# PERFORMANCE ANALYSIS OF DEPTH HARDNESS OF EN41B MATERIAL USING GAS NITRIDING PROCESS

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**Abstract -** *Gas nitriding is generally used to create hard and wear safe surfaces. It is acted in the temperature run 480 to 580°C. On the off chance that the substrate material requires heat treatment, it must be performed before nitriding. The gas is generally a blend of alkali and a transporter gas, e.g., nitrogen. To build the profundity hardness of EN41B material utilizing gas nitriding process. Gas nitriding process is heat treatment process utilized for improving wear obstruction, consumption opposition and to improve mechanical properties nearly applied to the scope of prepares containing nitride-framing components, for example, chromium, molybdenum, vanadium and aluminum. With the utilization of heater the gas nitriding process is conceivable by utilizing diverse info boundary as Process control, Process chamber upkeep, Time, Temperature, Gas movement control, Gas stream, Carbon content, Furnace temperature and so on, and watch its impacts on yield boundary like layer thickness, hardness, wear opposition, erosion obstruction, mechanical properties. To play out the trial, an exploratory structure lattice was comprised utilizing the plan of the investigations.*

***Key Words:*** Hardness, Gas Nitriding, EN41B Material, Depth hardness, Full factorial Techniques, Optimization, Process variables.

## 1. INTRODUCTION

Gas nitriding is a case hardening process in which nitrogen is brought into the outside of a ferrous compound by holding the metal at a reasonable temperature in contact with a nitrogenous gas, generally Ammonia. At raised temperature, the ammonia dissociates into its parts as indicated by the response:

$$2NH_3 \rightarrow 2N + 3H$$

The nitrogen, which is dynamic right now of deterioration of the ammonia gas, consolidates with the alloying components in the steel to shape nitrides. These nitrides structure at the steel surface as a fine scattering and grant incredibly high hardness to the steel surface without the requirement for extinguishing.

The hardness results that he accomplished were not high by the principles of today or even by the German gauges of the day. Hardness results for the most part measure the achievement of the procedure and are relied upon to be in the locale of roughly 60 to 64 HRC.[1][2]

## 2. EXPERIMENT PROCEDURE

**Table -1:** Range Of Process Parameters

| Parameter | Unit | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|
| Nitriding temperature | °C | 510 | 520 | 525 |
| Ammonia flow rate | m³/hr | 3 | 4 | 5 |
| Socking time | Hour | 90 | 90 | 90 |

**Fig-1:** Testing Component

**Material –** EN41B
**Dimension –** 45mm Ø
8mm thickness
**Depth –** 0.1mm to 0.4mm depth

For the procedure parameters level choice, need was given to mechanical appropriateness. In mechanical applications, the profundity hardness is especially imperative to build the segment life. Thus, to discover which components impact the material properties, the Socking time Constant 90hr and nitriding temperature and ammonia flow rate fluctuating. The impact of the cooling rate time examined in detail through number of trials. Likewise carbon content assume crucial job in variety of hardness of material. In this examination carbon content has been considered for hardness value.

## 3. RESULTS AND DISSCUSION

**Table -2a:** Experiment Procedure

| No | Nitriding Temperature °C | Ammonia Flow Rate $m^3/hr$ | Hour |
|---|---|---|---|
| 1 | 510 | 3 | 90 |
| 2 | 510 | 4 | 90 |
| 3 | 510 | 5 | 90 |
| 4 | 520 | 3 | 90 |
| 5 | 520 | 4 | 90 |
| 6 | 520 | 5 | 90 |
| 7 | 525 | 3 | 90 |
| 8 | 525 | 4 | 90 |
| 9 | 525 | 5 | 90 |

**Table -2b:** Experiment Results

| No | HRC 0.1 | HRC 0.2 | HRC 0.3 | HRC 0.4 | Dissociation |
|---|---|---|---|---|---|
| 1 | 64 | 59.8 | 53.8 | 49.5 | 30 |
| 2 | 65.8 | 62.4 | 55.3 | 51.5 | 25 |
| 3 | 66.2 | 63.6 | 54.5 | 46.6 | 38 |
| 4 | 66.4 | 61.8 | 59.3 | 56.4 | 35 |
| 5 | 66 | 59.9 | 50.6 | 44.9 | 38 |
| 6 | 68.7 | 62.9 | 53.2 | 49.2 | 35 |
| 7 | 66.4 | 61.8 | 59.3 | 54.4 | 35 |
| 8 | 68.2 | 62.5 | 59.5 | 54.3 | 34 |
| 9 | 69.2 | 64.0 | 59 | 56 | 33 |

## 4. FULL FACTORIAL METHOD

Full Factorial technique for two free factors was received. The Experimental procedure depended on Minitab Release 18.00 Full Factorial Design was utilized to get the mix of qualities that can improve the reaction inside the locale of the two dimensional perception spaces, which permits one to process an insignificant number of trial runs. The factors were Temperature, and Flow Rate, were submitted for the examination all the while. A 2×3 full factorial structure at the middle point, driving the absolute number of 9 investigations. The conduct of the current framework depicted by the accompanying condition (1), which incorporates all cooperation terms paying little heed to their importance.[4]

$$Y_k = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_{12} x_1 x_2 + \beta_{21} x_2 x_1 \quad (1)$$

Where β are the coefficients which have determined utilizing a proper strategy, for example, the least square technique.

The model parameter can be approximated at whatever point appropriate exploratory procedures are utilized to gather the information. The DOE reproduction was practiced with two boundaries: among Temperature and Ammonia Flow Rate separately.

Relapse Equation conditions were gotten from plan of investigations. Utilizing all qualities (tests 1 to 9) to the framework examination, the accompanying polynomial conditions were produced.

**Regression Equation**

**HRC** = 66.767 – 1.433TEMP_1 + 0.267TEMP_2 + 1.167TEMP_3 – 1.167FLOW RATE_1 - 0.100FLOW RATE_2 + 1.267FOLW RATE_3

**Table-3a:** Experiment Process

| Run | Std Order | Run Order | Pt Type | Blocks | Temperature | Ammonia Flow Rate |
|---|---|---|---|---|---|---|
| 1 | 9 | 1 | 1 | 1 | 525 | 5 |
| 2 | 2 | 2 | 1 | 1 | 510 | 4 |
| 3 | 6 | 3 | 1 | 1 | 520 | 5 |
| 4 | 4 | 4 | 1 | 1 | 520 | 3 |
| 5 | 3 | 5 | 1 | 1 | 510 | 5 |
| 6 | 7 | 6 | 1 | 1 | 525 | 3 |
| 7 | 1 | 7 | 1 | 1 | 510 | 3 |
| 8 | 5 | 8 | 1 | 1 | 520 | 4 |
| 9 | 8 | 9 | 1 | 1 | 525 | 4 |

**Table-3b:** Experiment Process

| Run | HRC | | | |
|---|---|---|---|---|
| | 0.1 | 0.2 | 0.3 | 0.4 |
| 1 | 69.2 | 64.0 | 59.1 | 56.0 |
| 2 | 65.8 | 62.4 | 55.3 | 51.5 |
| 3 | 98.7 | 62.9 | 53.2 | 49.2 |
| 4 | 66.4 | 61.8 | 59.3 | 56.4 |
| 5 | 66.2 | 69.6 | 54.5 | 46.6 |
| 6 | 66.4 | 61.8 | 59.3 | 54.4 |
| 7 | 64.0 | 59.8 | 53.8 | 49.5 |
| 8 | 66.0 | 59.9 | 50.6 | 44.9 |
| 9 | 68.2 | 62.5 | 59.5 | 54.3 |

**Table -4:** Analysis of Variance For The Experimental Results of Full Factorial Design

| Source | DF | Adj SS | Adj MS | F-Value | P-Value |
|---|---|---|---|---|---|
| Model | 4 | 19.387 | 4.8467 | 9.26 | 0.000 |
| Linear | 4 | 19.387 | 4.8467 | 9.26 | 0.000 |
| TEMP | 2 | 10.460 | 5.2300 | 9.99 | 0.000 |
| FLOW RATE | 2 | 8.927 | 4.4633 | 8.53 | 0.000 |
| Error | 4 | 2.093 | 0.5233 | | |
| Total | 8 | 21.480 | | | |

**Table -5:** Estimated Regression Coefficients For HRC

| Term | Coef | SE Coef | T-Value | P-Value | VIF |
|---|---|---|---|---|---|
| Constant | 66.767 | 0.241 | 276.88 | 0.000 | |
| TEMP | | | | | |
| 1 | -1.433 | 0.341 | -4.20 | 0.000 | 1.33 |
| 2 | 0.267 | 0.341 | 0.78 | 0.000 | 1.33 |
| FLOW RATE | | | | | |
| 1 | -1.167 | 0.341 | -3.42 | 0.000 | 1.33 |
| 2 | -0.100 | 0.341 | -0.29 | 0.000 | 1.33 |

Model Summary

| S | R-sq | R-sq(adj) | R-sq(pred) |
|---|---|---|---|
| 0.723418 | 98.25% | 99.70% | 99.56% |

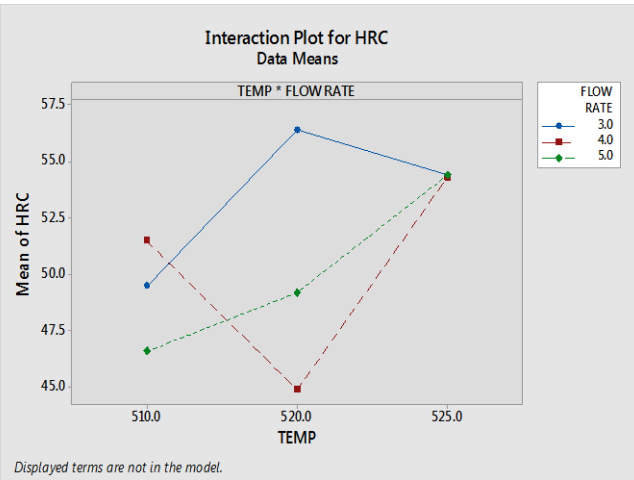


**Fig-2:** Interaction Plot For Hardness

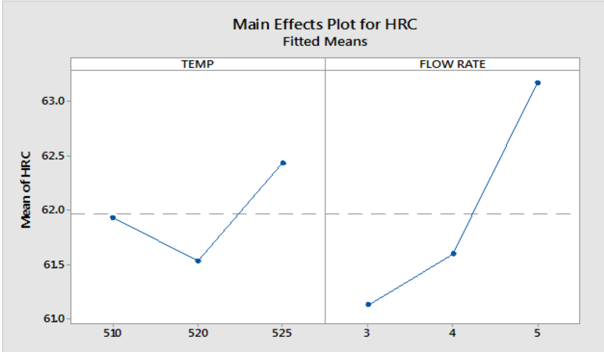


**Fig-3:** Main Effects Plot For Hardness

## 5. GREY RELATIONAL ANALYSIS

**Table-6:** Grey Relational Coefficient

| Sr. No. | Grey Relational Coefficient (GRC) | | | | Grey Relational Grade |
|---|---|---|---|---|---|
| | HRC0.1 | HRC0.2 | HRC0.3 | HRC0.4 | |
| 1 | 0.7115 | 0.7115 | 0.8084 | 0.8210 | 0.6105 |
| 2 | 0.8043 | 0.9217 | 0.8635 | 0.8798 | 0.6939 |
| 3 | 0.8283 | 1.0673 | 0.8260 | 0.7484 | 0.6940 |
| 4 | 0.8409 | 0.8629 | 1.0554 | 1.0673 | 0.7653 |
| 5 | 0.8161 | 0.7178 | 0.7115 | 0.7115 | 0.5914 |
| 6 | 1 | 0.9772 | 0.7883 | 0.8128 | 0.7156 |
| 7 | 0.8409 | 0.8629 | 1.0554 | 0.9819 | 0.7482 |
| 8 | 0.9736 | 0.9323 | 1.0673 | 0.9780 | 0.7902 |
| 9 | 1.0673 | 0.9892 | 1.0438 | 0.9819 | 0.8164 |

The response table of Full Factorial and Grey method analysis was used to optimize the effect of process parameters on EN41B. The highest grey relational grade of 0.8164 was observed in experiment run 9 which indicates that the optimal combination of control factor for mentioned responses.

## 6. CONCLUSION

The response table of Full Factorial-Grey method analysis was used to optimize the effect of process parameters on EN41B. The highest grey relational grade of 0.8164was observed in experiment run 9 which indicates that the optimal combination of control factors for mentioned responses. The optimal parameter values are at nitriding temperature525$_0$C, soak time 90 hrs and ammonia flow rate 5m3/hr. this experiment given the hardness are 0.1, 0.2, 0.3, and 0.4 respectively 69.2, 63.0, 59.1, 54.4 and dissociation 33.

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## BIOGRAPHIES

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