OPTIMIZING THE EFFECT OF CUTTING PARAMETERS IN CNC TURNING

K RAJESH
Registration No: 24618040
Research Scholar
Department of Mechanical
Shri JJT University

DR. S CHAKRADHAR GOUD
Research Supervisor
Department of Mechanical
Shri JJT University

DR. MUPPALA JANARDHAN
Co-Supervisor
Principal & Professor
Springfields Engineering College.

Abstract

Modern manufacturers, seeking to remain competitive in the market, rely on their Manufacturing engineers and production personnel to quickly and effectively set up manufacturing processes for new products. The impact of cutting parameters in the turning method normally impacts the floor roughness and machining time of product. Surface roughness is a vital aspect at the factor of view first-rate of the product. The important cutting parameters in turning technique on the whole cutting speed, feed rate, depth of cut, spindle velocity affect the surface end of the completed material. This paper evaluations the optimization of cutting parameters in turning process using Taguchi method. Taguchi technique is an effective device of optimization. A particularly designed orthogonal array of taguchi is used to look at the impact of slicing parameters thru the small range of experiments. In the process of metal cutting, the cutting performance of cutting tools varies with different parameter combinations, so the results of the performance indicators studied are also different. So in order to achieve the best performance indicator it is necessary to get the best parameter matching combination. In addition, in the process of metal cutting, the value of the performance index is different at each stage of the processing process. In order to consider the cutting process more comprehensively, it is necessary to use a comprehensive evaluation method that can evaluate the dynamic process of performance indicators

Keywords: *Manufacturing process, cutting parameters, optimizationturning method, Taguchi method*

Introduction

Hundreds, if not thousands, of parameters define how a CNC should operate in its many forms of automation. When talking about parameters, I usually stress the need to have some kind of support for them. You, as the CNC operator, are responsible for ensuring its proper operation. The convenience of backing up to a flash drive on modern CNC machines leaves no room for laziness in this regard. In addition, in the event of a CNC failure, having a backup of your parameters might save you a lot of time. Parameter settings are at the root of almost every CNC-related problem. An incorrect parameter setting is usually to blame for any undesirable machine behavior. Every CNC operator has to be aware of specific safety, efficiency, and simplification requirements.

Parameters for CNC Turning Machines

CNC, which stands for "computer numerical control," is cutting-edge equipment that can be instructed to carry out a wide range of machining operations. Since the output of these machines is governed by the needs of the work piece, it is very precise. There are now several types of CNC machines available for usage. The CNC turning machine is one such tool, and it is used to manufacture many different kinds of cylinders. In such devices, the cutting tool moves in a straight line while the work item is continually rotated.

Cutting Parameters for CNC Turning Machines

The cutting cycle may be reduced in length and the cutting machine's price reduced if the correct cutting parameters are used to get a clean cut. Multiple variables may be changed to modify the cutting tool's speed and motion to suit the material of the workpiece and the tool's size. Cutting speed is defined as the rate at which the cutting tool moves across the surface of the workpiece in feet per minute (SFM). As a rule, the material and the method of cutting will dictate the cutting speed. For instance, perfect grooving necessitates a lower cutting speed.

The cutting feed measures how far the cutting tool moves with each revolution. A single inch-turn is the standard measurement for this (IPR). Depending on the setup, either the tool or the workpiece may be fed into the tool. Spindle revolutions per minute (RPM) may be determined by dividing the cutting speed by the diameter of the workpiece (R.P.M). The pace at which this happens depends on a number of factors, including the region being cut into and the diameter of the incision. During a cutting operation, the "feed rate" is the speed at which the cutting tool penetrates the material. Spindle RPM plus cutter RPM equals total RPM (inches per minute) (IPM). This metric quantifies the depth of a tool's cut perpendicular to the axis of the material. A deep axial cut is necessary to lessen the strain on the cutting tool.

The radial depth of cut is the maximum depth to which a tool may penetrate a material when cutting in a circular motion. It has been suggested that decreasing the feed rate would enhance the cutting tool's performance.

Parametric Program

Increased productivity in the manufacturing sector may be possible because to parametric programming, a function of today's Computer Numerical Control (CNC) equipment. Many CNC procedures may benefit from the use of parametric programming. Some examples include creating a single CNC programmed for a set of components that all have a similar design, creating macros to automate the machining of unique design characteristics, and creating subprograms to group together a set of parts that are different in design but need the same operations. When used in these contexts, parametric programming may drastically cut down on the amount of time spent programming individual parts, which in turn speeds up both the production process and the creation of new products. These use cases are well suited to group technology manufacturing, in which families of identical components are assembled and then machined using either a set of interconnected machine tools or a single, flexible machining center. Grouping by design similarity and grouping by comparable machining needs are two typical techniques in group technology.

Despite being underutilized, parametric programming has the ability to boost CNC operations' productivity. For businesses that use group technology manufacturing, in which components with comparable design or operational needs are handled inside a machine cell, this is a very useful feature. In parametric programming, a parametric expression is used to provide the axis location (x, y, z, a, etc.), feed, and speed functions. Parametric programming is available on most CNC machines, allowing the operator to input a sub- or individual-part programmed directly into the controller. Then, if machining a comparable component or performing a similar operation on many parts is required, the corresponding part programmed is launched. The feature's parameters, such as the pocket's length, breadth, and depth, are loaded into the main programmed upon loading, and then passed a cyclically to the parametric subprogram. By taking this route, we can cut down on the overall size and complexity of the software as well as the amount of time spent on its development.

Research Methodology

Cutting Tool, high-speed tool steel is employed for the cutting tools. The high cutting rates at which high-speed tool steels can treat materials have made them popular. To be more specific, they are iron-based alloys that include carbon, chromium, molybdenum, vanadium, tungsten, or any combination thereof, and in certain instances, a substantial quantity of cobalt. As can be seen in Figure, the ideal solidification reaction, wear resistance, heat resistance, and viscosity for effective industrial cutting are all achieved by a careful balancing act between the carbon and alloy content. Table details the constituent chemicals that make up the blade. Table details the geometric characteristics of the single-point cutting tool used in this investigation.

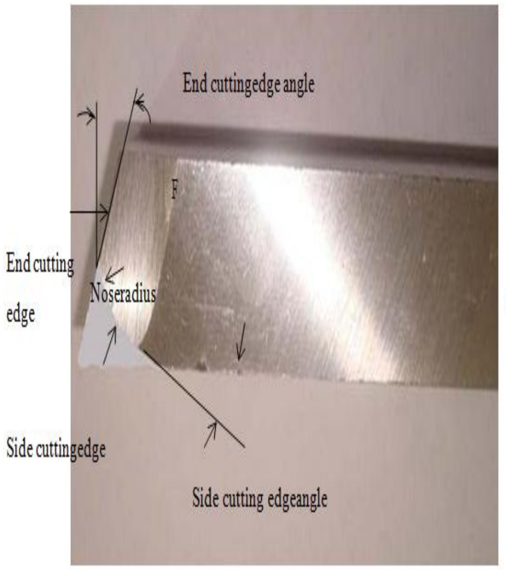


Figure: Single point HSS cutting tool

Table: Alloying composition of HSS cutting tool

C	Cr	W	V	Mn	Si	Fe
0.65-0.80	3.75-4.0	17.25	0.9-1.3	0.1-0.4	0.2-0.4	Balance

Table: Geometry of Single point cutting tool

Angle	Range (Degree)
Side cutting Edge Angle	15 to 18
End Cutting Edge Angle	8 to 15
End Relief angle	5 to 154
Rake angle	8 to 15
Clear anceangle	5 to 6

Design of Experiments

Taguchi analysis for L9 orthogonal array for turning operation

Table displays the feed rate, cutting speed, depth of cut, tool nose radius, and three cutting depth settings for milling an Al 6063T6 L9 orthogonal array. Taguchi study of an L16 or thoronol array for a drilling operation

The L16 orthogonal array of Al 6063T6 is represented by four parameters in Table, including federate, speed, depth of cut, drill bit die, and two levels.

Table Assignment of the levels for L9 orthogonal Array for turning operation

CUTTING PARAMETERS	UNIT	NOTATION	LIMITS	
			Level 1	Level 2
Federate (A)	mm/min	F	0.1	0.2
Speed (B)	RPM	V	500	1000
Depth of cut (C)	mm	D	5	10
Drill Bit diameter (D)	mm	R	10	12

RESULTS AND DISCUSSIONS

In this chapter, we show the findings from our experimental analysis and research on machinability during the turning process, utilizing the Taguchi technique. Using an orthogonal array, we ran few experiments and the data is shown in the tables below.

Table: Results of L9 turning of Al6063T6

Exp no.	Surface roughness (µm)	Material removal rate (mm^3/min)	Machining time (min)	Machining force (N)	Power (W)
1	2.023	235.619	11.475	3.000	1.963
2	7.141	392.699	6.602	2.500	3.272
3	7.682	628.319	4.421	2.667	5.236
4	1.765	1570.796	1.792	20.000	13.090
5	7.027	2513.274	1.208	16.000	20.944
6	7.214	942.478	2.476	4.000	7.854
7	1.581	4398.230	0.640	56.000	36.652
8	4.927	1649.336	1.954	10.500	13.744
9	7.649	2748.894	0.849	11.667	22.907

Table: Results of L16 turning of Al6063T6

Exp no.	Surface roughness (µm)	Material removal rate (mm^3/min)	Machining time (min)	Machining force (N)	Power (W)
1	1.348	235.619	10.375	3.000	1.963
2	1.253	235.619	14.147	3.000	1.963
3	1.393	628.319	4.008	8.000	5.236
4	1.455	628.319	5.010	8.000	5.236
5	7.522	235.619	12.890	1.000	1.963
6	6.439	235.619	15.719	1.000	1.963
7	8.423	628.319	4.834	2.667	5.236
8	3.096	628.319	6.013	2.667	5.236
9	1.229	1649.336	1.460	21.000	13.744
10	0.747	1649.336	2.021	21.000	13.744
11	0.997	4398.230	0.589	56.000	36.652
12	0.905	4398.230	0.766	56.000	36.652
13	5.840	1649.336	1.482	7.000	13.744
14	5.242	1649.336	2.088	7.000	13.744
15	4.770	4398.230	0.581	18.66	36.65

				7	2
16	3.492	4398.230	0.707	18.667	36.652

Table: Results of L9 Drilling of Al6063T6

Exp no.	Surface roughness (µm)	Material removal rate (mm^3/min)	Machining time(min)	Machining force (N)	Power (W)
1	4.692	0.314	8134.586	0.250	0.327
2	3.345	0.312	7846.294	0.233	0.458
3	2.782	0.318	8034.159	0.225	0.589
4	3.238	0.990	2582.408	0.700	0.916
5	3.120	0.754	3291.167	0.600	1.178
6	1.938	0.334	7767.039	0.250	0.654
7	2.446	1.802	1561.627	1.350	1.767
8	2.433	0.707	3982.148	0.500	0.982
9	2.036	0.660	4322.727	0.525	1.374

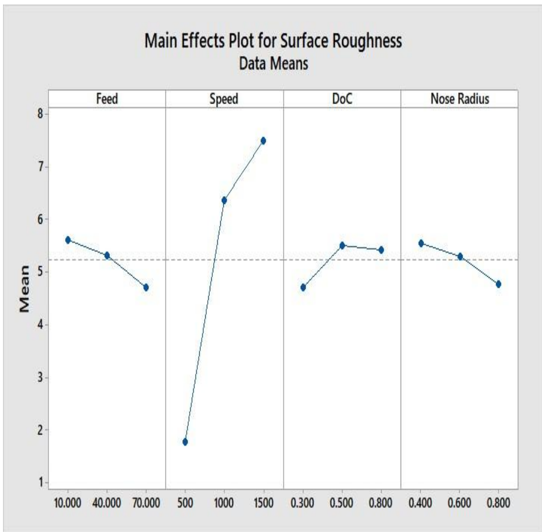
Table: Results of L16 drilling of Al6063T6

Exp no.	Surface roughness (µm)	Material removal rate (mm^3/min)	Machining time (min)	Machining force (N)	Power (W)
1	2.625	0.785	4008.347	1.000	0.654
2	2.571	0.942	3379.586	1.200	0.785
3	2.655	1.571	1980.595	1.000	0.654
4	3.790	1.885	1788.037	1.200	0.785
5	3.521	0.393	8865.520	0.500	0.654
6	2.624	0.471	6680.578	0.600	0.785
7	2.787	0.785	4008.347	0.500	0.654
8	2.385	0.942	3418.884	0.600	0.785
9	3.291	1.571	1980.595	2.000	1.309
10	3.436	1.885	1670.144	2.400	1.571
11	2.892	3.142	1013.876	2.000	1.309
12	2.672	3.770	825.248	2.400	1.571
13	3.096	0.785	4008.347	1.000	1.309
14	2.543	0.942	3536.777	1.200	1.571
15	2.124	1.571	2004.173	1.000	1.309
16	3.433	1.885	1768.388	1.200	1.571

Effect Of Cutting Parameters on Surface Roughness

An Al6063T6 component was manufactured on a computer numerically controlled lathe. The experimental setup, used cutting settings, and measured machinability factors are all tabulated. Tally Surf is used to keep track of the surface roughness of the material being worked on. The next section addresses how the cutting settings used affect the final surface roughness.

Main Effect of Cutting Parameters on Turning Of Al6063t6 Alloy Using L9 Orthogonal Array

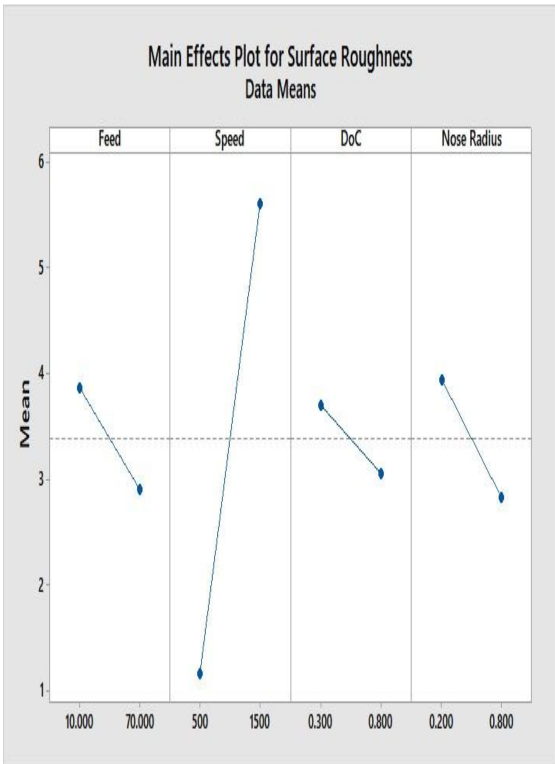


Graph: Main effect plot for surface roughness of A16063T6 turning under L9 array

Graph shows how a rougher surface is produced on the workpiece when the cutting speed is increased. When the feed rate and the Nose radius are both increased, the influence on the surface roughness is attenuated. As the depth of cut increases, the surface roughness gradually improves. Smoothest surfaces are achieved with a bigger feed rate, slower speed, and shallower depth of cut, and larger nose radius, as seen in Graph

Cutting tool surface roughness is reduced from 5.615 m to 4.719 m when the feed rate is increased from 10 to 70 mm/min. Roughness increases from 1.789 to 7.515 micrometers when rotational speed is increased from 500 to 1500 revolutions per minute. The surface roughness went from 5.566 micrometers to 4.791 micrometers when the nose radius of the tool was increased from 0.4 millimeters to 0.8 millimeters.

Main Effect of Cutting Parameters On Turning Of Al6063t6 Alloy Using L16 Orthogonal Array

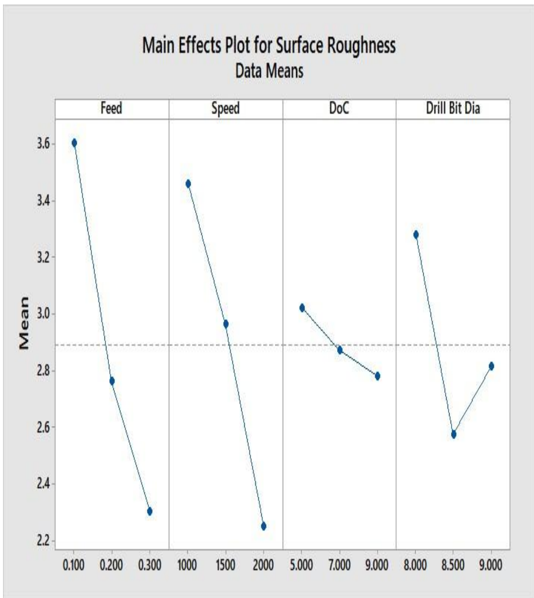


Graph: Main effect plot for surface roughness of A16063T6 turning under L16 array

Surface roughness rises with cutting speed, as seen in Graph 6.2. When the feed rate, depth of cut, and tool Nose radius are increased, the surface roughness value drops. In Graph 5.2, we see that the best results come from a combination of a high feed rate, a low speed, a deep cut, and a large nose radius.

Reduced surface roughness is achieved by raising the feed rate of the cutting tool from 10 to 70 millimeters per minute (from 3.866 m to 2.903 m). When the rotational speed is increased from 500 to 1500 RPM, the surface roughness rises from 1.166 micrometers to 5.603 micrometers (m). The surface roughness is reduced from 3.703 m to 3.066 m when the depth of cut is increased from 0.3 mm to 0.8 mm.

Main Effect of Cutting Parameters On Drilling Of Al6063t6 Alloy Using L9 Orthogonal Array

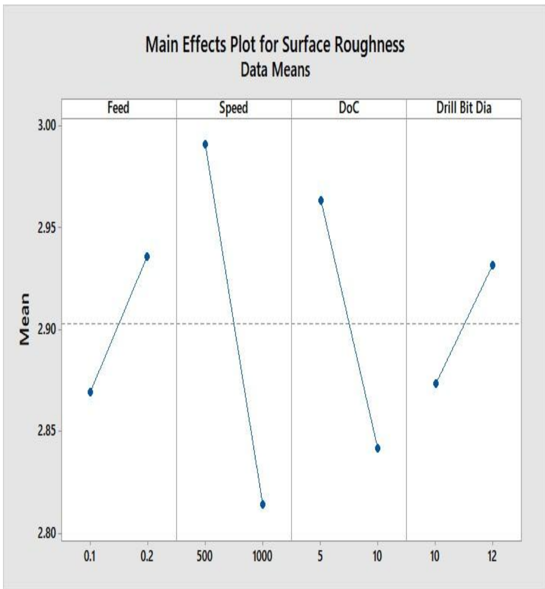


Graph: Main effect plot for surface of roughness of A16063T6 drilling under L9 array

Graph demonstrates how a reduction in surface roughness occurs as cutting speed rises. An increase in feed rate and depth of cut results in a smoother surface. Up to a particular diameter of drill bit, the surface roughness reduces. Graph shows that in order to get the smoothest possible surface, it is necessary to use a large feed rate, a large speed, a large depth of cut, and an average diameter drill bit.

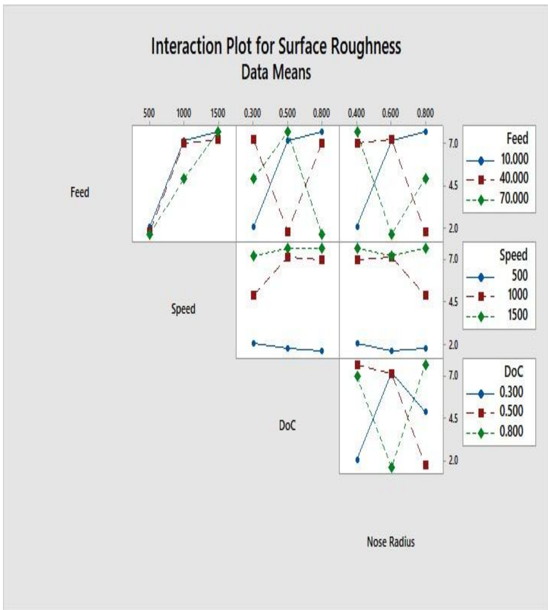
Surface roughness is found to reduce from 3.283 m to 2.576 m when the drill bit diameter is increased from 8 mm to 9 mm, and to rise from 2.576 m to 2.818 m when the drill bit diameter is decreased from 8.5 mm to 9 mm. By increasing the tool's depth of cut from 5 mm to 9 mm, the surface roughness is reduced from 2.889 m to 2.783 m.

Main Effect Of Cutting Parameters On Drilling Of Al6063t6 Alloy Using L16 Orthogonal Array



Graph : Main effect for surface roughness of A16063T6 drilling under L16 array

According to Graph, surface roughness reduces with increasing cutting speed. Surface roughness levels tend to rise when feed rates and drill bit sizes are increased. An example of how a low feed rate, quick speed, high depth of cut, and a tiny diameter drill bit may help bring down surface roughness to an acceptable level is shown in Graph. By doubling the feed rate of the cutting tool from 0.1 to 0.2 mm/min, the surface roughness is improved from 2.870 m to 2.936 m. When the depth of cut is increased from 5 mm to 10 mm, the surface roughness is reduced from 2.963 m to 2.842 m. By switching from a 10 mm to a 12 mm drill bit, the surface roughness is increased from 2.874 m to 2.932 m.

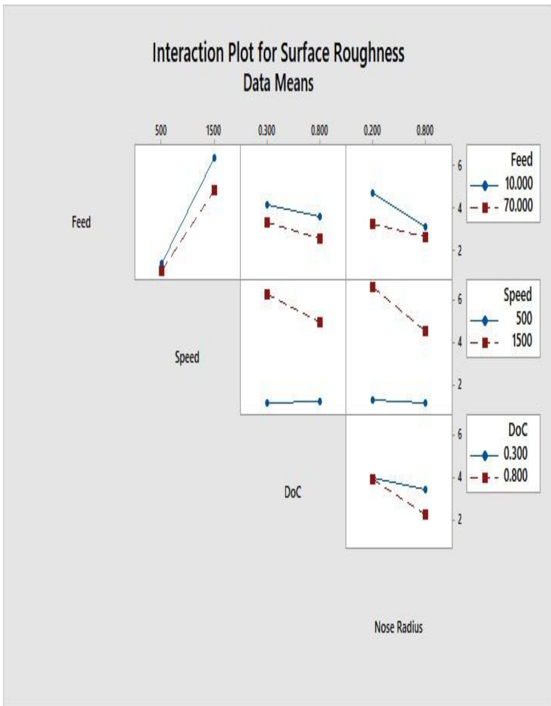


Interaction Effect of Cutting Parameters On Turning Of Al6063t6 Alloy Using L9 Orthogonal Array

Graph: Interaction effect plot for surface roughness of Al6063T6 turning under L9 array

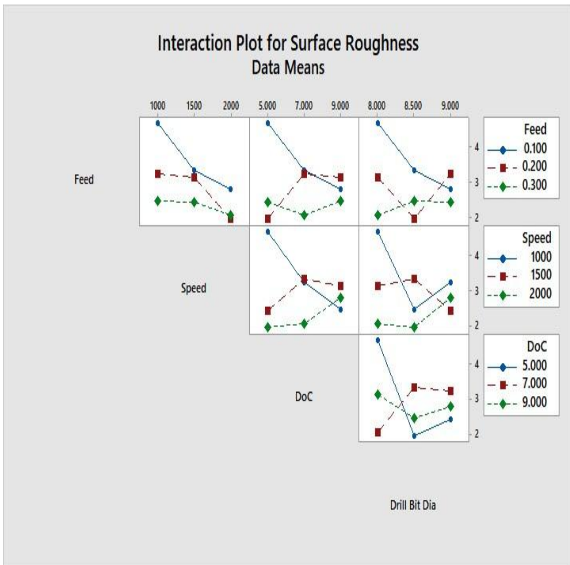
There is a dispute about the orthogonal array orientation and factor of L9. The results show that a high feed rate (70 mm/min), moderate speed (500 RPM), a deep depth of cut (0.8 mm), a moderate nose radius (0.6 mm), and an average nose radius (1.581 m) provide the best surface finish and the lowest surface roughness, respectively (0.02 mm).

Interaction Effect Of Cutting Parameters On Turning Of Al6063t6 Alloy Using L16 Orthogonal Array



Graph: Interaction effect plot for surface roughness of Al6063T6 turning under L16 array

Surface roughness of aluminum alloy during turning operation as a function of interaction impact of two components is shown in Graph 6.6 utilizing L16 orthogonal array.



Interaction Effect Of Cutting Parameters On Drilling Of Al6063t6 Alloy Using L9 Orthogonal Array

Graph : Interaction effect plot for surface roughness of Al6063T6 drilling under L9 array

Drilling an aluminum alloy with a L9 orthogonal array reveals the impact of two interacting components on the surface roughness. According to the statistics, the Smoothest surfaces result from high-speed cutting 2000 RPM, a shallow depth of cut of 5 mm, and an average drill bit diameter of 8.5 mm (value 1.938 m).

Conclusion

Mostly used Taguchi Method to productively decide the parameter combinations important to minimise surface roughness of the turned surface in CNC. Taken the performance parameters such as speed, feed rate, depth of cut and cutting speed into consideration while leaving the other parameters viz tool signature, type of lubricant and nose radius apart from the research. Taguchi's robust orthogonal array design method is suitable to analyse the surface roughness and material removal rate during turning operation. It is found that the parameter design of the Taguchi method provides a simple, systematic and efficient methodology for the optimization of the machining parameters.

References

1. *V. Sousa (2020) "Accessing the cutting forces in machining processes: An overview",Procedia Manufacturing,ISSNno:2351-9789,vol.51,pp.787–794,doi10. 1016/j.promfg.2020.10.110.*
2. *Shunmugesh. K (2014) "Optimization of Turning Parameters with Carbide Tool for Surface Roughness Analysis", International Journal of Engineering Research & Technology, ISSN: 2278-0181, Vol. 3, Issue 6,*
3. *Pathan LayeequzzamaKhan (2018) "Experimental Analysis and Investigation of Machining Parameters in Finish Hard Turning of AISI 4340 Steel", Procedia Manufacturing,Vol.20,Pages.265-270,https://doi.org/10.1016/j.promfg.2018.02.039*
4. *Chand R. Prem (2022) "Influence of Machining Parameter on Surface Roughness and Tool Life While Machining EN24 Grade Alloy Steel",Journal of Minerals and Materials Characterization and Engineering,ISSNno:2327-4085,Vol.10,No.3, Pages-242-253.*
5. *Mihir T. Patel (2014) "Optimization of Machining Parameters for Turning Different Alloy Steel Using CNC – Review", International Journal of Innovative Research in Science, Engineering and Technology, ISSN: 2319-8753, Vol. 3, Issue 2,*
6. *NilimaWagh(2015) "Optimization of Performance Parameters for En24 Alloy Steel on CNC Turning Machine Using Three Geometries of Inserts by Taguchi Method", International Journal for Research in Applied Science & Engineering Technology (IJRASET), ISSN: 2321-9653, Volume 3, Issue III*
7. *Venkat Pradeep Allu (2019) "Performance investigation of surface roughness in hard turning of AISI 52100 steel - RSM approach", Materials today, Proceedings, Volume 18, Part 1, Pages 261-269, https://doi.org/10.1016/j.matpr.2019.06.299*
8. *Ranganath. M. S (2014) "Experimental Investigation and Parametric Analysis of Surface Roughness in CNC Turning Using Design of Experiments", International Journal of Modern Engineering Research, ISSN: 2249–6645, Volume 4, Issue 9.*