Optimization of Hardening Process in Furnace through Taguchi Method

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Abstract— Heat treatment is the process of control heating and cooling of material to achieve certain mechanical property such as hardness strength, and reduction of residual stresses. Many heat treating processes require the precise control temperature over the heating cycle the research methodology based on the experimental work and the theoretical development of heat treatment furnace the new model take into account the real time furnace parameters determined from the experimental data account for the furnace detoriation and some of complex gradient and heating pattern that exist the furnace that is difficult model. Investigation carried out to study increasing hardness mechanical property of mild steel. Sample examined after heating at a certain respective temperature and soaked for respective time and respective behavior on sampled investigated. Using Rockwell hardness method of hardness testing. Results show that hardness of cast iron improved by heat treatment for particular application & optimization of hardness using taguchi method done in this article.

Key words: Heat treatment, Hardness, flowchart, Taguchi introduction, taguchi analysis, testing, result

I. INTRODUCTION

Heat treatment is a control process of heating and cooling of cooling of metals to alter there mechanical and physical properties without changing the product shape. The heat treatment process is defined as heating a metal at various temperature holding the for a various time duration and cooling at various rates, it helps to improve the machining, hardness, strength over a heating cycle.

The purpose of various heat treatment processes are as follows:

- To soften the material
- To improve machinability
- To improve cutting properties of tool
- To increase strength and hardness of material
- To improve various properties i.e. corrosion, resistance and heat resistance

Annealing, normalizing, hardening and tempering are the most important heat treatment processes lead to change in phase microstructure and desired mechanical properties in material.

The hardening treatment for most steels consists of heating the steel to a set temperature and then cooling it rapidly by plunging it into oil, water, or brine. Most steels require rapid cooling (quenching) for hardening but a few can be air-cooled with the same results. Hardening increases the hardness and strength of the steel, but makes it less ductile. Generally, the harder the steel, the more brittle it becomes. To remove some of the brittleness, you should temper the steel after hardening. Many nonferrous metals can be hardened and their strength increased by controlled heating and rapid cooling. In this case, the process is called heat treatment, rather than hardening. To harden steel, we cool the metal rapidly after thoroughly soaking it at a temperature slightly above its upper critical point.
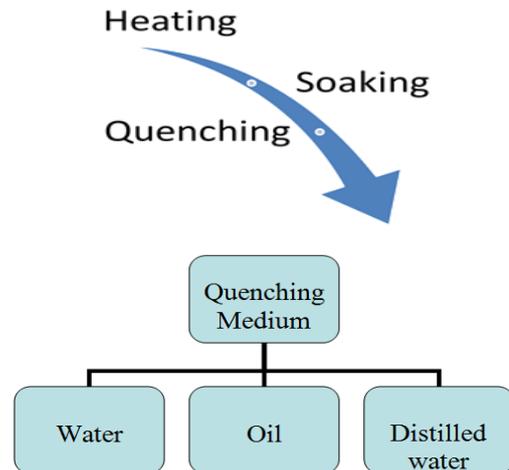
II. METHODOLOGY

Fig. 1: Methodology

First we remove the moisture which is present in the furnace. After that some samples of metals i.e., of mild steel are inserted into a furnace. Then we heat the metal samples at required experimental temperature i.e., 450^0c, 500^0c, 550^0c. Here the group of three metal samples heated at a time in furnace. And after the heating of a first group i.e., three samples of metal then soaking at a certain period of time i.e., 10min, 12min and 15min respectively. After soaking procedure we take off the samples from the furnace and immediately deep into the quenching medium for the purpose of cooling. In this heat treatment process we use three different quenching medium. These quenching mediums are water, oil and distilled water. The reason of using different quenching medium to understand how the hardness of same metal sample get changed. And finally after that we get the changed hardness values of metal samples.

III. TAGUCHI INTRODUCTION

The Taguchi method is a structured approach for determining the "best" combination of inputs to produce a product or service. Based on a Design of Experiments (DOE) methodology for determining parameter levels. Design of experiment is an important tool for designing processes and products. Traditional Design of Experiments focused on how different design factors affect the average result level.In Taguchi's DOE (robust design), variation is more interesting to study than the average.An experimental method to achieve product and process quality through designing in an insensitivity to noise based on statistical principles.A statistical / engineering methodology that aim at reducing the performance "variation" of a system. The input variables are divided into two board categories.

Control factor: the design parameters in product or process design.Noise factor: factors whoes values are hard-to-control during normal process or use conditions.To investigate how different parameters affect the mean and variance of a process performance characteristic. The Taguchi method is best used when there are an intermediate number of variables (3 to 50), few interactions between variables, and when only a few variables contribute significantly.

IV. STEPS INVOLVE IN TAGUCHI METHOD

The use of Taguchi's parameter design involves the following steps:-

1) Identify the main function and its side effects.
2) Identify the noise factors, testing condition and quality characteristics.
3) Identify the objective function to be optimized.
4) Identify the control factors and their levels.
5) Select a suitable Orthogonal Array and construct the Matrix.
6) Conduct the Matrix experiment.
7) Examine the data; predict the optimum control factor levels and its performance.
8) Conduct the verification experiment.

V. TAGUCHI DESIGN

In taguchi design we have mainly concentrate signal to noise ratio. We have considered three major parameters heating temperature, Heating time and soaking time. Here we have used a three level factorial design in taguchi method.

Factors	Level		
	1	2	3
Heating Time(min)	22	25	29
Heating Temperature(^{0}c)	450	500	550
Soaking Time(min)	10	12	15

Table 1: Three Level Factorial Design

Taking this parameters we have considered a three level factorial design in taguchi design of experiments. We have considered the formula of larger is better type of formulae in calculating signal to noise ratio. The formula that is used is depicted in below:-

$$S/N_L = -10 \log (1/n\sum_{i=1}^{n} 1/y_i^2)$$

Where, $\bar{y}$ = Average of observed data
n = Number of observations

The values are stored in the orthogonal array created with the help of design of experiments. The array is a example of how the array could be arranged. The array is shown below:-

	A	B	C
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Table 2: Array

The above example is filled with the experimental values and the values of the signal to noise ratios. The array here showed us the optimized value of different experiment conducted in different conditions. The table is shown:-

VI. ANALYSIS OF THE DATA

The data that is used in the above table is analysied and the result is that we get the optimin result in three ranks that are also shown in the given figure below. So we the optimize hardness is achieved at delta of 4.86. Thus if we want to get the best hardness in the furnace than we have to heat at the certain temperature only. The results are shown below :-
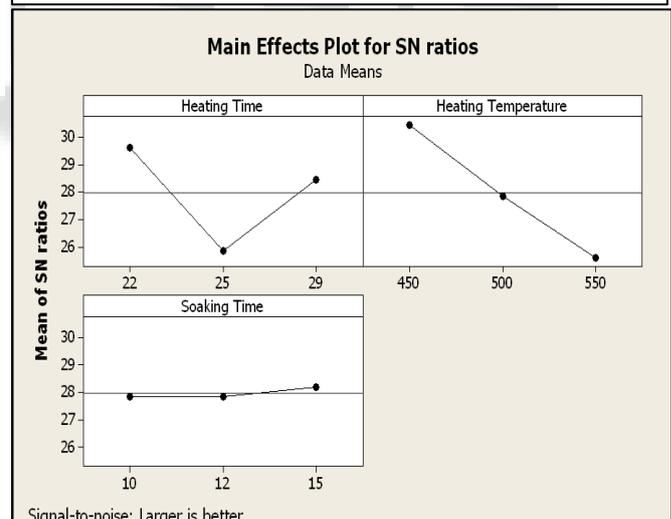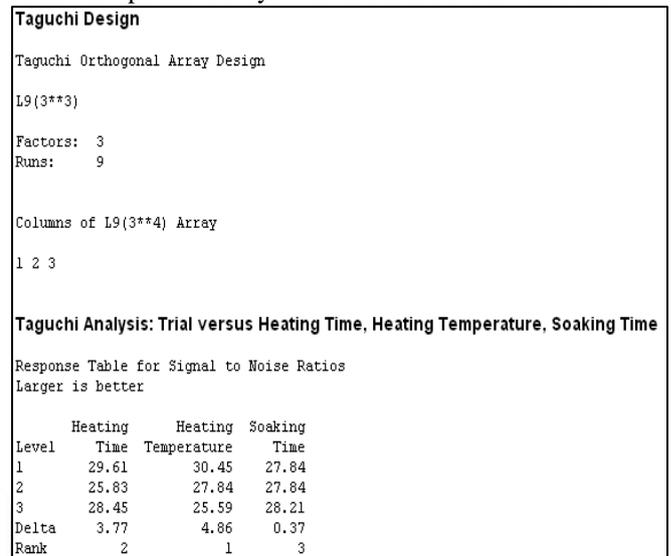
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Taguchi Design

Taguchi Orthogonal Array Design

L9(3**3)

Factors:  3
Runs:     9


Columns of L9(3**4) Array

1 2 3
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Taguchi Analysis: Trial versus Heating Time, Heating Temperature, Soaking Time

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Response Table for Signal to Noise Ratios
Larger is better

        Heating      Heating   Soaking
Level    Time    Temperature    Time
1       29.61       30.45      27.84
2       25.83       27.84      27.84
3       28.45       25.59      28.21
Delta    3.77        4.86       0.37
Rank       2           1          3
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Fig. 2: Analyzing of data

VII. RESULTS AND CONCLUSION

The heat treatment processes carried out here is the optimum way to achieve maximum hardness in the furnace and the final result in depicted in the form of the graph that is shown in below through which we can ensure the hardness of material M.S steel to be higher than the normal M.S material

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