OPTIMIZATION OF DRILLING PARAMETERS TO ACHIEVE MAXIMUM CIRCULARITY ON AISI 316 USING TOPSIS METHOD

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Abstract
CNC stands for computer numerical control, CNC machine offers a high level of precision, and quick and efficient work in the manufacturing process by removing material in form of layers compared to traditional manufacturing processes. CNC is mainly used in industries that require maximum accuracy components such as Aerospace, Military, Medical, Manufacturing, and so on. The main aim of the present study is to optimize the drilling parameters within the enclosed conditions to achieve the maximum circularity obtained in the drilling of AISI 316. Drilling operation is done using black oxide coated HSS Drill and the present experimentation is done in CNC Lathe (Fanuc Controller). The NC program is first executed in EMCO Launcher software to avoid any accidents during the machining of components. The matrices of test conditions consisted are cutting speed, feed rate, and depth of cut as variable parameters This study has developed mathematical models to predict and analyzed optimized values by which AHP-TOPSIS was applied for ranking and results are validated using CMM
Keywords: CNC Lathe Machine (FANUC), NC Drilling Code, CMM, AHP-Topsis Method, and Black oxide HSS Drill.

Introduction
CNC machining can be defined as the manufacturing process in which material is subtracted from the workpiece using computer controls via layer format for best precision and complex component manufacturing. Drilling is one of the most common as well as most complex operations among many kinds of machining methods in the manufacturing industry. It is a process of producing round holes in a solid material or enlarging existing holes with the use of multipoint cutting tools called drills or drill bits and in drilling operation, the material is removed via flutes. It is widely used in a variety of manufacturing industries including aerospace, automotive, electronics, equipment, and Manufacturing. Optimization of machining parameters not only increases the overall capacity of machining but also the quality of the output to a great extent.

Objectives
The objective of this research work is to optimize the drilling parameter to achieve maximum circularity on AISI 316 and analyzed optimized values by which AHP-TOPSIS was applied for ranking, and results are validated using CMM.

Literature Review
Arshad Noor Siddiqueea[1], the main objective of the journal is to study surface roughness under control parameters. In this journal, they have chosen four parameters like cutting fluid, speed, feed, and depth of cut to get the optimal setting for surface roughness on AISI 321 during drilling operation on a CNC lathe. FeritFicici[2], in this study, the performance of input parameters on Surface roughness in the drilling of 304 stainless steel was studied by changing the feed, speed, and depth of cut.

AdemCicek[3], in this journal, theeffect of process parameters on Surface Finish in Radial Drilling Process has been studied.Mr. Dhanke V. D [4], the purpose of this experiment is to minimize the burr size on AISI 1050 using Taguchi and RSM method.Murthy B.R [5], studied drilling process on glass fibre reenforced polymer (GFRP) under control process parameters.Yogendra Tyagi [6], focused on material remove rate and surface finish during drilling operation on mild steel using Taguchi method.Mr.Nalawde P.S [7], studied optimization of surface finish and drilling accuracy on EN-31 using HSSTiN-coated drills of 10mm diameter.Dayal Saran P [8], the main objective of this experiment is to find the effect of control parameters in radial drilling process. knowledge gap is the measurement of circularity using TOPSIS

Methodology

Design of Experiment (DOE)

Design of Experiment is a powerful approach to improve product design or improve process performance where it can be used to reduce the cycle time required to develop new products or processes. A design experiment is a test or series of tests in which the input variable (parameter) of a process is changed so that observation and identifying corresponding changes in the output response can be verified. The result of the process is analysed to find the optimum value or parameters that have the most significant effect on the process.

Drilling Parameters

The Drilling parameters that we change are speed, feed, and depth of cut. The above mentioned are the key parameters that affect the machining of the workpieces. Output parameters that were calculated are Circular Diameter or accuracy of drilling hole. The parameters which are varying are shown in table 1

Table.1 Cutting Parameters

Si. No	Symbols	Parameters	Level		
			I.	II.	III.
1.	A	Spindle Speed(rpm)	400	500	600
2.	B	Feed(mm/min)	0.04	0.05	0.06
3.	C	Depth of Cut(mm)	0.3	0.5	0.7

Analytic hierarchy Process

The analytic hierarchy process (AHP), also known as the analytical hierarchy process, is a structured technique for organizing and analysing complex decision data for a situation, based on mathematics. It provides an accurate approach to quantifying the weights of decision criteria within criteria by forming a pair-wise comparison. Each of the respondents compares the relative importance of each pair of items using a specially designed questionnaire.

Steps Followed:

Step 1: Define Main Goal.
Step 2: Structure the elements in criteria, sub-criteria, alternatives, etc.
Step 3: Make a pairwise comparison of element groups between criteria, sub-criteria, etc.
Step 4: Calculate weighting and consistency ratio from pairwise comparison.
Step 5: Evaluate alternatives according to weighting.
Step 6: Here we get the ranking.

Topsis Method

TOPSIS is a multi-criteria decision analysis technique used to find the best possible outcomes within multiple available alternatives and is known as a Technique for Order of Preference by Similarity to Ideal Solution. TOPSIS compares a set of alternatives based on a pre-specified criterion based on the mode of problem importance according to the personal perspective. It is based on the concept that the chosen alternative should have the shortest route for best results or positive ideal solution (PIS) and the longest geometric distance from the worst results or negative ideal solution (NIS). It is a method

of compensatory aggregation that compares a set of alternatives by identifying weights for each case, normalizing scores for each case, and calculating the geometric distance between each alternative and the ideal alternative, which is the best score in each case. Here Weights are calculated with the help of the Analytic Hierarchy Process (AHP) Method.
Procedure Steps followed for Topsis Method:
Step 1: Create a matrix of M alternatives and N Criteria. This matrix is known as the 'evaluation matrix'
Step 2: Normalize the evaluation matrix.
Step 3: From the normalized evaluation matrix calculate the weighted normalized decision matrix.
Step 4: Determine the best and the worst alternative for each criterion.
Step 5: Calculate the Euclidean distance between the target alternative and the best/worst alternative.
Step 6: For each alternative calculate the similarity to the worst alternative. The results are our TOPSIS scores.
Step 7: Rank alternatives according to the TOPSIS score in descending order.

Experimentation work

Workpiece Material

AISI 316 is the second most commonly available and widely used type of stainless steel after the AISI 304. The main key advantage of AISI 316 over AISI 304 is the Greater corrosion resistance, Greater tensile strength at higher operating temperatures Acidic resistance of solutions of nitric acid of concentration as high as 5% at 50 °C, etc. Machining of AISI 316 austenitic stainless steel is critical due to its supreme properties like high wear resistance, high toughness, low thermal conductivity, and high tensile strength. The work material is cut to required sizes of 30×5 mm^2, from AISI 316 Stainless Steel with the help of a horizontal CNC Lathe machine to perform drilling operations on them. The chemical composition of work materials is shown in Table 2

Table - 2 Chemical Properties of AISI 316

Composition	Percentage (%)
Fe	68.06
Cr	16 -17.2
Ni	10 -11
Mo	2 - 2.5
Mn	1.71
Si	0.50
Cu	0.1
C, P, S	1.00

Machine and tool setup

CNC Horizontal Lathe

CNC stands for computer numerical control and the main advantage of CNC over manual machines is the control, precision, accuracy, and complex geometry output. A lathe is a type of CNC machine in which a workpiece is rotated at a certain speed where the excess material is removed by the stationary cutting tool which is placed in the tool holder to produce a symmetrical object. These machines can produce a large variety of shapes, cuts, and details on a rotating work part according to the requirement of the component. CNC horizontal lathe machining works in the horizontal direction as the workpiece is held in the chuck horizontally. These CNC machines are mainly operated for cylindrical objects as they are clamped in the chuck for the removal of material. Because the workpieces have to lie horizontally, horizontal lathe machines used to have a larger space and tend to be large and they only

used a certain size of workpieces as workpiece length increases machining tends to be difficult. The material is removed by the shearing action between the cutting tool edge and the workpiece. So, the result is a precisely finished product of the required component. As CNC machines are so versatile, industries that require accurate production mainly use them, including automotive, electronics, aerospace, pharmaceutical part production, and others.

Fig 1 Central Drill Operation in CNC Lathe

Tool Setup

In this present study, chosen a drill bit of black oxide of diameter 12mm and a center drill of radius 4mm. High-speed steel (HSS or HS) is a subset of tool steels, mainly used for cutting purposes. High-speed steel is superior to the older high-carbon steel tools; it can withstand higher temperatures without losing its hardness. This property allows HSS to cut faster than high carbon steel, hence it is named high-speed steel. At room temperature, in their generally go to heat treatment, case hardened to improve the surface hardness HSS grades generally display high hardness and abrasion resistance linked to tungsten and vanadium content often used in HSS compared with common carbon and tool steels. HSS drill bits contain key elements such as carbon and are mostly used to work on other types of metal including aluminium and other softer grades of steel reduce nitrogen levels in the melting operation.

Fig. 2 HSS Drill Bit and Center Dill

Table -3: Composition of HSS

Element	Composition
Iron	63-65
Molybdenum	8.00
Chromium	4.00
Tungsten	1.50
Vanadium	1.00
Carbon	0.80

The composition of the HSS drill bit has been shown in table 1 and the major constitution of HSS is iron and molybdenum for an average of around 68% in the overall composition. And consist of other elements like chromium to improve the hardness of the HSS.Tungsten adds hardness and wears resistance to HSS alloys. Vanadium is added to the high-speed steel as a scavenger to remove slag impurities and to reduce nitrogen levels in the melting operation.

NC Code for CNC Operation

```
O0001;
T0000;
G00 X0.0;
G00 Y0.0;
T0404;
G97 S700 M04;
G00 Z2.0;
G00 X0.0;
M07;
G83 Z-4.0 Q200 R0.1 F0.05;
G00 Z2.0;
M05;
M09;
G97 T0000;
G00 X0.0;
G00 Z0.0;
M01;
N1 T0202;
G97 S420 M04;
G00 Z2.0;
G00 X0.0;
M07;
G83 Z-20.0; Q200 R0.1 F0.05;
G00 Z2.0;
M05;
M09;
G97 T0000;
G00 X0.0;
G00 Z0.0;
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M30;

Fig 3 NC Code Executed in Emco Launcher

The above CNC code has been successfully executed in the EMCO launcher simulation software and executed without any error. In the above image, we show the half sectional view of the drilling operation executed component of a diameter of 30mm and size of 50mm. Now the code can be executed in the CNC machine for accident and error-free component production.


Fig.4 Machined Workpieces

The final workpieces have been completed after the drilling process has been shown in fig 4 and the components are then sent to be measured into CMM Machine and the resulted values have been tabulated in results.

Results and Discussions

CMM Analysis

The experimental results of the experiment have been listed in Table.6 and the variation in diameter of the drilling has been shown using CMM Machine measured values. The main parameter affecting the circularity is the low depth of cut and the high speed.

Table 6 CMM Results			
Speed (rpm)	**Feed (Microns)**	**Depth of cut (mm)**	**Practical diameter in CMM (mm)**
400	0.04	0.3	12.756
400	0.06	0.7	12.490
600	0.04	0.7	12.128
500	0.04	0.5	12.467
400	0.05	0.5	12.501
500	0.06	0.3	12.222
500	0.05	0.7	12.251
600	0.06	0.5	12.087
600	0.04	0.3	12.092

6.2 AHP Analysis

AHP weighted analysis for the below matrix has been done as per procedure stated above and the finalized weights has been provided in weighted values has been used for weights in Topsis Method.

Table 4 AHP Weighted Analysis

Parameters	**Speed(rpm)**	**Feed(microns)**	**Depth of cut(mm)**	**Weighted Values**
speed	1	2	6	0.59
feed	0.5	1	3	0.29
Depth of cut	0.17	0.33	1	0.1

6.3 Topsis Analysis

The Topsis analysis has been successfully completed and finalized positive entropy and negative entropy has been noted and based on average entropy ranking has been provided accordingly.

Table 5 Topsis Analysis

Speed(rpm)	**Feed(microns)**	**Depth of cut (mm)**	**Positive entropy**	**Negative entropy**	**Average entropy**	**Ranking**
400	0.04	0.3	0.090	0	0	9
400	0.06	0.7	0.077	0.045	0.371	7
600	0.04	0.7	0.038	0.089	0.681	3
500	0.04	0.5	0.055	0.040	0.422	6
400	0.05	0.5	0.080	0.022	0.220	8
500	0.06	0.3	0.046	0.054	0.540	4
500	0.05	0.7	0.045	0.050	0.536	5
600	0.06	0.5	0.012	0.087	0.873	1
600	0.04	0.3	0.031	0.079	0.715	2

From the above table the experiment with 600rpm, feed with 0.06microns and depth of cut of 0.5mm is the most optimized values for circularity on AISI 316 material

CONCLUSION

In this paper drilling, experiments are carried out on a CNC lathe machine of Fanuc controller using a Black Oxide HSS drill bit with varying -speed, feed, and depth of cut. this output is measured on a CMM machine and this result is validated using the Topsis method. The most predominant parameter has been found for the best circularity for a particular speed, feed, and depth of cut analysis hierarchy

process used to find the weights of the parameters according to their priorities of the parameters compared with the speed the diameter increases as speed decreases and depth of cut has increased and the same time. The optimized values according to the experiment is given as Speed as 600 rpm, feed rate of 600 micron, and depth of cut of 0.5mm in TOPSIS method. Future scope of work: the above work can be extended in other optimized techniques like MOORA with different weightage techniques

References

[1] Arshad Noor Siddiquee et.al, (2014) "Optimization of Deep Drilling Process Parameters of AISI 321 Steel using Taguchi Method, 3rd International Conference on Materials Processing and Characterisation (ICMPC 2014), Elsevier, Procedia Materials Science 6, pp.1217 – 1225

[2] FeritFiciciet. al, (3 March 2012) "Optimization of Cutting Parameters for Surface Roughness of Stainless Steel in Drilling Process", International Journal of Science and Advanced Technologies' 2221-8386, Volume 2 No, pp.114-121 © 2016 IJEDR | Volume 4, Issue 2 | ISSN: 2321-9939 IJEDR1602072 International Journal of Engineering Development and Research (www.ijedr.org) 405

[3] AdemCicek et.al, (March 2012) "Application of Taguchi Method for Surface Roughness and Roundness Error in Drilling of AISI 316 Stainless Steel, Journal of Mechanical Engineering, pp.165-174

[4] Mr. Dhanke V et al, (July - August 2013) "Optimization of Process Parameters in Drilling of AISI 1015 Steel for Exit Burr Using RSM and Taguchi", International Journal of Mechanical Engineering and Technology, ISSN 0976 – 6340, Volume 4, Issue 4, pp. 327-337

[5] Murthy B.R.N et.al, (June 2012) "Process Parameters Optimization in GFRP Drilling through Integration ofTaguchi and Response Surface Methodology, ResearchJournal of Recent Sciences, ISSN 2277-2502, Vol. 1(6), pp.7-15

[6] Yogendra Tyagi et.al, (July 2012) "Parametric Optimization of Drilling Machining Process using Taguchi Design and ANOVA Approach", International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Volume 2, Issue 7, pp.339-347.

[7] Mr. Nalawade P.S et.al, (Jan- Feb. 2015) "Cutting Parameter Optimization for Surface Finish and Hole Accuracy in Drilling Of EN-31, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 12, Issue 1 Ver. I, pp.20-27

[8] Dayal Saran P et.al, (October 2014) "Experimental Analysis of the Effect of Process Parameters on SurfaceFinish in Radial Drilling Process", International Journal of Engineering and Innovative Technology (IJEIT), ISSN: 2277-3754, Volume 4, Issue 4, pp.49-56

