HEAT TREATMENT PARAMETERS TO OPTIMIZE HARDNESS BEHAVIOR OF CARBON STEEL USING TAGUCHI TECHNIQUE

S.KRISHNAMOORTHI, D.DINESH, R.KARTHIKEYAN, G.MANIKANDAN

Abstract: ***There are so many engineering materials exists in this Universe. However, here we are discussing steel. We go through the different parameter, which is used in this experiment, for instance, heat treatment temperature. The selected material was medium carbon steel .the maximum temperature is around 1370 degrees so I selected the three levels of temperatures below the melting point i.e. 800, 900, 1000. The 800 degrees the heating time is 1hr, the 900degrees the heating time is 1.15hr, the 1000 degrees the heating time is 1.30hr. The hardness value is good at the 1000 degrees i.e. is 80 its coolant is salt water. The method was used in this process is the Taguchi method with the L9 array with 3 levels and 4 factors. The result and the calculated values are drawn by using the Minitab app in this app the ANOVA type is the general linear model. The percentage of variation i.e. Rsqu is between the 0-100percent. The good Rsqu values are 90-100%. I got a value of 95.06%. Therefore, the chosen process parameters are good. The two types of graphs are plotted i.e. mean of signal noise ratio and main effect plot for signal noise ratio, the next graph is mean of means and main effect plot for SN ratio.***

Keywords: heat treatment, melting point, temperature, hardness, taguchi methods, minitab, ANOVA, S/Nratio,Rsqu.

I. INTRODUCTION

The Heat treatment used to heating or chilling, the metals and to give the high temperatures, of the material. Carbon steel is steel with carbon content up to 2.1% by weight. The medium carbon steel has good weld ability, better machinability and low hardenability. The heated medium carbon steel is having lower ductility. In this paper the muffle furnace used to heat the materials. All our electric muffle furnaces feature rust and corrosion free stainless steel housing, compact and light weight construction and branded heating elements and programmable PID controller, ensure safe operation every time. Experiments can be designed in many different ways to collect this information.

Revised Manuscript Received on May 03, 2019.

S.KRISHNAMOORTHI[1], Assistant Professor, Department of Mechanical Engineering, Chennai Institute of Technology, Chennai, Tamil Nadu, India

D.DINESH[2],Assistant Professor, Department of Mechanical Engineering, Chennai Institute of Technology, Chennai, Tamil Nadu, India..

R.KARTHIKEYAN[3],Assistant Professor, Department of Mechanical Engineering, Chennai Institute of Technology, Chennai, Tamil Nadu, India.

G.MANIKANDAN[4],Assistant Professor, Department of Mechanical Engineering, Madha Institute of Engineering and Technology, Chennai, Tamil Nadu, India

Experimental design can be used at the point of greatest leverage to reduce design costs by speeding up the design process, reducing late engineering design changes, and reducing product material and labour complexity. Designed Experiments are also powerful tools to achieve manufacturing cost savings by minimizing process variation and reducing rework, scrap, and the need for inspection. This Toolbox module includes a general overview of Experimental Design to assist you in conducting designed experiments. Heat treatment process done in various stages after selecting the material. For removing internal stresses from material process done. Value of hardness and strength will increase after the experiment [1].Taguchi parametric design and optimization approach was used Minitab17 program to analyse the data find the optimal strength and hardness for improvement mechanical behaviour [3]. Taguchi's L9 orthogonal array has been chosen; nine experiments have been conducted and analysis is carried out using Signal to-noise ratio. [4]. I referred the above base journals and I got an idea to do the project in the improving hardness by varying the factors and parameters. The above journals are having the different temperature I used the different temperature i.e. 800, 900, 1000. The hardness is varying the increasing the temperatures highest hardness value is at the 1000 degrees of the cooling substance salt water. Reaching the room temperature is taking the very late time.

II. MATERIALS AND METHODS

b. MATERIALS:

Medium Carbon steel is a metal alloy. Medium carbon steel purchased at bharath steel at Gundy, Chennai, and tamilnadu. The size of materials is 30 cm length and 5cm dia of rounder metals. The nine samples are used in this paper. The carbon metal gains hardness and strength but becomes less ductile and more difficult to weld.

Fig.1.1.Image of Medium Carbon Steel

a. EXPERIMENTAL PROCEDURE:

The above table gives the information about the different temperatures and the heating time and the cooling substance. The heating of pieces done using a muffle furnace. The maximum temperature of using furnace is 1000 degrees. The maximum temperature of selected work piece i.e. medium carbon steel is 1370 degrees. From room temperature 27 degree to 800 degrees the heating time is 1hr after reaching the 800 degrees the work piece is cooled using three types of cooling substance. Water, salt water and oil. After the first process the next temperature is 900 degrees its heating time is 1.15hr. The next temperature is 1000 degrees for this temperature the heating time is 1.25hr.

Table1.1. The Tabulation of Heating Parameters

S.NO	TEMP DEGREE CELSIUS	HEATING TIME HOURS	COOLING SUBSTANCE
1	800	1	Water
2	900	1.15	Salt water
3	1000	1.25	oil

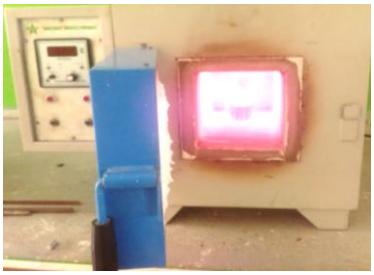

Fig.1.2. Image of Muffle Furnace

The heated piece is quenched by using the coolant. After the quenching the work piece the hardness is tested .The process is continued for the three types of temperatures .The depending on temperature the heating time and the quenching tine is vary. Among the three temperatures the hardness value may be increase or decrease .I got good hr. value at the 1000 degrees at oil quenching i.e. 80.the hardness process is tested by applying the load. The quenched piece is placed on the hardness machine the diamond tip touched the piece then applies the load. This is done at the three places of surface of the quenched piece.

c. TAGUCHI METHOD FOR DESIGN OF EXPERIMENT:

The DOE i.e. Design of Experiment can be done by using the mini tab software.in this software the procedure is open the app and click the stat option in that option go to DOE and click the DOE and select TAGYCHI option in the taguchi option go to the CREATE TAGUCHI DESIGN. Go to the create taguchi design option and design the experimental table in this option we can select the no of levels and no of factors .We using in this experiment L9 array. In this array we have the 3 level and the 4 factor.

Table.1.2.Experiment Layout of L9 Orthogonal Array

S.NO	TEMP	HEATING TIME	COOLING SUBSTANCE	HREC VALUE
1	800	1	WATER	62
2	800	1.15	SALT WATER	73
3	800	1.25	OIL	67
4	900	1	OIL	70
5	900	1.15	SALT WATER	64
6	900	1.25	WATER	75
7	1000	1	SALT WATER	80
8	1000	1.15	OIL	66
9	1000	1.25	WATER	58

After selecting the factors and levels then go to the display the available design option and select the L9 array and click on ok .after the selecting the array the next option is selecting the design After the selection of design the next option is selection of factors in the option name the factors i.e. temperature, heating time, cooling time and cooling substance. The completion of naming the factors then enter the levels i.e. the temperature is having the three levels i.e. 800, 900, 1000.The heating time having the three levels i.e. 1hr ,1.15hr, 1.25hr.

After selecting the levels and factors then click on the ok option. In the creating taguchi design the last option is selecting options. After the selecting the option then click on enters option. After submitting the entire details in correct options we got the L9 array model table in the new sheet. After creating taguchi design again go to stat option and click on the AOVA in the ANOVA go to the GENERAL LENEAR MODEL option in that option go to the FIT GENERAL LENEAR MODEL after entering in this option we got two options i.e. response and factors. In the response place enter the result value i.e. HRC value and in the factors enter the four factors temp, heating time cooling time and cooling substance. After completion of the response and factors in that

table we can see a some option in it i.e. random/nest, model, options, coding, stepwise, graphs, result and storage.

The completion of all the options then click ok option we got the soft copy with calculated values and the result. IN this soft copy we can see the following data factors information, analyses of variance, model summary, coefficients, and regression equation. The completion of the calculated result we can plot the graphs between result and factors .Go to the graph option in Minitab software and select the type of we need and fill the all option in given factors and result. This experimentation graph is plotted between the mean of signal noise ratio and the main effects plot for signal noise ratio the next graph is plotted between the mean of means and main effect plot for signal noise ratio.

III. RESULTS AND DISCUSSION:

a) General Linear Model: HRC VALUES versus TEMP, SUBSTANCE Method

i. ANALYSIS OF VARIANCE

Table: 1.3.ANOVA Table

Source	Df	Adj Ss	Adj Ms	F-Value	P-Value
Temp	2	8.667	4.333	0.46	0.683
Heating Time	2	26.000	13.000	1.39	0.418
Cooling Substance	2	324.667	162.333	17.39	0.054
Error	2	18.667	9.333		
Total	8	378.000			

Analysis of variance (ANOVA) tests is the equal to the means and populations. This is the importance factors and compared the response variables levels. To perform an ANOVA, you must have a continuous response variable and at least one categorical factor with two or more levels. We are collected the ANOVA data from normally distributed populations with equal variances and factor levels. Although, ANOVA works well if the violate start. The original data may correct these violations. The "analysis of variance “approach to determine the means difference. All part of the larger population is different characteristics. The ANOVA, Minitab used to determine the degrees of freedom of F value. Adjusted sums of squares values are measures the different components of the model. The order of the predictors in the model does not affect the calculation of the adjusted sums of squares. In the Analysis of Variance table, Minitab separates the sums of squares into different components that describe the variation due to different sources. The adjusted sums of squares and the adjusted mean squares consider the degrees of freedom.

ii. REGRESSION EQUATION

Table: 1.4.Regression Equation Table

HRC VALUES	=	68.33 - 1.00 TEMP_800 + 1.33 TEMP_900 - 0.33 TEMP_1000 +2.33 HEATING TIME_1.00 - 0.67 HEATING TIME_1.1 – 1.67 HEATING TIME_1.30 - 7.00 COOLING SUBSTANCE_1 + 7.67 COOLING SUBSTANCE_2 - 0.67 COOLING SUBSTANCE_3

If the model contains both continuous and categorical variables, the regression equation table can display an equation for each combination of levels for the categorical variables. To use these equations for prediction, you must choose the correct equation, based on the values of the categorical variables, and then enter the values of the continuous variables. The mean having the two types i.e. fitted mean and standard mean .The fitted mean having the three factors and the standard mean having those three factors.

First term in mean is temp the fitted mean temp value is 67.33 at the 800 degrees and next value is 69.67 at the 900 degrees and the next value is 68 at the 1000 degrees. The se means value of 800 temps is 1.76 and at the 900 temp is 1.76 and at the 1000 temp is 1.76. The next term is heating time value in fitted mean is 70.67 at the 1hr and 67.67 at the 1.15hr and 66.67 at the 1.30hr. The se means value at1hr is1.76 and at the 1.15 hr. is 1.76 and at the 1.30hr is 1.76.The last and third term is cooling substance the cooling substances are water, salt water, oil. The fitted mean of water is 61.33 and fitted mean of the salt water is 76 and fitted mean of the oil is 67.67.The as mean of water is 1.76, the as mean of the salt water is 1.76, the as mean of the oil is 1.76.

The below graph is ploted betmeen the mean of signal noise ratio and main effect plot for signal noise ratios . The factors are using in this graph is temp, heating time, cooling substance. The temprature graph is ploted between the 36.5 to 37 mean of signal noise ratio and 800, 900, 1000 main effect plot for signal noise ratio.the deviation of the graph is seen at the 36.77. The heating time graph is ploted between the 36.6 to 37 mean of signal noise ratio and 1hr, 1.15hr, 1.30 hrmain effect plot for signal noise ratio.The deviation of the graph is seen at 36.57. The cooling substance of the graph is ploted between the 35.5 to 37.5 mean of signal noise ratio and 1, 2, 3.i.e. water, salt water and oil in the main effect plot forsignal noise ratio.The variation of the graph is seen at the 36.55.

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Table: 1.5. Design Parameters with S/N Ratio and Mean Values

S.No	Temp	Heating Time	Cooling Substance	Value	S/N Ratio	MEAN
1	800	1	Water	62	35.9216	62.6667
2	800	1.15	Salt Water	73	37.4412	74.3333
3	800	1.25	Oil	67	36.2730	65.0000
4	900	1	Oil	70	37.0767	71.3333
5	900	1.15	Salt Water	64	35.8751	62.0000
6	900	1.25	Water	75	37.5750	75.6667
7	1000	1	Salt Water	80	37.8133	78.0000
8	1000	1.15	Oil	66	36.4647	66.6667
9	1000	1.25	Water	58	35.4433	59.3333

The below graph is ploted betmeen the mean of signal noise ratio and main effect plot for signal noise ratios . The factors are using in this graph is temp, heating time, cooling substance. The temprature graph is ploted between the 36.5 to 37 mean of signal noise ratio and 800, 900, 1000 main effect plot for signal noise ratio.the deviation of the graph is seen at the 36.77. The heating time graph is ploted between the 36.6 to 37 mean of signal noise ratio and 1hr, 1.15hr, 1.30 hrmain effect plot for signal noise ratio.The deviation of the graph is seen at 36.57. The cooling substance of the graph is ploted between the 35.5 to 37.5 mean of signal noise ratio and 1, 2, 3.i.e. water, salt water and oil in the main effect plot forsignal noise ratio.The variation of the graph is seen at the 36.55.

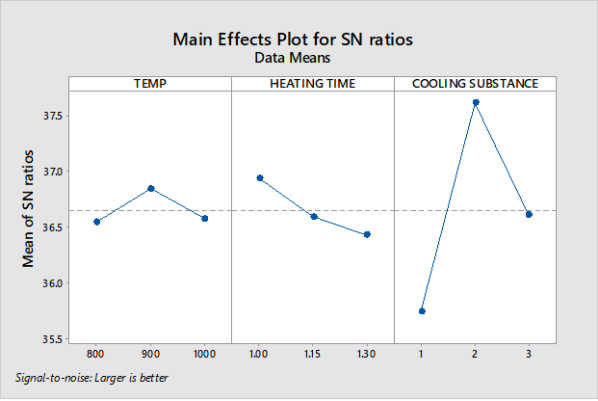

FIG:1.3.Mean Of S/N Ratios And Main Effects Plot For S/N Ratios Graphs

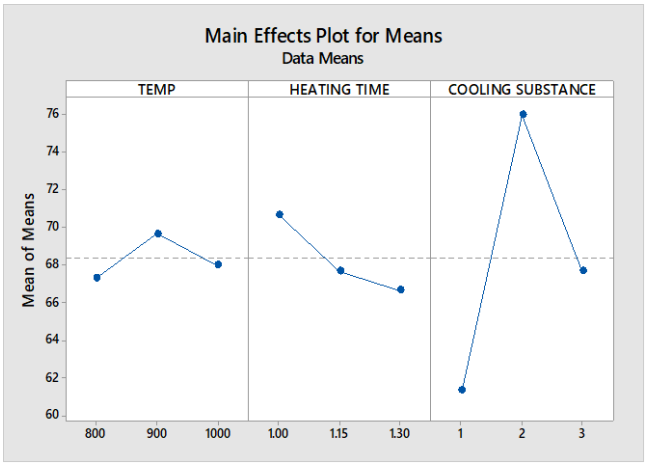

Fig: 1.4. Mean Of Means and Main Effects Plot for Means Graphs

The above graph is plotted between the mean of means and the main effect plot for means. The factors used in the graph are temp, heating time, and cooling substance. The temprature graph is ploted between the 66.5 to 70 mean of signal noise ratio and 800, 900, 1000 main effect plot for signal noise ratio.the deviation of the graph is seen at the 70. The heating time graph is ploted between the 66.6 to 70.5 mean of signal noise ratio and 1hr, 1.15hr, 1.30 hrmain effect plot for signal noise ratio.The deviation of the graph is seen at 68.5. The cooling substance of the graph is ploted between the 60.5 to 76 mean of signal noise ratio and 1, 2, 3.i.e. water, salt water and oil in the main effect plot forsignal noise ratio.The variation of the graph is seen at the66.5 .

IV. CONCLUSION

1. The selected material was medium carbon steel .the maximum temperature is around 1370 degrees so I selected the three levels of temperatures below the melting point i.e. 800, 900, 1000.
2. The 800 degrees the heating time is 1hr, the 900degrees the heating time is 1.15hr, the 1000 degrees the heating time is 1.30hr.
3. I tested the hardening before heating i.e. 47.33.The material was placed in the furnace .The maximum temperature of the furnace which was used in this process is 1000 degrees. The furnace used in the process was muffle furnace. In this process the cooling substance was water, salt water, oil.
4. After heating the 800 degrees it was cooled by the using the coolant water and tested the hardness its value is 62.At the same temp the coolant was salt water its hardness value is 73.At the same temp the coolant was oil its hardness value is 67.
5. The 900 degrees the hardness value is 70 its coolant is oil. At the same temp the hardness value is 64 its coolant is salt water. At the same temp the hardness value is 75 its coolant is water.

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6. The 1000 degrees the hardness value is 80 its coolant is salt water. At the same temp the harness value is 58 its coolant is water. At the same temp the hardness value is 66 the coolant is oil.
7. The hardness value is good at the 1000 degrees i.e. is 80 its coolant is salt water. The method was used in this process is taguchi method with the L9 array with 3 levels and 4 factors.
8. The result and the calculated values are drawn by using the Minitab app in this app the ANOVA type is general linear model. The percentage of variation i.e. Rsqu is between the 0-100%.The good Rsqu values is 90-100%. I got the value 95.06%so the chosen process parameters are good.
9. The two types of graphs are plotted i.e. mean of signal noise ratio and main effect plot for signal noise ratio, the next graph is mean of means and main effect plot for SN ratio.

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AUTHORS PROFILE

S.KRISHNAMOORTHI, working as Assistant Professor, Department of Mechanical Engineering, Chennai Institute of Technology, Chennai, Tamil Nadu, India.

S.DINESH, working as Assistant Professor, Department of Mechanical Engineering, Chennai Institute of Technology, Chennai, Tamil Nadu, India.

R.KARTHIKEYAN, working as Assistant Professor, Department of Mechanical Engineering, Chennai Institute of Technology, Chennai, Tamil Nadu, India.

.

G.MANIKANDAN, working as Assistant Professor, Department of Mechanical Engineering, Madha Institute of Engineering and Technology, Chennai, Tamil Nadu, India.