a temperature for a period of time and cooling at some specified rate.[16-30] Selection of suitable metal or alloy is key requirement in manufacturing industry. Shaft structures are most likely used as a part in different engineering processes, from machining to automobiles. Selection of suitable shaft material properties requires study of various parameters during production. Heat treatment is most commonly used to alter some property in production industry. Keeping all in view the present work was planned with following objectives:

- To study mechanical properties of shaft & square specimen before heat treatment.
- To analyze effect of heat treatment on mechanical properties of sample specimens under different heat treatment processes.
- To characterize specimen for analysis of mechanical behavior under heat treatment operation.
- To compare mechanical behavior under different heat treatment parameters before and after heat treatment.

Materials and Methods

Material: Work plan for present study is to compare the mechanical properties of two alloys (Having comparable properties) with different shape specimen i.e. Low alloy steel rod and Mild steel specimens of square shape (Purchased from local market) before & after heat treatment. Dimensions of square shape specimen were 4.9 cm x 4.9 cm and

thickness 0.7 cm. Dimensions of shaft were Dia. x length = 16 mm x 140 mm, with ultimate tensile strength 950 MPa and yield tensile strength 670 MPa , elongation 15 %, yield stress (0.2%) = 672 MPa, Hardness (Rockwell)= 32 HRC.

Figure 1: Shaft and square specimens before heat treatment.

Heat Treatment Process: In present wok specimens were analyzed before and after heat treatment (HT), to observe changes in mechanical properties after heat treatment. Here two HT operations namely annealing and normalizing were performed and data obtain is compared to conclude effect of heat treatment on mechanical properties.

Heat treatment was performed in Electrical Muffle furnace at the predetermined temperature range as per sample material phase diagram & process parameters.

Figure 2 : Samples after heat treatment.

RESULTS & DISCUSSIONS

HARDNESS MEASUREMENT-: Samples were prepared for hardness testing. Hardness test was performed before and after heat treatment for both specimens. Rockwell hardness Tester in HRC mode is used for hardness measurement with a load of 150 Kg.

Indenter Used = Diamond Cone

Load Applied = 150 Kg

In case of annealing both samples show some decrease in hardness after HT, as expected. Normalizing process results in increase in hardness for both samples. Phase change in the alloy with formation of martensite (it contributes to hardness of material), results in improvement in hardness after HT.

Additionally results show that increase in hardness after normalizing is more for square shape sample than in case of shaft sample. This can be attributed to percentage of carbon in the iron alloy which is another factor that decides, how much of improvement will be there in hardness after heat treatment. [31-32]

Table 1 : Hardness test data before and after HT for both samples.

SPECIMEN	LOAD APPLIED (Kg)	TOUCH POINT HARDNESS (HRC)	HARDNESS (HRC)*		
			Before HT	After HT (Annealing)	After HT (Normalizing)
Square Specimen	150	255	49	47	56
Shaft shape specimen	150	255	31	28	34

*Average value of three points on specimen.

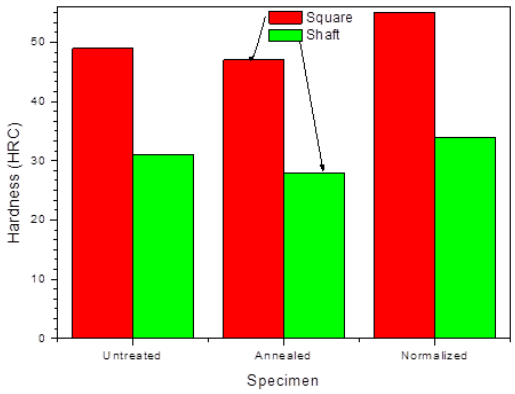

Figure 3 : Plot showing variation of hardness with heat treatment process.

Toughness/ Impact Strength: Results shows that in square sample there is variation in toughness in both normalizing and annealing. Annealing results in increase in toughness while normalizing decreases it for both square and shaft specimen. Decrease in toughness after normalizing found to be more in case of square specimen (mild steel) than for shaft (low alloy) , which further related to amount of

carbon content and variation in hardness after heat treatment.

Additionally, toughness requires a reasonable value of ductility in the material, so that material delays fracture or we can say material deform first before facing fracture. As material lost hardness, it retains some amount of toughness. In case of annealing operation there is decrease in hardness, which on the one hand give indication that amount of energy absorbed before fracture will increase, on other hand it requires strength so that to withstand applied load or to resist fracture. Similar theory applicable for normalizing operation. Charpy test technique used in present work. [31, 32]

Table 2 : Toughness test data for both samples.

SPECIMEN/ HT OPERATION	Toughness (Joules)		
	Before HT	After HT (Annealing)	After HT (Normalizing)
Square Specimen	38	40	33
Shaft shape specimen	56	58	53

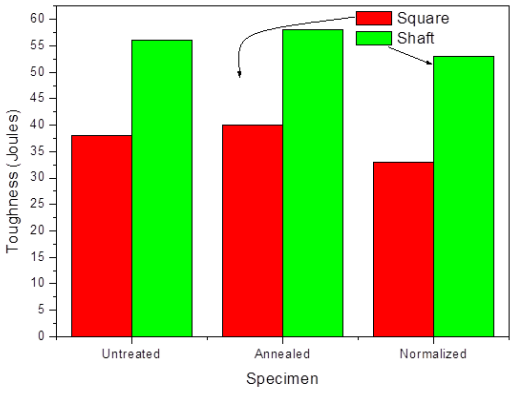

Figure 4 : Plot showing variation of toughness with heat treatment process.

CONCLUSIONS

Comparative study of all characterizations data and various parameters involved in heat treatment, we conclude that annealing and normalizing have significant and different effect on the properties of alloys. Additionally type of alloy and its composition is key factor which decides outcomes of heat treatment, rather than shape of the component in production process. Following conclusions have been drawn:

1. Both annealing and normalizing have significant effect on mechanical properties of both sample structures.
2. Annealing reduces hardness with destruction of cementite/pearlite networks during phase transformation by heat treatment. Normalizing results in formation of martensite, cementites and hence improves hardness.
3. Toughness data shows that hardness is inversely proportional to the toughness in both annealing and normalizing process, which is in agreement with theory.
4. Further, increase in hardness after normalizing is more for square shape sample than in case of shaft sample which supports role of carbon content during heat treatment process.

After all heating rate, phase transformation, specimen condition, soaking rate also contributes towards variation in properties of specimen after heat treatment.

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