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TO STUDY CHANGE IN MECHANICAL PROPERTIES OF TWO DIFFERENT METAL PARTS BEFORE AND AFTER HEAT TREATMENT PROCESS

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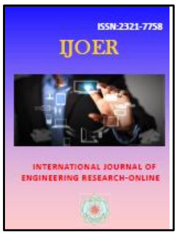

ABSTRACT

The work have been planned to analyze the effect heat treatment on properties of two different shape steel specimens under different heat treatment processes. Heat treatment temperature, soaking time and cooling rate were selected as per phase diagram of specimen material. Mechanical properties of steel specimens were tested and compared before & after heat treatment. Different heat treatment parameters compared with respect to their effect on properties of specimens in reference with effect of shape or we can say fabrication process to obtain any shape.
Keywords: heating, steel, soaking, furnace heating.

1. Introduction

Heat treatment is industrial process often used to alter properties of metal/alloy parts during fabrication process.[1-15] It is heating of metal to some pre-defined temperature and cooling at some rate (which is heat treatment process specific value).[10-22] Selection of suitable metal or alloy is key requirement in manufacturing industry. Selection of suitable machine part and hence mechanical properties requires study of various parameters during production operations. [23-32] 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 & spring specimen before heat treatment.
- To analyze effect of heat treatment on mechanical properties of sample specimen 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.

2. Materials and methods:

Material: Present study is aim to compare the mechanical properties of two different shape specimen fabricated from two alloys with comparable properties i.e. Low alloy steel rod (Shaft structure) and Mild steel rod for spring structure (Purchased from local market). Mild steel rod was converted to spring specimen with conventional method of preparing metal rod rings in workshop (turn around mandrel in desired dimensions). [30]

Heat Treatment Process: Two different Heat treatment 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

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predetermined temperature range as per sample material phase diagram & process parameters.

Figure 1 : Shaft and spring specimens before heat treatment.

Figure 2: Samples after heat treatment.

3. 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. Further effect of dislocations/defects in material as a result of fabrication mechanism are clearly indicated by amount of hardness recovered after normalizing (more in case of shaft sample , as spring is acted upon by bending forces). In addition to these defects amount of carbon percentage in alloy also play important role in variation of hardness for specimen.

Table 1: Hardness testing Data**.**

SPECIMEN	LOAD APPLIED (Kg)	TOUCH POINT HARDNESS (HRC)	HARDNESS (HRC)*		
			Before HT	After HT (Annealing)	After HT (Normalizing)
Spring shape specimen	150	255	47	46	51
Shaft shape specimen	150	255	31	30	36

*Average value of three points on specimen.

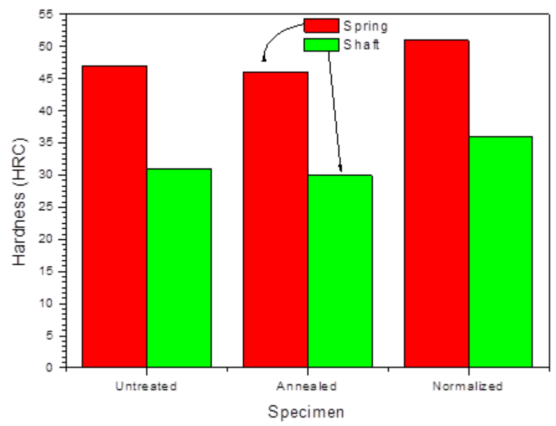

Figure 3: Plot showing variation of hardness with heat treatment process.

Toughness/ Impact Strength: Both normalizing and annealing have significant effect on toughness. Annealing results in increase in toughness while normalizing decreases it, results indicate similar behavior for both specimens. Again effect of fabrication defects and composition of alloy reflects in observed values of toughness after HT.

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.

Table 2: Toughness test data (Before & after HT)

SPECIMEN/ HT OPERATION	Toughness (Joules)		
	Before HT	After HT (Annealing)	After HT (Normalizing)
Spring shape specimen	40	41	37
Shaft shape specimen	56	58	52

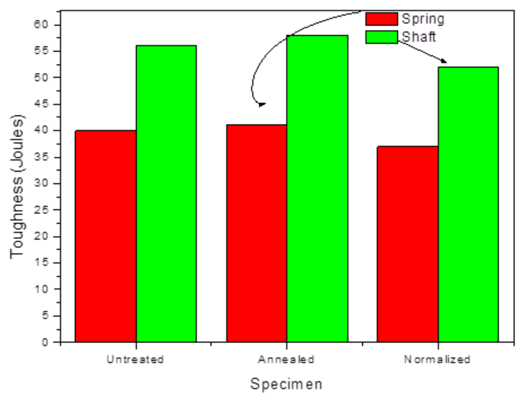

Figure 4: Plot showing variation of toughness with heat treatment process.

Conclusions:

Comparative analysis of results obtained from mechanical behavior before and after heat treatment, we conclude that annealing and normalizing have different effect on the mechanical properties of alloys. Additionally type of alloy, its composition and alloy part production method are key factors which decides outcomes of heat treatment.

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 shaft shape sample than in case of spring sample which at first indicates effect of carbon content in alloy during heat treatment process and in addition effect of alloy part fabrication method (Bending defects in this case).

5. Similar behavior observed for toughness of specimens after HT.

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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