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ANALYSIS OF MACHININNG OPERATION OF 304 STAINLESS STEEL

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Abstract:

Every manufacturing Industry aims at producing a large number of products within relatively lesser time. Along with this they aim at producing fine surface finish as much as possible. They aim at minimizing their cost of production. They adopt some technique which may be statistical or partially statistical for the purpose of achieving above task. In this project a similar effort has been made to optimize the speed, feed and depth of cut using Taguchi method and Central Composite Design of ANOVA (Analysis Of Variance) .Taguchi L18 orthogonal array is used to analyse the result. At last ANOVA is used to decide the confidence level and determine the percentage contribution of individual factors on outcome. Further the effort is to find the optimum cutting parameters and at the same time confirm the outcomes obtained from ANOVA.

Key Words: Feed force, Cutting force, Radial force and material removal rate, Analysis-of-Variance (ANOVA) etc.

Introduction

Turning is the most common lathe machining operation. During the turning process, a cutting tool removes material from the outer diameter of a rotating workpiece. The main objective of turning is to reduce the workpiece diameter to the desired dimension. There are two types of turning operations, rough and finish.

In mechanical manufacturing, high cutting edge parameters provide opportunities to increase productivity, but this also includes the greater risk of further degradation and tool life. Over the past decade great strides have been made in the development of cutting tools to make 'hard cutting' machines. The costs involved in producing new conversion tools are very high. To overcome this cost factor researchers have tried to bring about changes in the turnaround system using existing tools. A good understanding of cutting conditions, temperature production, failure methods, and cutting power leads to effective control of the conversion process. Most researchers investigated the effects of different cutting parameters in responses (output) with one variable at a time. The current study considers simultaneous variations in cutting speed, feed, cutting depth, tool nasal radius and percentage of solid liquid lubricants according to the factoral design for testing, prediction, responses. This method is known as response surface methodology (RSM).

B.Vijaya Ramnath et al. [1] this study, the Taguchi method was used to obtain optimal condition for Friction Stir Welding of AA8011-6062 aluminium composite. Experimental results were evaluated using ANOVA. The results can be drawn as follows: , A maximum tensile strength of 153MPa was exhibited by the FSW joints fabricated with the optimized parameters of 1400 r/min rotational speed, 75mm/min welding speed, 7 kN axial force, shoulder diameter of 15.54mm, pin diameter of 5.13mm, and tool material hardness of 600 HV. , Tool rotation speed was the major factor affecting the impact strength , Tool rotational speed of 1200 r.p.m, welding speed of 100 mm/min and Axial force of 5 KN is the optimum machining condition to get a good impact strength , The optimum machining condition to get high tensile strength is tool rotation speed of 1400 r.p.m, welding speed of 75 mm/min and axial force of 125.73 kN. , Welding speed has negligible influence on Tensile strength.

Mukesh Kumar Verma, et al. [2-3] Machining of EN 8 STEEL is important because it is used in axle, gear etc.. so machining parameters optimization plays a very important role for fabrication of component using EN 8 steel. Effect of depth of cut is the most significant factor on feed force in turning operation of EN 8 steel. It has 57.89% contribution which is highest in compare to other input process parameters. Effect of feed is significant factor on feed force in turning operation of EN 8 steel. It has 26.82% contribution. Effect of speed is significant factor on feed force in turning of EN8 steel. It has 14.68% contribution. Effect of depth of cut is the most significant factor on cutting force in turning operation of EN 8 steel. It has 70.37 % contribution which is highest in compare to other input process parameters. Effect of feed is significant factor on feed force in turning operation of EN 8 steel. It has 16.43 % contribution. Effect of speed is significant factor on feed force in turning of EN8 steel. It has 13.06 % contribution.

Ramendra Singh Niranjan et al. [4] Machining of Inconel 718 offers many difficulties in machining but due to high application of this super alloy, machining operation parameters optimization plays a very important role for fabrication of components using Inconel 718. Effect of cutting speed is most significant factor on radial cutting force in turning operation of Inconel 718. It has 97.17% contribution which is highest in compare to other input process parameter. Effect of feed is significant factor on radial cutting force in turning operation of Inconel 718. It has 1.12% contribution which is minimum in all three input process parameter. Effect of depth of cut is significant factor on radial cutting force in turning operation of Inconel 718. It has 1.14% contribution.

Ali Abdallah et al. [5] A parameter design that used the Taguchi method is a simple, systematic, and efficient methodology for the optimization of process parameters. Based on the results obtained in this study, the following can be concluded: the Taguchi optimization method was applied to find the optimal process parameters, which maximized MRR and minimized the surface roughness (Ra) during the cutting process. Taguchi orthogonal array, S/N ratio, and ANOVA were used for the optimization of the cutting parameters. ANOVA results show that feed rate, cutting speed, and depth of cut affect the MRR and surface roughness. A confirmation experiment was conducted and verified the effectiveness of the Taguchi optimization method.

Jean Brice Mandatsy Moungomo et al. [6] This study showed that dry machining results in longer shavings that alter the surface of the workpiece and thus impact the surface finish. Furthermore, this machining condition increases the temperature that promotes the mass concentration of metal particles, especially for 6061 R recycled alloy, which is more ductile than 6061 R-T6 recycled alloy. The use of lubrication during the machining of the two recycled alloys causes chip fragmentation, gives a good surface finish and reduces the mass concentration of metal particles to almost 82%. The lubrication, the high hardness and the reduction of the feed give a good surface finish for the two recycled alloys. Both 6061 R and 6061 R-T6 recycled alloys have good machinability. Thus, we note that the feed, the hardness of the material and the lubrication considerably influence the machinability of the two recycled alloys. The machinability of the two recycled alloys can be assessed by considering the predictive models established in this study.

Ranganath M S et al. [7] This work presented an experimentation approach to study the impact of machining parameters on surface roughness. Strong interactions were observed among the turning parameters. Most significant interactions were found between work materials, feed and cutting speeds. A Systematic approach was provided to design and analyze the experiments, and to utilize the data obtained to the maximum extend. The following are conclusions drawn based on the experimental investigation conducted at three levels by employing Taguchi technique to determine the optimal level of process parameters. From the data collection it has been observed that the increase in cutting speed tends to improve the finish, thus the average surface roughness value decreases.

N. Zeelan Basha [8] This investigation attempts the application of genetic algorithm and found that optimal solution of the cutting conditions achieved on spindle speed (rpm)= 1999.999, feed rate (mm/min)= 0.041 and depth of cut (mm)=0.6 for giving the minimum value of surface roughness(µm)=0.611 using genetic algorithm. The confirmatory test was conducted and found that the percentage of error within 0.32%.

Mahir Akgu¨et al. [9] In this study, the effects of cutting tool coating and cutting parameters on cutting force and surface roughness in turning AA 6061 alloy have been investigated experimentally and statistically.

Rafael F. Garcia et al. [10] This work presented the comparative study between the surface roughness of AA 6082-T6 produced by dry and RQL turning, seeking the parameters optimization. The main conclusions are: • Box–Behnken design (BBD) and analysis of variance (ANOVA) confirmed that the feed rate (f) is the most signifcant input variable on the Ra and Rz mean values among those analysed (vc, f, ap) for both dry and RQL machining. However, the combination of these variables (vc, f, ap) contributes signifcantly to improve the quality of the turned surface. • BBD assisted in determining the most appropriate combination for the optimization of the input variables aiming the lowest Ra and Rz values. • The application of RQL eliminated the waviness (undesired undulation characteristic in the machined surface) produced by the dry machining. • The optimal combination of parameters (input variables) for the lowest roughness values in dry machining was vc=851 m/min, f=0.07 mm/rev. and ap=2 mm.These values measured in validation tests were Ra=(0.44±0.05) µm and Rz=(2.73±0.20) µm. • As for RQL machining, the optimized parameters were vc=403 m/min, f=0.05 mm/rev. and ap=0.5 mm. The roughness values obtained were Ra=(0.18±0.01) µm and Rz=(0.96±0.06) µm. These values are very low for the turning of aluminum alloys under traditional machining conditions. Consequently, the results present the robustness and the reliability of the methodology proposed for this work.

Vladimir Aleksandrovich Rogov et al. [11] The experimental results revealed that: Taguchi method is a powerful technique for designing and analyzing the experimental results in machining researches. The smallest Ra values occurred in turning of AA2024 are 0.814µm and 0.64µm for standard cutting tool and cutting tool with holes in tool holder, respectively. The smallest natural frequency values occurred in turning of AA2024 are 2038.6 Hz and 2124 Hz for standard cutting tool and cutting tool with holes in tool holder, correspondently. The dominant factor affecting the Ra is spindle speed with 81.301% for standard cutting tool; while these variables are feed rate and tool overhang with 47.328% and 46.006%, respectively, for cutting tool with holes in tool holder. Natural frequency is strongly affected by tool overhang with 96.12% and 90.536% for standard cutting tool and cutting tool with holes, respectively. Further study could use composite materials with high damping capacities in the holes of the cutting tool with holes in tool holder to increase stiffness of the cutting tool and to see how the composite materials affect the vibration level and surface roughness.

C. Veera ajay et al. [12] in this work presented the high surface finish can be obtain at higher cutting speed at this condition it have a lower cutting force. If the DOC increases during machining, the quality of the surface finish will reduce. Finally for obtaining polished it is recommended to go for higher cutting speed (s) and lower depth of cut (d) and feed rate (f).

A. Saravana kumar et al. [13] This work demonstrates the application of L27 orthogonal array (Taguchi method) in the optimization of process parameters during turning operation. The following conclusions are drawn based on the experimental results of this study: In this experiment, Taguchi method is effectively applied and optimum result is obtained. The experimental results show that feed is the major influencing parameters among the three controllable factors (Spindle speed, depth of cut) on surface roughness. Minimum surface roughness obtained at optimum level Spindle speed 1200 rpm, feed 0.15 mm/rev and depth of cut 0.5mm. Whenever increases in speed it reduces the surface roughness and increase in feed, increases the surface roughness. Surface roughness and roundness error are minimum at optimum level which generates turned parts with good surface finish.

Pankaj Kumar Singh et al. [14] Machining activity on Al alloy 2011 are performed and cutting parameters for example feed rate, depth of cut and shaft speed have been improved for metal removal rate(MRR) and surface roughness by utilizing Taguchi method. CNC lathe machine is utilized for turning activity so as to decide metal removal rate (MRR). The primary target of the present research is to explore the impact of procedure parameters on the presentation of by and large machining procedure and on surface unpleasantness in turning activity utilizing CNC machining of Aluminium composite.

Mata Dayal Agrahari, et al. [15] the experimental analysis for the effect of control parameters on forces in the dry turning of Al-7075 is performed. The results showed that both the cutting and feed force increases with an increase in feed and depth of cut. Whereas the spindle speed showed the least influence on the forces. Further, the FE based numerical simulation of the turning process is performed to estimate the forces using Deform-3D software. The obtained simulation results are in agreement with the experimental cutting and feed force with 16.40% and 13.79% average relative error. Hence, the simulation-based technique is found suitable to predict the process performance in terms of cutting forces reducing the experimental efforts. This study has also revealed the scope to validate other responses like tool wear, chip morphology, and residual stress, etc. and to compare the obtained simulation results with other FE based simulation tool.

G. List et al. [16] The proposed study allows a better knowledge of the tool wear mechanisms during machining of aluminium alloy with uncoated cemented carbide. At low cutting conditions, the built-up edges are formed on the tool rake face and take over the function of the cutting edge. The interface temperature is low and the adhesion of BUE is principally achieved in mechanical way. Continuous sliding of BUE fragments between tool and chip causes an increasing tool wear. These particles coming off with the chip material can be a cause of abrasion on the tool rake face. At low cutting speed, as the adhesion mechanism is more mechanical than physical, the use of large rake angle and polished tool surface can be suggested. At severe cutting conditions, temperature is higher; mechanisms of tool wear involve chemical action and diffusion. On the one hand, aluminium elements diffuse into the tool through the Co binder phase. No diffusion of tool chemical species towards the chip was detected. On the other hand, a thin built-up layer is formed on the tool surface.

P. Venkata Ramaiah et al. [17] The influence of spindle speed, feed and depth of cut on cutting temperature and cutting forces in turning operation is studied. Optimum machining parameter combination has been found using fuzzy logic technique which yields good results in turning of Al 6061 with minimum cutting force and temperature. This method can also be used for other process while turning different materials.

Prabakaran M P et al. [18] The present work deals with the mathematical modelling and analysis of machining response such as the surface roughness and tool wear in the turning of aluminum alloy 6061. There are several process parameters namely spindle speed, depth of cut and feed rate used to determine the quality of surface roughness. Experiments are conducted as per central composite face centered design. Among the following process parameter the spindle speed, depth of cut and feed rate for the purpose of analysis. Response surface methodology is utilized to develop an effective mathematical model to predict optimum level.

M.S. Najiha et al. [19] This paper presents an experimental investigation of coated carbide cutting tool performance on the surface roughness of aluminum alloy 6061-T6 machining through end mill processes using the minimum quantity lubrication technique. It is observed that the surface roughness depends significantly on depth of cut and feed rate, followed by spindle speed for both the coated carbide inserts. The performance of the dual-layered coating of TiAlN+TiN is competent as compared to the surface quality obtained with TIAlN-coated inserts.

Sohail Akram et al. [20] The aim of this research was to investigate the residual stresses in an aluminum alloy Al-6061 workpiece after machining. Numerical simulations of orthogonal cutting of the workpiece were carried out at various preselected combinations of feed rate and cutting speed. The simulation results showed that residual stresses were insensitive to changes in cutting speed, however, residual stresses were clearly affected by the change in feed rate.

Devendra Singh et al. [21] in this paper aims to investigate the effect of nose radius on surface roughness, in CNC turning of Aluminium (6061) in dry condition. The effect of cutting conditions (speed, feed and depth of cut) and tool geometry (nose radius) on surface roughness were studied and analysed. The analysis of the results for surface roughness shows that the nose radius is the most significant factor followed by feed.

Sonali Priyadarshini et al. [22] In this paper, the effects of the machining parameters were evaluated on surface roughness, when step turning of Al Alloy under dry cutting condition were performed by using Taguchi methodology.

Every metal working industry is facing the problem of improving the production rate without sacrificing these parameters. The present paper reveals the facts about why one cannot increase the cutting parameters of the turning process in order to achieve the higher rate of production. Further there may some another methods which ensures improving of the production rate without affecting the above said factors i.e. tool life, surface finish and cost of production. Such methods should be ideal one for the mass production industry where there is a large number of quantities being machines with little or no variations at all.

MATERIALS AND METHODS

Type 304 is the most versatile and widely used stainless steel. sometimes it is referred to its old name 18/8 which is derived from the nominal composition of type 304 being 18% chromium and 8% nickel. Stainless steel 304 is an austenitic grade that can be severely deep drawn. This property has resulted in 304 being the dominant grade used in applications like sinks and saucepans.

Type 304L is the low carbon version of Stainless steel 304. It is used in heavy gauge components for improved weldability. Some products such as plate and pipe may be available as “dual certified” material that meets the criteria for both 304 and 304L. 304H Stainless Steel304H, a high carbon content variant, is also available for use at high temperatures.

Figure-Stainless Steel 304

Chemical Composition

The following table shows the chemical composition of Stainless Steel 304-

Table 1

Element	**Content (%)**
Carbon, C	0.0-0.07
Manganese, Mn	0.0-2.0
Silicon, Si	0.0-1.0
Phosphorus, P	0.0-0.05
Sulphur, S	0.0-0.03
Chromium, Cr	17.50-19.50
Nickel, Ni	8.00-10.50
Iron, Fe	Balance (66.345-74)
N	0.00-0.11

MECHANICAL PROPERTIES

Mechanical Properties	Metric
Ultimate Tensile Strength	505 MPa
Tensile Yield Strength	215 MPa
Hardness (Rockwell B)	70
Modulus of Elasticity	193-200 GPa
Charpy Impact	325 J

Experimental Procedure:

The experiment was done to analyze the effect of control parameters such as feed rate, speed and depth of cut on surface roughness. The design parameters were studied at three levels & three factors. The design of experiments is based on Taguchi method of selection of orthogonal array L9. The experiment was carried out in dry condition on NH-22 LATHE MACHINE.

Figure – NH-22 Lathe Machine

Cutting Tool

Cemented carbides are a class of hard materials used extensively for cutting tools, as well as in other industrial applications. It consists of fine particles of carbide cemented into a composite by a binder metal.

Dynamometers for Force Measurement

The Kistler 9257B, which can measure the forces and torque in the 3-orthogonal axis.

Figure – Dynamometer

Process variables and their Limits: The working ranges of the parameters for subsequent design of experiment, based on Taguchi's L18 Orthogonal Array (OA) design have been selected. The process variables (with their units and notations) are listed in Table -

Design of Experiments

A well planned set of experiments, in which all parameters of interest are varied over a specified range, is a much better approach to obtain systematic data. Mathematically speaking, such a complete set of experiments ought to give desired results.

In the present investigation experiment consists of turning of Stainless Steel 304 alloy on a lathe machine. Three process parameters along with their 3-levels are given below-

Table 1. Process parameters and their levels

Factors	Unit	Level-1	Level-2	Level-3
Speed	Rpm	325	420	490
Feed	mm/rev	0.1	0.16	0.2
DOC	mm	0.5	1.0	1.5
Cutting Fluid		dry	wet	

RESULT DISCUSSION AND ANALYSIS

The following observation noted for experiments carried out for taguchi's orthogonal L18 array.

Table- experimental results with L18 Orthogonal array

Exp.	Cutting Fluid	N (rpm)	Feed (mm/rev)	Doc (mm)	Fx (N)	Fy (N)	Fz (N)	MRR (mm3/s)
1	Dry	325	0.1	0.5	1	5	10	0.425
2	Dry	325	0.16	1.0	23	36	65	2.721
3	Dry	325	0.2	1.5	88	95	72	7.633
4	Dry	420	0.1	0.5	1	6	12	0.549
5	Dry	420	0.16	1.0	12	2	20	3.512
6	Dry	420	0.2	1.5	61	53	39	9.891
7	Dry	490	0.1	0.5	44	38	29	2.564
8	Dry	490	0.16	1.0	57	51	22	9.231
9	Dry	490	0.2	1.5	38	39	18	1.282
10	Wet	325	0.1	1.5	135	105	52	3.826
11	Wet	325	0.16	0.5	57	63	49	0.680
12	Wet	325	0.2	1	58	54	62	3.401
13	Wet	420	0.1	1	99	88	93	2.199
14	Wet	420	0.16	1.5	80	74	77	7.197
15	Wet	420	0.2	0.5	71	81	62	1.099

16	Wet	490	0.1	1.5	56	56	40	5.728
17	Wet	490	0.16	0.5	54	62	64	1.026
18	Wet	490	0.2	1	52	46	53	5.131

FEED FORCE:

Regression Equation-

FEED FORCE = 24.9 + 0.0 Cutting fluid _Dry + 37.4 Cutting fluid _Wet + 0.0 Spindle Speed_325 – 6.3 Spindle Speed_420 – 10.2 Spindle Speed_490 + 0.0 Feed_0.10 – 8.8 Feed_0.16 + 5.3 Feed_0.20 + 0.0 Depth of Cut_0.5 + 11.0 Depth of Cut_1.0 + 42.5 Depth of Cut_1.5

Table- Analysis of Variance for Feed Force

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	7	13079.1	1868.4	2.92	0.061
Cutting Fluid	1	6309.4	6309.4	9.85	0.011
N	2	316.3	158.2	0.25	0.786
FEED	2	614.3	307.2	0.48	0.633
D.O.C	2	5839.0	2919.5	4.56	0.039
Error	10	6405.4	640.5		
Total	17	19484.5			

Table- Response Table for Signal to Noise Ratios (Smaller is better) for feed force

Level	Cutting Fluid	N(rpm)	FEED(mm/rev)	DOC(mm)
1	-24.78	-29.85	-25.06	-23.06
2	-36.88	-28.71	-31.96	-31.86
3		-33.92	-35.47	-37.56
Delta	12.10	5.20	10.41	14.49
Rank	2	4	3	1

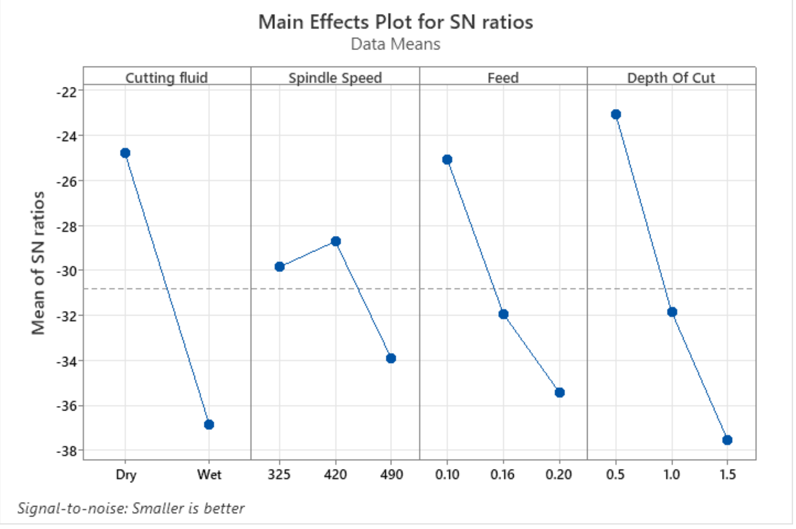

Figure- Effect of process parameters on feed force

Table - Response Table for Means for Feed Force

Level	Cutting Fluid	N(rpm)	FEED(mm/rev)	DOC(mm)
1	36.11	60.33	56.00	37.00
2	73.56	54.00	47.17	48.00
3		50.17	61.33	79.50
Delta	37.44	10.17	14.17	42.50
Rank	2	4	3	1

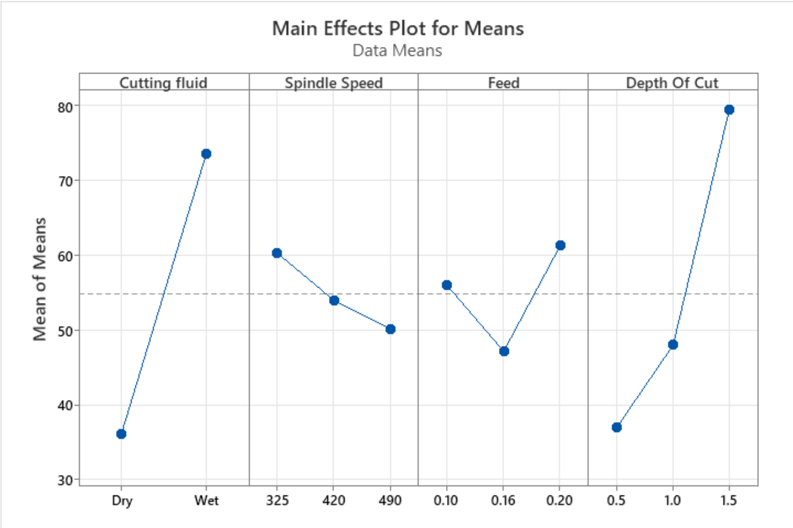

Figure- Effect of process parameters on feed force

• For feed force the cutting fluid is most significant factor as can be seen from p- value and followed by depth of cut, feed and spindle speed.

• R-sq value is around 70% indicating a fair variation of response around its means due to above factors from parameter level values. R-sq predicted value is very small which indicates that the system explains very little variability of response data around its means.

• The main effect plot for means shows the optimal conditions for feed force at dry condition when spindle speed is 490 RPM, feed is 0.16mm/rev and depth of cut is 0.5mm.

CUTTING FORCE

Regression Equation-

CUTTING FORCE = 30.2 + 0.0 Cutting fluid _Dry + 32.7 Cutting fluid _Wet + 0.0 Spindle Speed_325 – 10.7 Spindle Speed_420 – 12.7 Spindle Speed_490 + 0.0 Feed_0.10 – 1.7 Feed_0.16 + 13.3 Feed_0.20 + 0.0 Depth of Cut_0.5 + 1.3 Depth of Cut_1.0 + 31.3 Depth of Cut_1.5

Table- Analysis of Variance for Cutting Force

Source	**DF**	**Adj SS**	**Adj MS**	**F-Value**	**P-Value**
Regression	7	9936.7	1419.5	2.37	0.104
Cutting Fluid	1	4802.0	4802.0	8.03	0.018
N	2	556.4	278.2	0.46	0.641
FEED	2	811.1	405.6	0.68	0.530
D.O.C	2	3767.1	1883.6	3.15	0.087
Error	10	5983.8	598.4		
Total	17	15920.4			

Table- Response Table for Signal to Noise Ratios (Smaller is better) for Cutting Force

Level	Cutting Fluid	N(rpm)	FEED(mm/rev)	DOC(mm)
1	-26.57	-32.76	-29.24	-28.56
2	-36.62	-28.42	-30.09	-29.26
3		-33.61	-35.47	-36.97
Delta	10.04	5.19	6.23	8.41
Rank	1	4	3	2

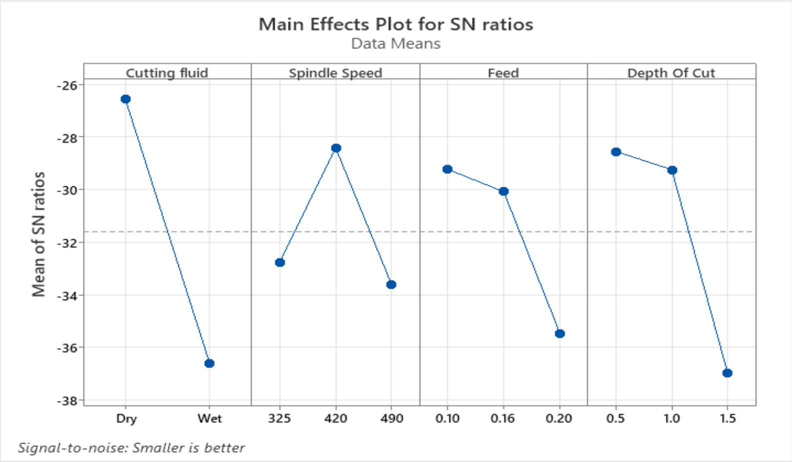

Figure- Effect of process parameters on Cutting Force

Table - Response Table for Means for Cutting Force

Level	Cutting Fluid	N(rpm)	FEED(mm/rev)	DOC(mm)
1	37.22	6133	49.67	42.67
2	69.89	50.67	48.00	44.00
3		48.67	63.00	74.00
Delta	32.67	12.67	15.00	31.33
Rank	1	4	4	2

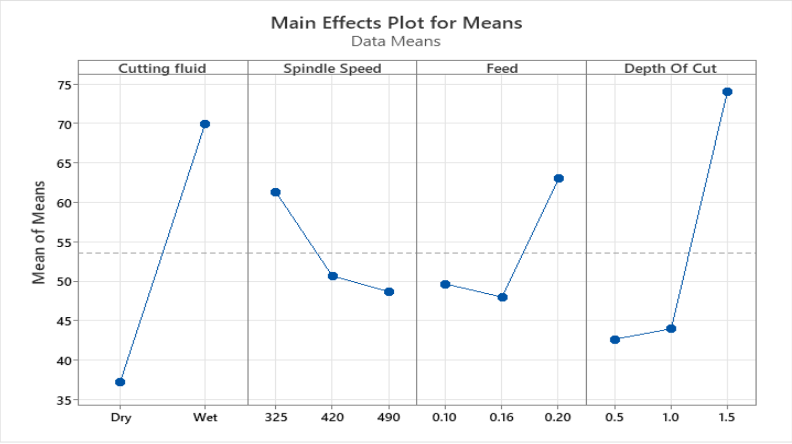

Figure- Effect of process parameters on Cutting Force

• For cutting force, the cutting fluid is most significant factor as can be seen from p-value and followed by depth of cut, feed and spindle speed.
• R-sq value is above 60% indicating a fair variation of response around its means due to above factors from parameter level values. R-sq predicted value is very small which indicates that the system explains very little variability of response data around its means.
• The main effect plot for means shows the optimal conditions for cutting force is at dry condition when spindle speed is 490 RPM, feed is 0.16mm/rev and depth of cut is 0.5mm.

RADIAL FORCE

Regression Equation-

RADIAL FORCE = 18.4 + 0.0 Cutting fluid _Dry + 29.56 Cutting fluid _Wet + 0.0 Spindle Speed_325 – 1.0 Spindle Speed_420 – 13.8 Spindle Speed_490 + 0.0 Feed_0.10 + 10.3 Feed_0.16 + 11.8 Feed_0.20 + 0.0 Depth of Cut_0.5 + 18.0 Depth of Cut_1.0 + 14.7 Depth of Cut_1.5

Table- Analysis of Variance for Radial Force

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	7	3243.6	891.9	2.33	0.109
Cutting Fluid	1	3930.9	3930.9	10.28	0.009
N	2	714.1	357.1	0.93	0.425
FEED	2	498.1	249.1	0.65	0.542
D.O.C	2	1100.4	550.2	1.44	0.282
Error	10	3822.9	382.3		
Total	17	10066.4			

Table- Response Table for Signal to Noise Ratios (Smaller is better) for Radial Force

Level	Cutting Fluid	N(rpm)	FEED(mm/rev)	DOC(mm)
1	-28.12	-32.74	-29.27	-28.59
2	-35.51	-32.06	-32.80	-33.54
3		-30.64	-33.38	-33.32
Delta	7.38	2.10	4.10	4.95
Rank	1	4	3	2

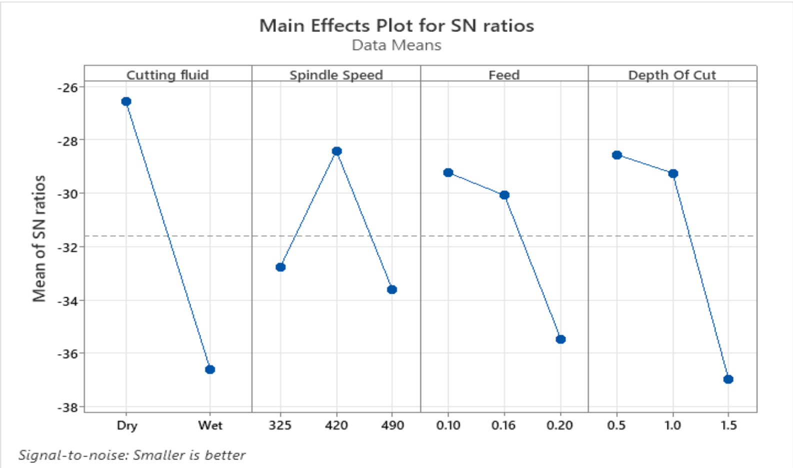

Figure- Effect of process parameters on Radial Force

Table - Response Table for Means for Radial Force

Level	Cutting Fluid	N(rpm)	FEED(mm/rev)	DOC(mm)
1	31.78	51.50	39.17	35.67
2	61.33	50.50	49.50	53.67
3		37.67	51.00	50.33
Delta	29.56	13.83	11.83	18.00
Rank	1	3	4	2

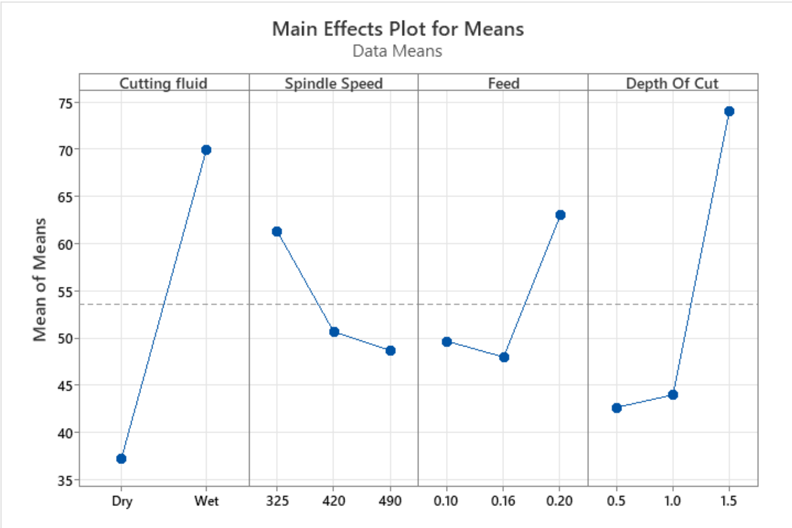

Figure- Effect of process parameters on Radial Force

• For radial force, the cutting fluid is most significant factor as can be seen from p- value and followed by depth of cut, spindle speed and feed.

• R-sq value is around 60% indicating a fair variation of response around its means due to above factors from parameter level values. R-sq predicted value is very small which indicates that the system explains very little variability of response data around its means.

• The main effect plot for means shows the optimal conditions for radial force is at dry condition when spindle speed is 490RPM , feed is 0.10 mm/rev and depth of cut is 0.5mm.

Material Removal Rate (MRR)

Regression Equation-

MRR = -0.762 + 0.0 Cutting fluid _Dry – 0.750 Cutting fluid _Wet + 0.0 Spindle Speed_325 + 1.080 Spindle Speed_420 + 1.055 Spindle Speed_490 + 0.0 Feed_0.10 + 1.624 Feed_0.16 + 2.182 Feed_0.20 + 0.0 Depth of Cut_0.5 + 2.411 Depth of Cut_1.0 + 6.537 Depth of Cut_1.5

Table- Analysis of Variance for MRR

Source	**DF**	**Adj SS**	**Adj MS**	**F-Value**	**P-Value**
Regression	7	153.624	21.9463	24.87	0.000
Cutting Fluid	1	2.529	2.5290	2.87	0.121
N	2	4.561	2.2804	2.58	0.125
FEED	2	15.481	7.7092	8.74	0.006
D.O.C	2	131.116	65.5579	74.29	0.000
Error	10	8.824	0.8824		
Total	17	162.448			

Table- Response Table for Signal to Noise Ratios (smaller is Better) for MRR

Level	Cutting Fluid	N(rpm)	FEED(mm/rev)	DOC(mm)
1	-8.241	-6.309	-4.880	2.132
2	-8.249	-8.541	-8.959	-9.911
3		-9.885	-10.895	-16.955
Delta	0.009	3.576	6.016	19.087
Rank	4	3	2	1

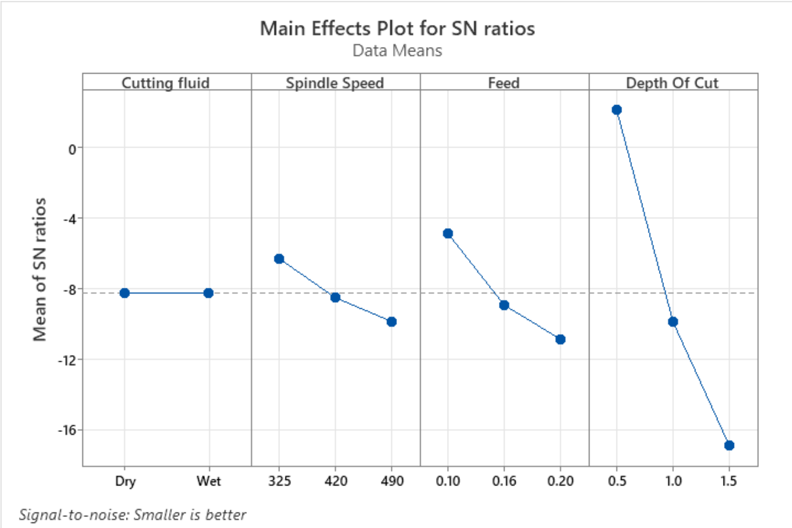

Figure- Effect of process parameters on MRR

Table - Response Table for Means for MRR

Level	Cutting Fluid	N(rpm)	FEED(mm/rev)	DOC(mm)
1	4.2009	3.1143	2.5575	0.8435
2	3.4512	4.1945	4.1812	3.2547
3		4.1693	4.7395	7.3800
Delta	0.7497	1.0802	2.1820	6.5365
Rank	4	3	2	1

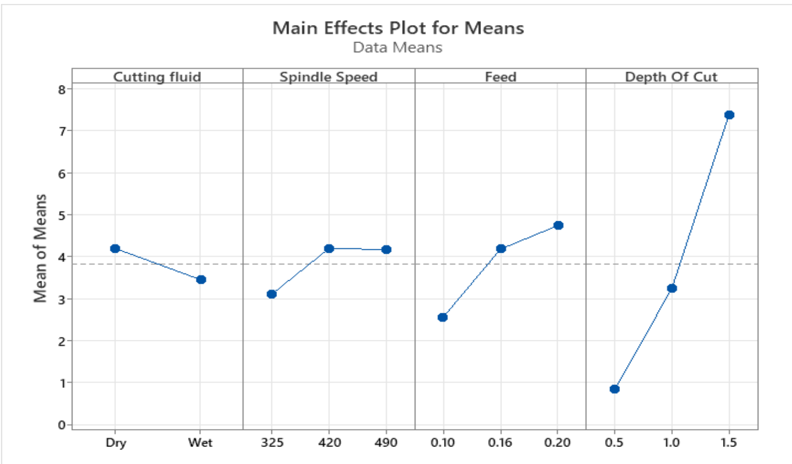

Figure- Effect of process parameters on MRR

• For material removal rate , the depth of cut is most significant factor as can be seen from p-value and followed by feed , cutting fluid and spindle speed.
• R-sq value is around 95% indicating a good prediction of variation of response around its means due to above factors from parameter level values. R-sq predicted value is above 80% which indicates that the system explains very little variability of response data around its means.
• From main effect plot for means shows the optimal conditions for material removal rate is at dry condition when spindle speed is 420 RPM, feed is 0.20 mm/rev and depth of cut is 0.5mm.

CONCLUSION

The study demonstrates that when feasible process parameters are selected, 304 Stainless steel alloy could be efficiently turned using ceramic carbide insert. From the analysis of the experiment we can conclude the following statements-

For feed force the cutting fluid is most significant factor , for cutting force , the cutting fluid is most significant factor , for radial force , the cutting fluid is most significant factor and for material removal rate, depth of cut is most significant factor.

It also can be concluded that from main effect plot for means which shows that the optimal conditions for feed force at dry condition when spindle speed is 490 RPM, feed is 0.16mm/rev and depth of cut is 0.5mm. The main effect plot for means shows the optimal conditions for cutting force is at dry condition when spindle speed is 490RPM, feed is 0.16mm/rev and depth of cut is 0.5mm. The main effect plot for means shows the optimal conditions for radial force is at dry condition when spindle speed is 490 RPM, feed is 0.10 mm/rev and depth of cut is 0.5mm. From main effect plot for means shows the optimal conditions for material removal rate is at dry condition when spindle speed is 420 RPM, feed is 0.20 mm/rev and depth of cut is 0.5mm.

The research into the machining of 304 stainless steel alloy is continuing in several fronts, including turning processes. An experimental approach to the evaluation of material removal rate, feed force, radial force and cutting force in naming 304 Stainless steel alloy by coated cemented carbide using Taguchi method and ANOVA.

SCOPE FOR FUTURE WORK

The study reviewed the machinability performance of different steels under various cutting fluids and various application methods. With the advancements in cutting tool materials, coatings, and tool side texturing has drawn attention of researchers. Further, restructuring of MQL systems by applying new nozzle design, nozzle distance, and integrating it with either cleaning jet, electrostatic or ultrasonic vibration has also been reported by peers. Many research groups are also examining nanoparticle additives for better cooling and lubricating ability in MQL based systems.

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