

Optimization of 3Cr2W8V Material Process Parameters using Design of trial (DOE) styles

Rohit Dattatray Joshi¹, Mr. P. G. Sarasambi², Prof. Dr. A. D. Desai³,
Prof. Dr. S. D. Shinde⁴, Mr. S. P. Godase⁵

P.G. Student, Department of Mechanical Engineering¹

Professor, Department of Mechanical Engineering³

Assistant Professor, Department of Mechanical Engineering^{2,4,5}

Shree Ramchandra College of Engineering, Lonikand, Pune, Maharashtra, India

Abstract: *Hard turning is one among the pivotal process in advanced machining technology for machining of hardened brands like admixture brand, titanium, nickel- base admixture, Inconel etc. Hard turning offers the benefits like increase productivity, micro face finish, reduced cycle time, reduction of processing costs, and meliorate material parcels. Optimization of 3Cr2W8V Material Process Parameters using Design of trial (DOE) styles concentrated on optimizing of face roughness in hard turning of 3Cr2W8V tool brand using Taguchi system. The main ideal of the trial is carried out for correlation between cutting parameters analogous as cutting condition, spindle speed, feed rate, depth of cut with face roughness. Four cutting parameters analogous as cutting condition, spindle speed, feed rate, and depth of cut. The result showing that the feed rate and spindle speed are significantly affected on face roughness; the depth of cut significantly effects on cycle time. The variation in optimal slice condition is preferred in various product and manufacturing industriousness. The comparison of effect of process parameters like spindle speed, feed rate and depth of cut between dry turning and wet turning during turning operation on performance characteristics is carried out to examine the effect of dry and wet machining. The process parameters like spindle speed, feed rate and depth of cut, etc. optimized by using different optimization ways to find out the which suitable machining condition for hard turning*

Keywords: Dry and Wet Turning, Surface Roughness, Taguchi, Anova, Optimization

I. INTRODUCTION

The face finish of the products is a truly important aspect as it determines the alignment between the corridor and smooth working during the operation. A vibration during machining affects the face finish of the products, which in turn depends upon cutting force. thus, it's truly essential to understand the commerce between cutting force, vibration, face finish, substance- junking rate (MRR) and wear and tear of the tools. Different work piece paraphernalia are hardened up to 68 HRC and used for specific operations. lately, colourful assiduity pertaining to the machining of hardened paraphernalia generally use different brands like AISI H10, AISI H11, AISI H12, AISI H13, AISI 21, AISI M42, AISI T1, AISI T4 and AISI T5. H21 Steel is a hot work tool brand for oil painting oil oil painting or air solidifying to grow high hot quality, conservation of hardness and warmth checking resistance. Its specific operations in the assiduity are as mentioned below

1. Dies, mandrels, and other heavy-duty hot forming process tools.
2. Extrusion of rod and tube.
3. Hot impact extrusion process tools.
4. Various tools for product of nuts, screws, rivets, bolts and hollow bodies, various dies of press machine
5. Different dies of casting.
6. Dies of forming process.
7. Cutting blades of hot shearing.



1.1 Taguchi Method

Optimization of quality traits using the parameter layout of the Taguchi fashion is epitomized in the following way.

1. Identification and assessment of quality traits and process parameters
2. Identification of number of situations for the process parameters and possible relations between the process parameters
3. computation of S/ N rate
4. dissect the experimental results using the S/ N rate and ANOVA
5. Selection of the optimal situations of process parameters

II. LITERATURE SURVEY

Hua and Liu (2018) conducted dry turning of Inconel 718 and investigated the influence of speed, feed and nose radius on surface roughness and the degree of work hardening. The performance of a machined part is significantly influenced by its various surface integrity characteristics. However, the surface integrity of a machined part depends on the material and the cutting conditions employed. The present work investigates the effects of the cutting speed, the feed rate, and the tool nose radius on machined surface roughness, microhardness, and degree of work hardening of Inconel 718. Dry turning tests are performed using three different cutting speeds, three different feed rates, and two cutting tools with different nose radius. The results indicate that the feed rate and the tool nose radius have dominant effect on the machined surface roughness, whereas no clear tendency between the cutting speed and the surface roughness can be found

Sampaio et al. (2018) compared dry and minimum quantity lubrication (MQL) turning of SAE 1045 steel to study effect of process factors on surface roughness, cutting force, and tool wear phenomenon and chip morphology using PCBN tools. Minimum quantity of lubrication (MQL) is an efficient practice in machining of soft materials. Its application during machining of hard materials has not yet been completely explored in scientific research. This work evaluates the wear process of PCBN cutting tools, as well as machining forces, workpiece surface roughness and white layer depth, chip morphology, and chip microstructure in hard turning of induction hardened SAE1045 steel using MQL and compared to dry machining

Masoudi et al. (2017) investigated the effect of workpiece hardness, tool materials and nozzle position on surface roughness, cutting force and tool wear during turning of AISI 1045 steel. Minimum quantity lubrication (MQL) is a replacement for dry machining in which a minimum quantity of lubricant fluid is mixed up with compressed air and sprayed periodically on the machining area. In this research the effects of different parameters on the MQL turning of AISI 1045 steel have been investigated to evaluate the cutting force, surface roughness, and tool wear in comparison with the wet and dry machining. The research is aimed to study the effect of the MQL nozzle position, workpiece hardness and tool type on the output parameters.

Benlahmidi et al. (2017) investigated effects of speed, feed, depth of cut and hardness of the material on cutting power, surface roughness and cutting pressure during turning of hardened H11 steel. The surface finish of machined parts is known to have considerable effect on some properties such as wear resistance and fatigue strength. Thus, the quality of the surface has a significant importance for evaluating the productivity of machine tools, and mechanical parts. In this paper, the effects of cutting speed, feed rate, depth of cut and workpiece hardness on surface roughness, cutting pressure, and cutting power in the hard turning of hardened AISI H11 (X38CrMoV5-1) using CBN7020 tools were experimentally investigated. The response surface methodology (RSM) and analysis of variance (ANOVA) were used to check the validity of quadratic regression model and to determine the significant parameter affecting the output responses



Suyama et al. (2017) carried out internal turning of hardened steel AISI 4340 with CBN tools and investigated the influence of speed, feed and overhang length of the boring bar on MRR and surface roughness. The machining of hardened materials with hardness over 45 HRC has been an alternative to grinding since the 1970s, with the commercial availability of cubic boron nitride (CBN) and ceramic tools. However, the low toughness of these types of tool materials makes them very sensitive to damages caused by vibrations, which are critical for operations like internal turning, where the tool resembles a cantilever beam and therefore is susceptible to large deflections

Negrete et al. (2016) optimized cutting variables, i.e. speed, feed and depth of cut using Taguchi method to reduce power consumption while turning of AISI 1018 steel. Environmental and energy efficiency awareness of manufacturers and customers along with high electricity costs have promoted the development of strategies to reduce energy consumption in manufacturing processes. Machine tools are one of the main contributors to energy consumption in the industrial sector. Several studies have been undertaken to optimize the cutting parameters in order to minimize the power consumed in the removal of material.

Ferreira et al. (2016) performed hard turning of AISI H13 steel by applying alumina based ceramic tools with conventional multi radii tools and studied the effect of speed and feed on surface roughness. The present study shows an experimental investigation on the turning of AISI H13 steel with ceramic tools: conventional and wiper. Wiper geometry has as main objective obtained a smoother surface after the cutting process. Turning tests were performed to evaluate the evolution of the surface roughness and tool wear; and the influence of the flank wear on the surface roughness.

Rashid et al. (2015) conducted hard turning operations on AISI 4340 steel with CBN cutting tool as per Taguchi method to optimize process parameters with respect to surface roughness. In all the trials, AISI 4340 steel workpiece (hardened up to 69 HRC) was machined with a commercially available CBN insert (Warren Tooling Limited, UK) under dry conditions. The surface topography of the machined samples was examined by using a white light interferometer and a reconfirmation of measurement was done using a Form Talysurf. The machining outcome was used as an input to develop various regression models to predict the average machined surface roughness on this material.

Klocke et al. (2015) studied different machinability aspects using different types of tools such as TiN, TiAlN, TiB₂ coated, diamond like carbon (DLC) and diamond and cutting speed. The influence of tool coating and material on the machinability of low-leaded brass alloys (Pb < 0.2%) was analyzed in external turning. Carbide tools with various coatings as well as polycrystalline diamond (PCD) tools were applied. As workpiece materials, three low-leaded brass alloys CuZn38As, CuZn42 and CuZn21Si3P were used. Their machining behavior was compared to the leaded (Pb < 3.32%) brass CuZn39Pb3.

Lawal et al. (2015) used different types of cutting fluids during turning of AISI 4340 steel and studied the wear process of coated carbide inserts. The understanding of cutting fluids performance in turning process is very important in order to improve the efficiency of the process. This efficiency can be determined based on certain process parameters such as flank wear, cutting forces developed, temperature developed at the tool chip interface, surface roughness on the work piece, etc. In this study, the objective is to determine the influence of cutting fluids on flank wear during turning of AISI 4340 with coated carbide inserts.

Chen et al. (2014) carried out hard turning of GCr15 steel using PCBN tools to investigate the effect of cutting speed and feed on cutting force and surface topography experimental results of turning experiments on GCr15 bearing steel hardened to 60–64 HRC. The objective was to determine the effect of the cutting parameters on cutting force, chip



morphology and resultant workpiece surface quality, more specifically surface texture, microstructural alterations, changes in microhardness and residual stresses distribution. Experiment results show that tensile stress can be produced under some cutting conditions, the machined superficial hardened layer depth shows an increasing tendency with the improvement of the workpiece hardness, and that the surface roughness value shows a decreasing tendency when the workpiece hardness is over 50 HRC

III. PROBLEM DEFINITION

In ultramodern manufacturing diligence, the machining of hardened brands similar as 3Cr2W8V poses significant challenges due to their high strength, hardness, and thermal resistance. Achieving superior face finish and minimizing tool wear while maintaining high productivity is a critical demand, especially in operations involving hot forming dies, extrusion tools, and impact extrusion tools. Traditional machining styles frequently affect in increased tool wear and tear, sour face quality, and advanced processing costs. Hard turning has surfaced as a feasible volition to grinding, offering benefits similar as reduced cycle time, bettered face integrity, and lower functional costs. still, the effectiveness of hard turning largely depends on the applicable selection and optimization of machining parameters like spindle speed, feed rate, depth of cut, and cutting terrain (dry or wet). Shy optimization may lead to poor face finish, inordinate vibration, and reduced tool life. Therefore, there is a pressing need to totally dissect and optimize these parameters to enhance face quality, material junking rate (MRR), and tool performance during the hard turning of 3Cr2W8V tool sword.

IV. OBJECTIVES

This study aims to optimize machining parameters for hard turning of 3Cr2W8V tool steel using the Taguchi method. The focus is on analyzing the effects of spindle speed, feed rate, depth of cut, and cutting environment (dry or wet) on key performance metrics such as surface roughness, material removal rate (MRR), and tool wear. By employing the Taguchi method for experimental design and analysis, the goal is to identify the optimal combination of machining parameters that minimize surface roughness and tool wear while maximizing MRR. The optimized parameters will be validated through confirmation experiments to ensure improved machining efficiency and product quality.

V. METHODOLOGY

This study focuses on optimizing machining parameters for hard turning of 3Cr2W8V tool brand using the Taguchi system. 3Cr2W8V, known for its high hardness and thermal resistance, serves as the work piece material. A (specify tool type, e.g. coated carbide insert) is named for its durability in hard turning operations. The Taguchi system structures the experimental design, examining the goods of spindle speed, feed rate, depth of cut, and cutting terrain (dry or wet). An applicable orthogonal array, analogous as L9 or L16, efficiently plans the trials, reducing the number of trials while effectively covering the parameter space. Trials are conducted predicated on the combinations specified in the orthogonal array. Measured responses include face roughness (Ra), material junking rate (MRR), and tool wear and tear and gash. Face roughness is assessed using a profilometer, MRR is calculated from the volume of material removed over time, and tool wear and tear and gash is estimated through bitty examination. Data analysis involves calculating Signal to Noise (S/N) rates for each response to identify optimal machining parameter situations. Analysis of Variance (ANOVA) determines the significance of each parameter on the responses. The optimal parameter settings are validated through substantiation trials to ensure result responsibility.

Each affiliation must include, at the very least, the name of the company and the name of the country where the author is based (e.g. Causal Productions Pty Ltd, Australia).



VI. EXPERIMENTAL SETUP

6.1 MATERIAL 3Cr2W8V

Table 6.1 Chemical Composition

| Sr. No. | Element | CONTENT (%) |
|---------|---------|-------------|
| 1 | C | 0.26-0.36 |
| 2 | Mn | 0.15-0.40 |
| 3 | Si | 0.15-0.50 |
| 4 | Cr | 3.00-3.75 |
| 5 | Ni | 0.3 |
| 6 | W | 8.50-10.00 |
| 7 | V | 0.30-0.60 |
| 8 | Cu | 0.25 |
| 9 | P | 0.03 |
| 10 | S | 0.03 |

Table 6.2 Physical Properties

| Sr. No. | Properties | Metric | Imperial |
|---------|---------------|------------------------|--------------------------|
| 1 | Density | 8.19 g/cm ³ | 0.296 lb/in ³ |
| 2 | Melting point | 1432°C | 2610°F |

TABLE 6.3 MECHANICAL PROPERTIES

| Sr. No. | Properties | Metric | Imperial |
|---------|------------------------|-------------|-----------------|
| 1 | Hardness, Rockwell C | 40.0 - 55.0 | 40.0 - 55.0 |
| 2 | Bulk modulus | 140 GPa | 20300 ksi |
| 3 | Shear modulus | 80.0 GPa | 11600 ksi |
| 4 | Poisson's ratio (25°C) | 0.27-0.30 | 0.27-0.30 |
| 5 | Elastic modulus | 190-210 GPa | 27557-30458 ksi |

TABLE 6.4 THERMAL PROPERTIES

| Sr. No | Properties | Metric | Imperial |
|--------|----------------------|-------------|---------------------------------|
| 1 | CTE, linear | 12.4 μm/m°C | 6.89 μin/in°F |
| 2 | Thermal conductivity | 27.0 W/mK | 187 BTU-in/hr-ft ² F |

TABLE 6.5 PROCESSING PROPERTIES

| Sr. No. | Properties | Metric | Imperial |
|---------|------------------------------------|---------------|---------------|
| 1 | Processing temperature (tempering) | 595 - 675°C | 1100 - 1250°F |
| 2 | Processing temperature (tempering) | 1095 - 1205°C | 2003 - 2201°F |
| 3 | Annealing temperature (hardening) | 870 - 900°C | 1600 - 1650°F |



6.2 Tool – Tin Coated Insert



Fig. 6.1 Tin coated inserts

6.3 Material Before Turning



FIG. 6.2 MATERIAL BEFORE CUTTING

6.4 Experimental Set-up



FIG. 6.3 EXPERIMENTAL SET UP

The material selected for experimentation is 3Cr2W8V tool steel. For this material, chemical composition is given in Table. The size of the work piece 60 mm diameter and 260 mm length. The material hardness is 40-55 HRC. 2 mm



thickness material removed from the top and bottom of workpiece to remove surface irregularity. The following machining parameters considered in this study such as cutting condition, spindle speed, feed rate, and depth of cut, cycle time. The feasible range of the cutting parameters was defined by varying the spindle speed vary from 600-850 rpm, feed rate varies from 0.08-0.16 mm/rev; depth of cut vary from 0.2-0.5 mm. Therefore, three levels of the cutting parameters alongside two levels of 1 cutting parameter, i.e. cutting environment like 'Dry' and 'Wet' were selected shown in Table 6.1-6.5.

VII. EXPERIMENTAL PROCEDURE

7.1 Experimental Procedure

Turning experiments were conducted using a CNC turning lathe. The specification of the machine shown in following table. After machining, surface roughness was measured.



FIG. 7.1 SURFACE ROUGHNESS MEASUREMENT

TABLE 7.1 PROCESS PARAMETERS AND LEVEL

| Sr. No. | Cutting parameters | Level | | |
|---------|---------------------|-------|------|------|
| | | 1 | 2 | 3 |
| 1 | Spindle Speed (rpm) | 600 | 650 | 700 |
| 2 | Feed (mm/rev) | 0.08 | 0.12 | 0.16 |
| 3 | Depth of cut (mm) | 0.2 | 0.3 | 0.5 |

Table 7.2 L9 DOE table with results

| EXP. No. | CUTTING CONDITION | SPINDLE SPEED (RPM) | FEED (MM/REV) | DEPTH OF CUT (MM) | SURFACE ROUGHNESS | SIGNAL TO NOISE RATIO | MEANS |
|----------|-------------------|---------------------|---------------|-------------------|-------------------|-----------------------|--------------|
| 1 | DRY | 600 | 0.08 | 0.2 | 0.863 | 1.2798 | 0.863 |
| 2 | DRY | 600 | 0.08 | 0.3 | 0.841 | 1.5040 | 0.841 |
| 3 | DRY | 600 | 0.08 | 0.5 | 0.858 | 1.3302 | 0.858 |
| 4 | DRY | 650 | 0.12 | 0.2 | 0.979 | 0.1843 | 0.979 |
| 5 | DRY | 650 | 0.12 | 0.3 | 0.952 | 0.4272 | 0.952 |



| | | | | | | | |
|---|-----|-----|------|-----|-------|---------|-------|
| 6 | DRY | 650 | 0.12 | 0.5 | 0.946 | 0.4822 | 0.946 |
| 7 | DRY | 700 | 0.16 | 0.2 | 1.752 | -4.8707 | 1.752 |
| 8 | DRY | 700 | 0.16 | 0.3 | 1.752 | -2.5421 | 1.340 |
| 9 | DRY | 700 | 0.16 | 0.5 | 1.373 | -2.7534 | 1.373 |

Table 7.3 L9 DOE table with results

| EXP. NO. | CUTTING CONDITION | SPINDLE SPEED (RPM) | FEED (MM/REV) | DEPTH OF CUT (MM) | SURFACE ROUGHNESS | SIGNAL TO NOISE RATIO | MEANS |
|-----------|-------------------|---------------------|---------------|-------------------|-------------------|-----------------------|--------------|
| 10 | DRY | 600 | 0.08 | 0.2 | 0.808 | 1.85177 | 0.808 |
| 11 | DRY | 600 | 0.08 | 0.3 | 0.790 | 2.04746 | 0.790 |
| 12 | DRY | 600 | 0.08 | 0.5 | 0.842 | 1.49376 | 0.842 |
| 13 | DRY | 650 | 0.12 | 0.2 | 0.930 | 0.63034 | 0.930 |
| 14 | DRY | 650 | 0.12 | 0.3 | 0.880 | 1.11035 | 0.880 |
| 15 | DRY | 650 | 0.12 | 0.5 | 0.826 | 1.66040 | 0.826 |
| 16 | DRY | 700 | 0.16 | 0.2 | 0.766 | 2.31542 | 0.766 |
| 17 | DRY | 700 | 0.16 | 0.3 | 0.684 | 3.29888 | 0.684 |
| 18 | DRY | 700 | 0.16 | 0.5 | 0.883 | 1.08079 | 0.883 |

Table 7.4 L9 DOE table with results

| EXP. NO. | CUTTING CONDITION | SPINDLE SPEED (RPM) | FEED (MM/REV) | DEPTH OF CUT (MM) | SURFACE ROUGHNESS | SIGNAL TO NOISE RATIO | MEANS |
|----------|-------------------|---------------------|---------------|-------------------|-------------------|-----------------------|-------|
| 19 | WET | 600 | 0.08 | 0.2 | 0.870 | 1.209615 | 0.87 |
| 20 | WET | 600 | 0.08 | 0.3 | 0.934 | 0.593062 | 0.934 |
| 21 | WET | 600 | 0.08 | 0.5 | 1.073 | -0.61199 | 1.073 |
| 22 | WET | 650 | 0.12 | 0.2 | 1.169 | -1.35629 | 1.169 |
| 23 | WET | 650 | 0.12 | 0.3 | 1.113 | -0.9299 | 1.113 |
| 24 | WET | 650 | 0.12 | 0.5 | 0.792 | 2.025496 | 0.792 |
| 25 | WET | 700 | 0.16 | 0.2 | 1.136 | -1.10757 | 1.136 |
| 26 | WET | 700 | 0.16 | 0.3 | 0.958 | 0.37269 | 0.958 |
| 27 | WET | 700 | 0.16 | 0.5 | 0.863 | 1.279784 | 0.863 |

Table 7.5 L9 DOE table with results

| EXP. NO. | CUTTING CONDITION | SPINDLE SPEED (RPM) | FEED (MM/REV) | DEPTH OF CUT (MM) | SURFACE ROUGHNESS | SIGNAL TO NOISE RATIO | MEANS |
|----------|-------------------|---------------------|---------------|-------------------|-------------------|-----------------------|-------|
| 28 | WET | 600 | 0.08 | 0.2 | 0.840 | 1.514414 | 0.84 |
| 29 | WET | 600 | 0.08 | 0.3 | 0.895 | 0.963539 | 0.895 |
| 30 | WET | 600 | 0.08 | 0.5 | 0.949 | 0.454676 | 0.949 |
| 31 | WET | 650 | 0.12 | 0.2 | 1.253 | -1.95902 | 1.253 |
| 32 | WET | 650 | 0.12 | 0.3 | 1.125 | -1.02305 | 1.125 |
| 33 | WET | 650 | 0.12 | 0.5 | 0.958 | 0.37269 | 0.958 |
| 34 | WET | 700 | 0.16 | 0.2 | 0.987 | 0.113657 | 0.987 |
| 35 | WET | 700 | 0.16 | 0.3 | 1.120 | -0.98436 | 1.12 |
| 36 | WET | 700 | 0.16 | 0.5 | 0.617 | 4.194297 | 0.617 |



7.2 Signal to Noise Ratio

The use of S/N ratio is measured responses to develop products and methods in sensitive to the noise factor. This means the diploma of predictable responses of product within the presence of noise factors. The parameters setting with a maximum S/N ratio, yield optimum cost with minimal variance. In this look at decrease the better performance function is selected to get minimum floor roughness.

7.3 Residual plots

The adequacy of the version has been investigated by using the exam of residuals. The residual is the distinction among a determined fee and its corresponding fitted price. Residual plots are especially useful in regression and ANOVA analysis due to the fact they imply the extent to which a version debt for the variation within the discovered data. The residual plots are classified into four categories normal possibility plot, versus fits, histogram, and versus order.

Table 7.6 Response Table for Signal to Noise Ratios

| Sr. No. | Level | Spindle Speed | Depth of Cut | Feed Rate |
|---------|-------|---------------|--------------|-----------|
| 1 | 1 | 1.3714 | -1.1355 | -0.2600 |
| 2 | 2 | 0.3646 | -0.2036 | -0.3550 |
| 3 | 3 | -3.3887 | -0.3137 | -1.0377 |
| 4 | Delta | 4.7601 | 0.9319 | 0.7777 |
| 5 | Rank | 1 | 2 | 3 |

Table 7.7 Response Table for Means

| Sr. No. | Level | Spindle Speed | Depth of Cut | Feed Rate |
|---------|-------|---------------|--------------|-----------|
| 1 | 1 | 0.8540 | 1.1980 | 1.0497 |
| 2 | 2 | 0.9590 | 1.0443 | 1.0643 |
| 3 | 3 | 1.4883 | 1.0590 | 1.1873 |
| 4 | Delta | 0.6343 | 0.1537 | 0.1377 |
| 5 | Rank | 1 | 2 | 3 |

7.4 Analysis of Variation (Anova)

Analysis of variance is a crucial technique for analyzing the effect of categorical factors on a response. An ANOVA decomposes the variability within the response variable amongst the different factors. Depending upon the sort of analysis, it's going to be important to work out which factors have a big effect on the response, and the way much of the variability in the response is variable due to each factor.

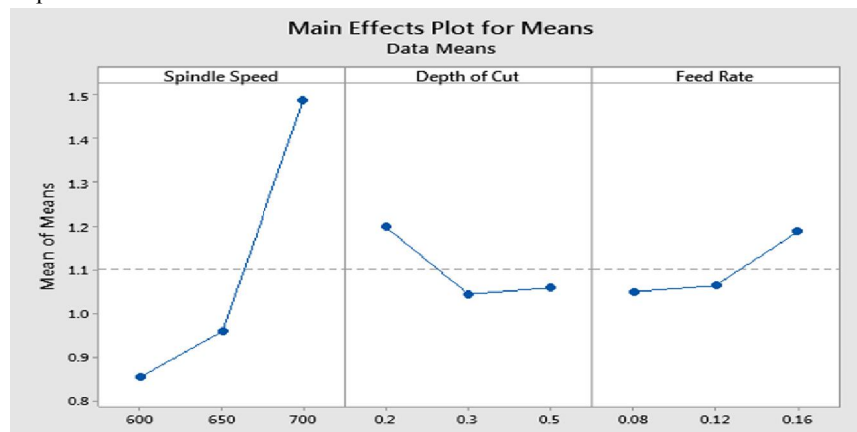


Fig. 7.2 Main effect plot for means

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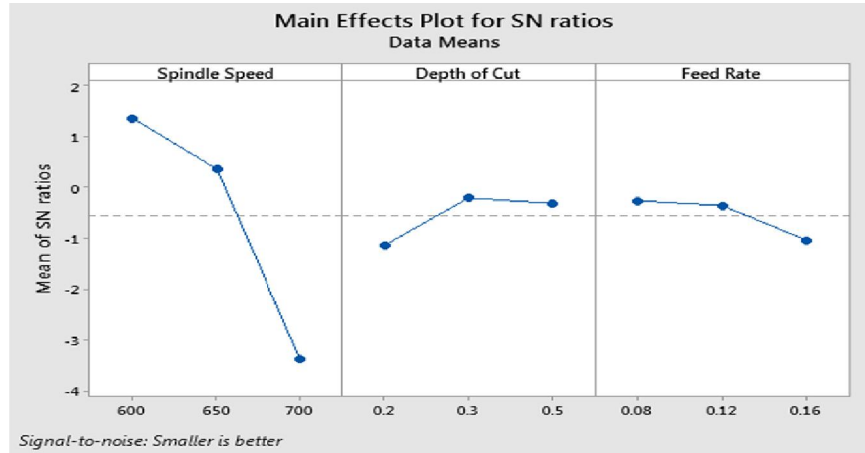


Fig. 7.3 Main effect plot for means

Table 7.8 Response Table for Means

| Sr. No. | Source | DF | Seq SS | Contribution | Adj SS | Adj MS | F-Value | P-Value |
|---------|---------------|----|----------|--------------|----------|----------|---------|---------|
| 1 | Spindle Speed | 2 | 0.466265 | 98.32 | 0.466265 | 0.233133 | 9543.74 | 0.000 |
| 2 | Depth of Cut | 2 | 0.006370 | 1.34 | 0.006370 | 0.003185 | 130.38 | 0.008 |
| 3 | Feed Rate | 2 | 0.001559 | 0.33 | 0.001559 | 0.000779 | 31.91 | 0.030 |
| 4 | Error | 2 | 0.000049 | 0.01 | 0.000049 | 0.000024 | | |
| 5 | Total | 2 | 0.474243 | 100 | | | | |

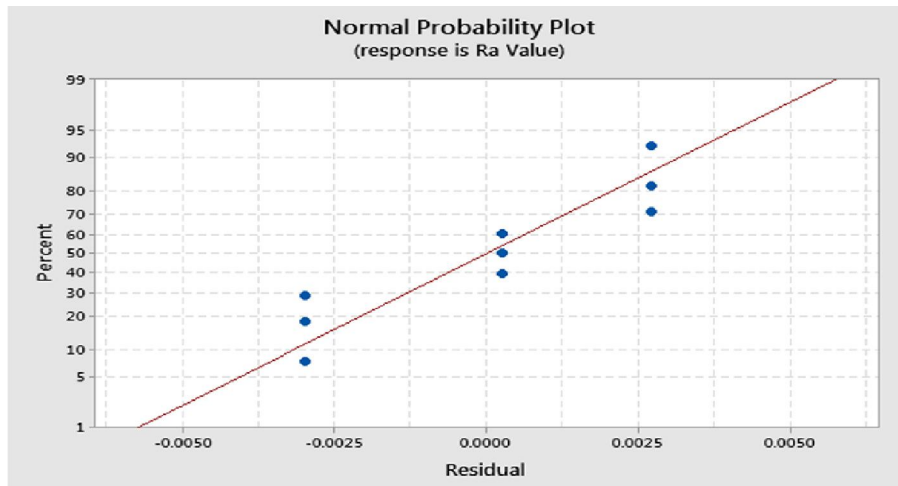


Fig. 7.4 Normal probability plot



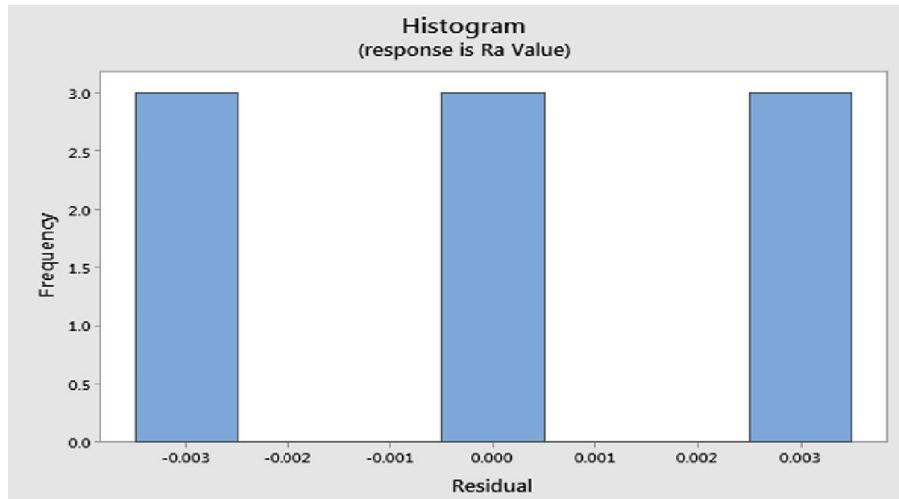


Fig. 7.5 Histogram

VIII. CONCLUSION

The Taguchi technique became used to decide optimum cutting parameters on difficult turning of 3Cr2W8V tool steel. Eighteen test runs primarily based on orthogonal arrays had been performed. Experimental results had been analyzed using S/N ratio and ANOVA. Based on the results obtained, the following conclusions may be drawn

1. The first optimized condition for surface roughness under Table 7 is spindle speed 600 rpm, feed rate 0.08 m/min, and depth of cut 0.3 for dry turning condition
2. The Second optimized condition for surface roughness under Table 8 is spindle speed 850 rpm, feed rate 0.16 m/min, and depth of cut 0.3 for dry turning condition
3. The third optimized condition for surface roughness under Table 9 is spindle speed 650 rpm, feed rate 0.12 m/min, and depth of cut 0.5 for wet turning condition
4. The first optimized condition for surface roughness under Table 10 spindle speed 850 rpm, feed rate 0.16 m/min, and depth of cut 0.5 for wet turning condition
5. Anova suggests spindle speed and feed significantly effect on surface roughness.
6. Taguchi method is one of the best approaches for optimum process condition.

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