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TO STUDY MECHANICAL PROPERTIES OF SPRING LIKE SPECIMEN BEFORE AND AFTER DIFFERENT HEAT TREATMENT OPERATIONS

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Abstract:
In this work we have analyzed the effect heat treatment on properties of spring shape steel specimens under various heat treatment processes. Specimen was 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. Specimen was tested for mechanical properties before and after heat treatment. Two processes annealing and normalizing compared with respect to their effect on properties of spring shape specimens in reference with standard data for steel used.

Keywords: Steel; Heat Treatment; Soaking; Cooling; Strength; Hardness.

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1. Introduction

Heat treatment is process widely used alter the physical and chemical properties of a material as per requirement. [1-19] Heat treatment is used to change mechanical properties such as hardness, elasticity, toughness, ductility, plasticity, strength, malleability. Heat treatment can involve the heating of a material and then chilling. In case of heat treatment annealing, quenching, tempering, case hardening, carburizing. [20-25] Present work was planned to study heat treatment process, in reference to their effect on properties of metal components used in various engineering application. The main objectives of this work are:

- To study various heat treatment processes.
- To study properties of spring shape specimen.
- To analyze effect of heat treatment on mechanical properties of spring shape specimen.
- To compare mechanical behavior before and after heat treatment.

2. Materials and Methods

Composition & properties of materials used and various Methods applied in present work are as follows:-

Mild steel rod: Mild steel rod (Purchased from local market) was used to prepare specimen for present investigation. Rod was converted to spring specimen with conventional method of preparing metal rod rings in workshop (turn around mandrel in desired dimensions) [26-30]

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Figure 1: Mild Steel Spring Specimens.

Figure 2: specimen after heat treatment

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3. Results and Discussions

Hardness Measurement-: Samples were prepared for hardness testing. Hardness test was performed before and after heat treatment. 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

Table 3.4: Hardness data (Before & After HT)

Specimen/Ht Operation	Load Applied (Kg)	Touch Point Hardness (Hrc)	Hardness (Hrc)	
			Before HT	**After HT**
Specimen 1(Annealing)	150	240	Experiment 1 = 46	Experiment 1 = 44
			Experiment 2 = 46	Experiment 2 = 43
			Experiment 3 = 47	Experiment 3 = 43
			Average ~= 46	Average ~= 43
Specimen 2(Normalizing)	150	240	Experiment 1 = 48	Experiment 1 = 51
			Experiment 2 = 47	Experiment 2 = 51
			Experiment 3 = 47	Experiment 3 = 52
			Average ~= 48	Average~= 51

Touch point hardness-: It refers to hardness when indenter just touches the surface of specimen, before actually pressing it.

Annealing which differs from normalizing in terms of cooling rate, temperature range, holding or cooling mechanism. Here first step is to heat sample at slow rate to critical temperature range and then cooling is performed inside the furnace at specific rate. HT treatment not always bring out increase in hardness, additionally in case of annealing there is decease in hardness, which can be because, annealing is implemented in materials which undergone cold working, casting or quenching during fabrication, further metal/alloy becomes softer after annealing, which can be attributed to phase change due to slow heating and cooling rate that offers enough time for formation of phase with reduced hardness which is favorable for machining of material. [30-33]

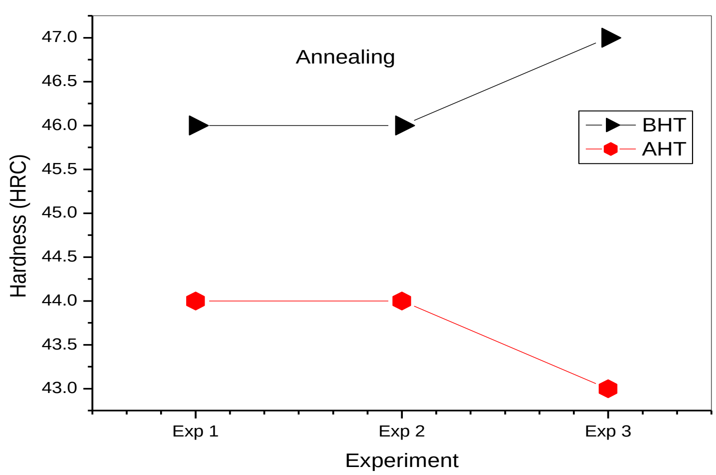

Figure 3: Plot of variation in hardness before and after heat treatment (Annealing).

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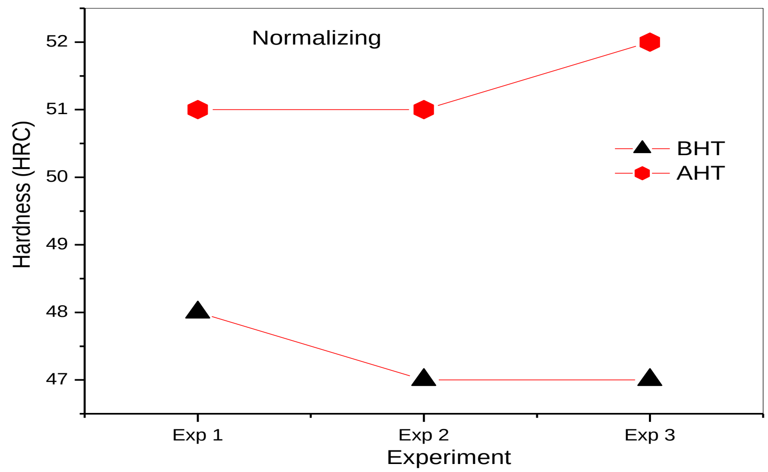

Figure 4: Plot of variation in hardness before and after heat treatment (Normalizing).

Tensile Test: Here characteristics of results obtained for "Extension" of specimen, for two different HT processes can be related to value of hardness for respective samples. Increase in hardness results in decrease in ductility and vice versa. Additionally as ductility decreases, extension also decreases. Hence when normalizing operation performed, hardness increase after HT which decreases ductility and finally decrease in extension. Similar theory applicable for specimen undergoes annealing operation. Our results are in agreement with theory. [30-37]

Table 1: Extension characteristics (Before & After HT)

SPECIMEN/HT OPERATION	**Load (Kg)**	**Extension (cm) BHT**	**Extension (cm) AHT**
Specimen 1(Annealing)	5	0.5	0.6
	10	1.1	1.3
	15	1.6	2.0
	20	2.0	2.4
Specimen 2(Normalizing)	5	0.5	0.4
	10	1.0	0.8
	15	1.5	1.2
	20	2.0	1.7

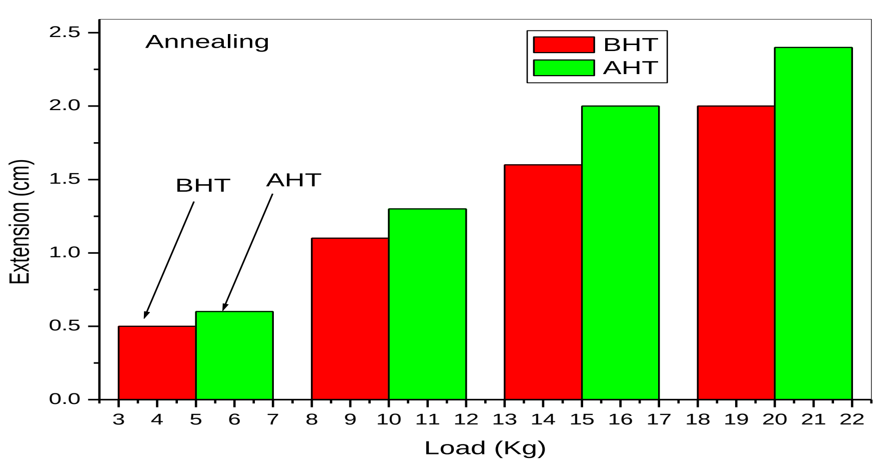

Figure 5: Plot of variation in extension with load (Annealing, Before & After HT)

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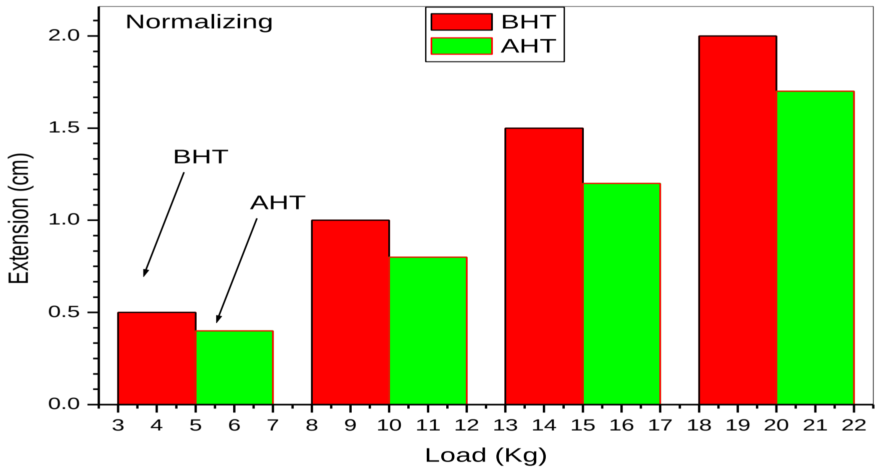
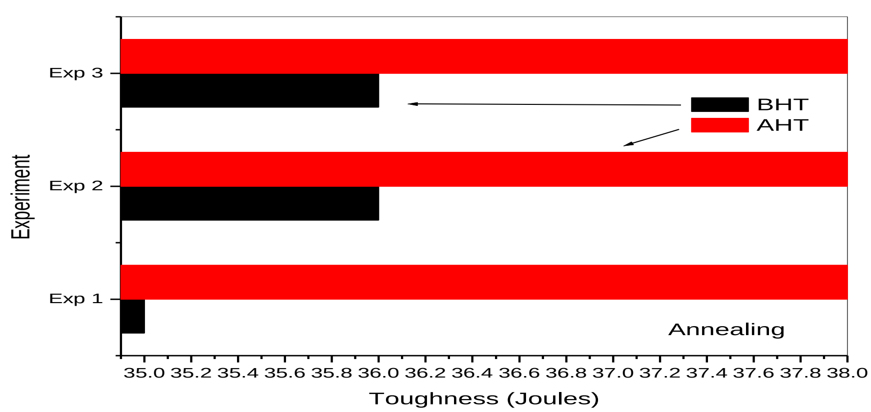


Figure 6: Plot of variation in extension with load (Normalizing, Before & After HT)

Toughness/ Impact Strength: 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 data (Before & After HT)

SPECIMEN/ HT OPERATION	**Toughness (Joules)**	
	Before HT	**After HT**
Specimen 1(Annealing)	Experiment 1 = 35	Experiment 1 = 38
	Experiment 2 = 36	Experiment 2 = 38
	Experiment 3 = 36	Experiment 3 = 38
	Average ~= 36	Average ~= 38
Specimen 2(Normalizing)	Experiment 1 = 36	Experiment 1 = 33
	Experiment 2 = 36	Experiment 2 = 32
	Experiment 3 = 37	Experiment 3 = 32
	Average ~= 37	Average~= 32



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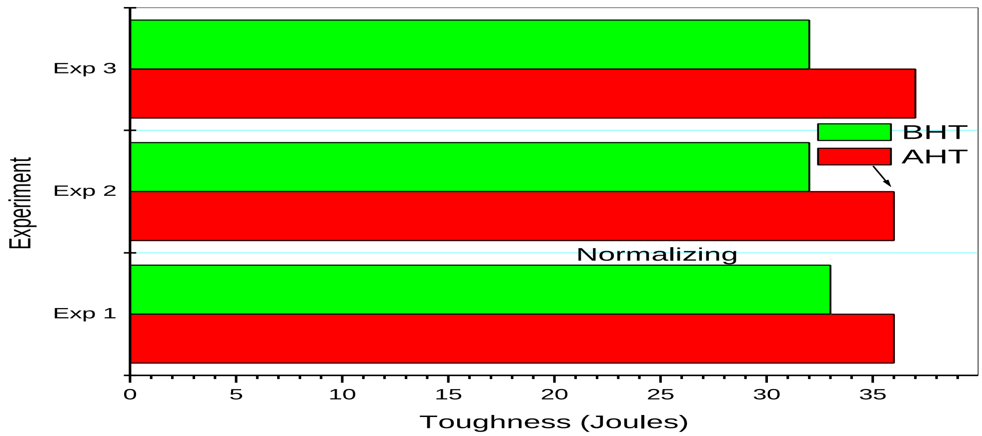

Figure 7: Plot of variation in toughness with heat treatment parameters (Annealing & Normalizing, Before & After HT)

4. Conclusions

From all the characterizations and study of various parameters involved in heat treatment, we conclude that annealing and normalizing have significant and different effect on the properties of alloys. Following conclusions have been drawn:

1) Heat treatment of spring shape mild steel specimen results in variation in mechanical properties to a significant amount.
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) Annealing increase extension characteristic of spring structure while Normalizing results in decrease in extension.
4) Annealing increases toughness in spring structure, whereas normalizing result in decrease in toughness.

Annealing and normalizing differs in terms of heating rate, soaking time & cooling rate which effects the overall phase transformation and hence properties of material after heat treatment.

Here one cannot mention which HT operation brings improvement in properties, as both processes and their experimental data have their own significance. Annealing provides better machinability and normalizing favors strength oriented applications of material in production field.

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