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Performance Investigation of EN-24 and D-3 Steel Material in Respect of Temperature Generation during Machining Operation: A Taguchi Method Based Study

ChandraPrakash Choudhary[1], Rakesh Kumar[2], Pankaj Sharma[3]

[1,2,] Mechanical Engineering Department, Jagannath University, Jaipur, India
[3] Mechanical Engineering Department, JNIT, Jaipur, India

ABSTRACT

In present study CNC machining is selected for research work. CNC is one of the best machines which can perform machining process on normal metal to supper alloys. The only requirement is materials must be electric conductive. CNC machines now play important role in modern industry. In present work four input parameters are selected for research study which are materials of work pieces, feed, speed and depth of cut. Taguchi method is selected for this study so each factor has three levels as per machine technical specifications. The CNC machine which is used for this study is installed at JNIT workshop. The two materials which are selected for this study are EN-08, and D-3 (tool steel). Two response parameter cutting time and temperature during machining is selected as output. Signal to noise ratio is selected as analysis tool which help to find the rank among input parameters. In present paper single response optimization is also present for both parameters.

Introduction

CNC Turning is a part of designing. Architects need to discover mechanical arrangements that can make complex plans conceivable. Inside a gathering that client may see and utilize each day, each and every part connects with each other. This is valid for vehicles, Smart telephones, airplane, etc; the conceivable outcomes are unfathomable. For instance, there are around 10,000 sections in only one vehicle. Architects make gatherings of numerous parts, and utilizing a wide range of materials, through CAD (Computer Assisted Drawing) programming. Each piece of a get together is made of various materials, and requirements various calculations, measurements and surface characteristics. The architect brings every one of these necessities into specialized drawings which are designated "diagrams". In any case, who will assemble these parts? To answer that question,we need to choose the most ideal approach to deliver each part. There are numerous methods of doing this, such as welding, processing, projecting, and 3D Printing. One vital technique is CNC Turning A CNC Lathe is a machine on which material pivots a hub at high velocity, and where cutting tools driven by PC programming are moved to remove unnecessary material to get the normal part. The CNC Turning Machinist gets the plan. Then, at that point client utilizes the Lathe from various perspectives to discover arrangements to construct the part. These machines are over the top expensive, in light of the fact that they can do astounding things. To have a thought of this, think achieving exactness under ten microns, which is multiple times more slender than a human hair.The CNC Turning Machinist needs to utilize a PC to advise the Lathe how to move the tools and trim the part.User additionally needs to set up the machine with every one of the cutting tools. These tools can cut pretty much every material (treated steel, plastic, delicate steel, aluminum, bronze, etc) however we need to pick well. Client additionally pick the cinching technique. This is the place where the material will be held firm. At the point when the machine begins cutting material, the Machinist ensures that the measurements precisely fit the diagram particulars. For this, exceptionally exact assessment tools are utilized. A keen mechanic will get the part to fit the diagram details at the principal endeavor. The completed and quality controlled part is shipped off the mechanical production system with each and every other part, and eventually, if everybody has managed their work competently, the completed gathering will meet assumptions and please its clients. CNC machine is available in figure 1 for general data.

Pusavec et al (2011) fostered an examination for various blends of cooling and grease machining states of steel grade material. With these diverse arrangement of mixes, the surface trustworthiness qualities of machined surface as a component of profundity have been dissected. The cryogenic machining interaction can be executed to improve all significant surface uprightness attributes, accordingly improving the eventual outcome quality level. It is shown that dry machining conditions are the most appropriate conditions for machining material steel.

Ezugwu et al (2005) created ANN model for the investigation and expectation of the connection among cutting and cycle boundaries during high velocity turning of nickel based Inconel 718 amalgam. The cutting boundaries are cutting rate, feed, and profundity of cut, cutting time, and coolant pressure. The yield boundaries estimates extraneous cutting power, hub power, shaft engine power utilization, surface harshness, flank wear and nose wear. Delayed machining brings about consistent expansion in segment powers, power utilization, flank wear and nose wear.

Figure 1 CNC lathe machine (Courtesy: CIPET, Jaipur)

Iwata (1972) proposed a logical strategy for applying an opportunity obliged programming idea to decide the ideal cutting conditions thinking about the probabilistic idea of target capacity and limitations. It is shown that the ideal cutting conditions are altogether influenced by the probabilistic idea of the coefficients in the limitations.

Thakur et al (2009) endeavored Taguchi's advancement strategy to contemplate the machinability of Inconel 718 as for cutting power, cutting temperature, and tool life in fast turning of Inconel 718 utilizing solidified tungsten carbide cutting tool. The connection between the components cutting velocity, feed and profundity of cut and the exhibition measures are communicated by different relapse conditions. It is accounted for that the legitimate choice of the cutting boundaries improves the machinability of hard to machine material, Inconel 718 with top caliber with least number of tests.

Objective of the Research Paper

The prime aim of present study are to investigate the effect of heat transfer rate during the machining process on test material EN-08 and D-3 tool steel using CNC turning machine. In present study machine process parameters are selected for the investigation of the output parameters like cutting time and object body temperature during the machining process. In present study Design of experiment technique is selected for making the experiment tables.

Machine Technical Information

Technical specifications of machine is present in table 1 for full detailed manner. This machine is industrial version not the prototype version, so wide range of turning operation is possible to make using this machine.

Table 1 CNC LATHE TECHNICAL SPECIFICATION

Description	Unit	values
Capacity		
Std. Turning Dia.	mm	135
Max. Turning Dia.	mm	165
Swing Over Bed		300
Max. Turning Length	mm	200
Dist. Between Center	mm	300
Slides		
Cross (X axis) Travel	mm	100
Longitudinal (Z axis) Travel	mm	220

Main Spindle		
Spindle Nose		A2-4
Spindle Bore	mm	36
Max. Bar Capacity	mm	25
Chuck Size	mm	135
Speed Range	rpm	50 - 4500
Full Power Speed Range	rpm	1333 - 3000
Spindle Motor (Cont. Rating) (15 Min. Rating)	kW	3.7 / 5.5
Turret		
No. of Stations	-	8
Tool Size	mm	20 x 20
Max. Boring Bar Capacity	mm	32
Accuracy		
Positioning	mm	0.008
Repeatability	mm	0.007

Object and Design of Cut

Two different steel grades are selected for this research work which are EN-08 and D3 die steel. D3 steel is processed using heat treatment process. The raw work piece of these materials are present in figure 2 for EN-08 and D3 steel respectively. The dimensional values are present in figure 3 for both materials.

EN-08

D3

Figure 2 Raw work Piece of EN-08 and D3 steel

Total length of raw work piece is set up to 80 mm in length having the raw diameter of 30 mm. The 9 work pieces are made for both test pieces. For stepped turning 30 mm length is selected for cutting operation which is show in figure 3. 1 mm is simple turning for whole work piece to improve of measurement during cutting process.

After 1 mm turning, 15 mm stepped turning is done for diameter 27 mm and rest 15 mm length is stepped turning for 25 mm diameter and the dimensions are show in figure 3.1 for this research work.

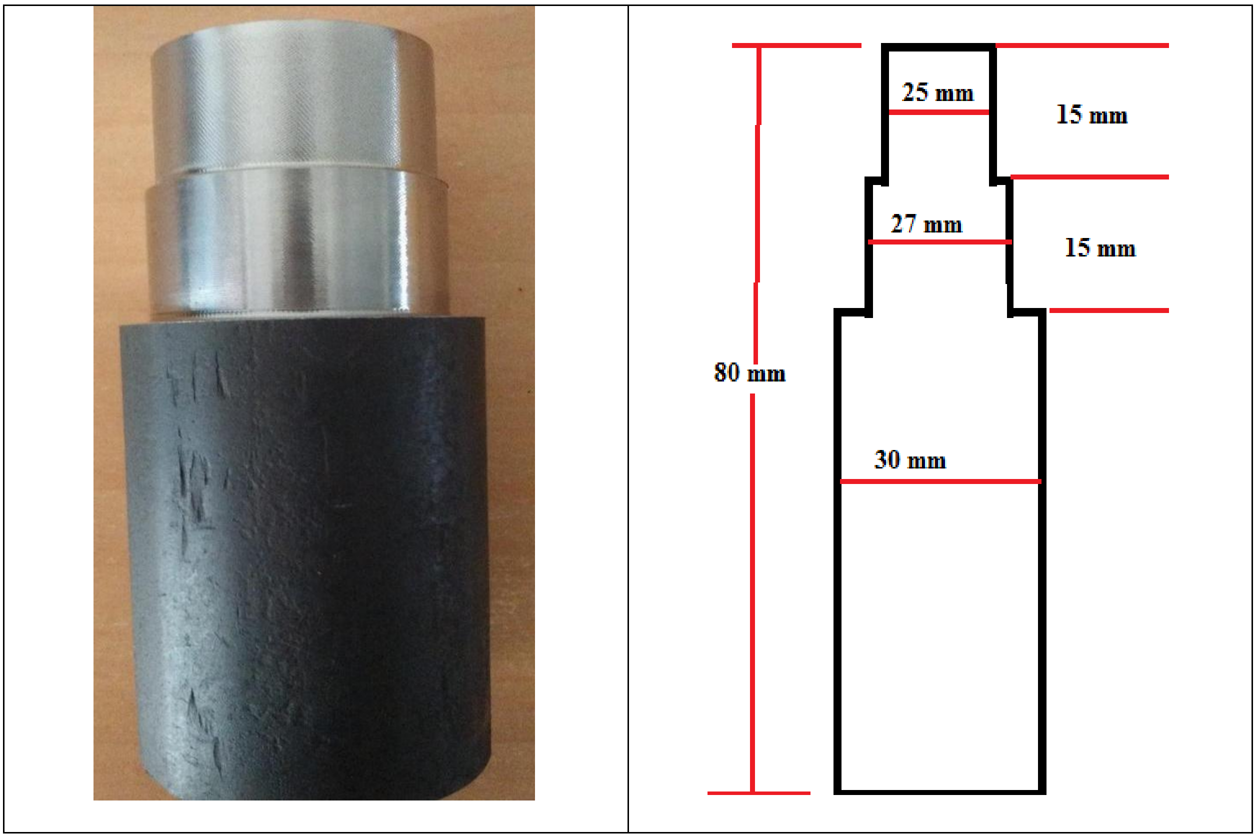

Figure 3 Stepped turning test piece Dimensions

Taguchi method for making Experiments

The final factor and levels select for this research study are present in table 2 which is present in bellow section.

Table 2 DIFFERENT LEVEL FOR ALL FACTORS USED IN THIS RESEARCH WORK

Factor	L-I	L-II	L-III	Unit
Feed rate	0.6	0.8	1	inch/min
Speed	1400	1600	1800	RPM
DOC	0.25	0.35	0.45	mm

In table 3, the orthogonal array L18 is present which is made by using taguchi method, All these experiments then performed on the CNC lathe machine.

Table 3 Orthogonal Array L18 for present study

Run	material	Feed	Speed	DOC	Cutting Time	Temperature
1	1	0.6	1400	0.25	5.45	143.28
2	1	0.6	1600	0.35	6.02	140.14
3	1	0.6	1800	0.45	7.08	139.80
4	1	0.8	1400	0.25	4.48	143.30
5	1	0.8	1600	0.35	4.17	140.93
6	1	0.8	1800	0.45	4.25	139.80
7	1	1	1400	0.35	6.02	141.11
8	1	1	1600	0.45	3.68	138.18
9	1	1	1800	0.25	3.96	139.06
10	2	0.6	1400	0.45	4.97	136.80
11	2	0.6	1600	0.25	4.63	139.28
12	2	0.6	1800	0.35	4.78	137.98
13	2	0.8	1400	0.35	4.18	140.45
14	2	0.8	1600	0.45	3.03	134.15
15	2	0.8	1800	0.25	4.36	139.95
16	2	1	1400	0.45	3.56	136.66
17	2	1	1600	0.25	2.97	134.50
18	2	1	1800	0.35	2.98	139.33

Result and Discussion

S/N ration analysis for Cutting Time

Signal to noise ratio analysis is performed for cutting time using option "smaller is better" and the results are present in table 4 for the same. As seen in table 4, the S/N ratio is more useful then original data of cutting time.

Table 4 S/N ratio analysis for Cutting time

Run	material	Feed	Speed	DOC	Cutting Time	S/N Ratio
1	1	0.6	1400	0.25	5.45	-14.7321
2	1	0.6	1600	0.35	6.02	-15.5909
3	1	0.6	1800	0.45	7.08	-16.9956
4	1	0.8	1400	0.25	4.48	-13.0333
5	1	0.8	1600	0.35	4.17	-12.4040
6	1	0.8	1800	0.45	4.25	-12.5744
7	1	1	1400	0.35	6.02	-15.5973
8	1	1	1600	0.45	3.68	-11.3171
9	1	1	1800	0.25	3.96	-11.9605
10	2	0.6	1400	0.45	4.97	-13.9302

Run	material	Feed	Speed	DOC	Cutting Time	S/N Ratio
11	2	0.6	1600	0.25	4.63	-13.3210
12	2	0.6	1800	0.35	4.78	-13.5891
13	2	0.8	1400	0.35	4.18	-12.4246
14	2	0.8	1600	0.45	3.03	-9.6188
15	2	0.8	1800	0.25	4.36	-12.7819
16	2	1	1400	0.45	3.56	-11.0355
17	2	1	1600	0.25	2.97	-9.4465
18	2	1	1800	0.35	2.98	-9.4729

The rank identification is done by using DELTA formulation using average of S/N ratio calculated in table 4. the final results for cutting time is present in table 5, in which rank is identified for present study.

Table 5 rank identification for cutting time

Level	material	Feed	Speed	DOC
1	-13.80	-14.69	-13.46	-12.55
2	-11.74	-12.14	-11.95	-13.18
3		-11.47	-12.90	-12.58
Delta	2.06	3.22	1.51	0.63
Rank	**2**	**1**	**3**	**4**

The same result is present in figure 4, the table 5 show the rank for cutting time. The first ranked parameter is feed rate and least ranked factor is depth of cut of the machine. Figure 4 help to find the optimal solution for cutting time which present in table 6 for cutting time.

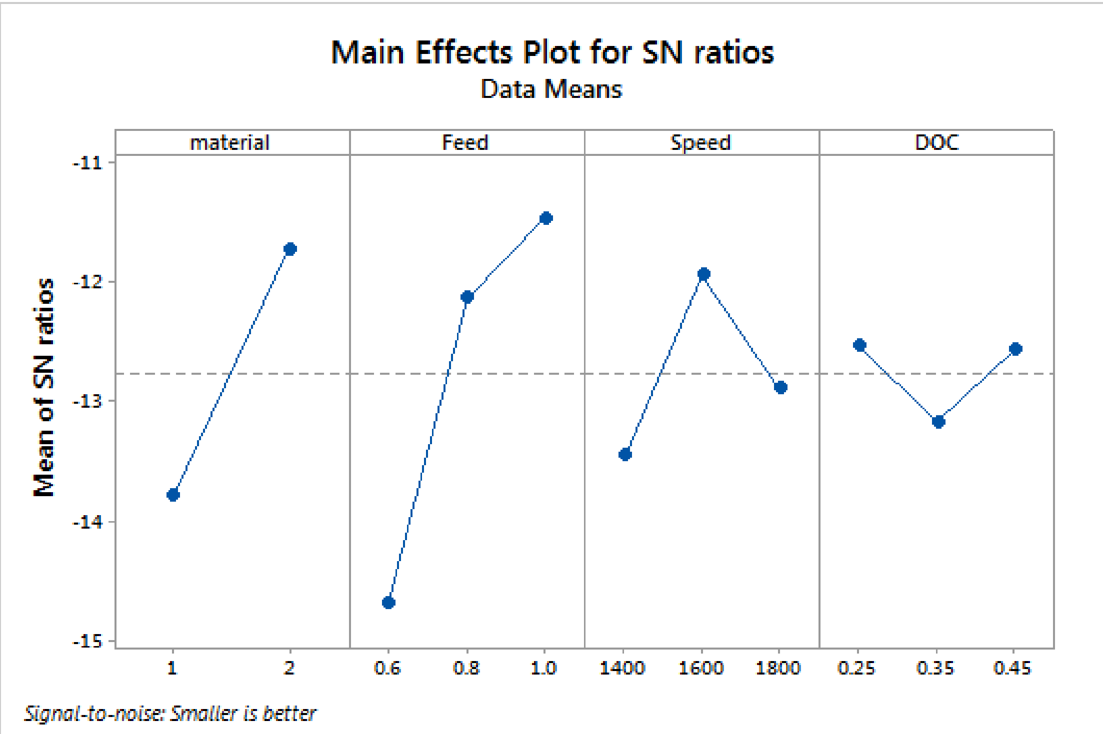

Figure 4 S/N ratio analysis of Cutting time

Optimal Solution for Cutting Time

Table 6 Optimal solution for cutting time

material	Feed	Speed	DOC
D3	1	1600	0.25

S/N ration analysis for Temperature

Signal to noise ratio analysis is performed for temperature using option "smaller is better" and the results are present in table 7 for the same. As seen in table 7, the S/N ratio is more useful then original data of temperature.

Table 7 S/N ratio analysis for temperature

Run	material	Feed	Speed	DOC	Temperature	S/N Ratio
1	1	0.6	1400	0.25	143.28	-43.1237
2	1	0.6	1600	0.35	140.14	-42.9312
3	1	0.6	1800	0.45	139.80	-42.9101
4	1	0.8	1400	0.25	143.30	-43.1249
5	1	0.8	1600	0.35	140.93	-42.9801
6	1	0.8	1800	0.45	139.80	-42.9101
7	1	1	1400	0.35	141.11	-42.9912
8	1	1	1600	0.45	138.18	-42.8089
9	1	1	1800	0.25	139.06	-42.8640
10	2	0.6	1400	0.45	136.80	-42.7217
11	2	0.6	1600	0.25	139.28	-42.8778
12	2	0.6	1800	0.35	137.98	-42.7963
13	2	0.8	1400	0.35	140.45	-42.9504
14	2	0.8	1600	0.45	134.15	-42.5518
15	2	0.8	1800	0.25	139.95	-42.9195
16	2	1	1400	0.45	136.66	-42.7128
17	2	1	1600	0.25	134.50	-42.5744
18	2	1	1800	0.35	139.33	-42.8809

The rank identification is done by using DELTA formulation using average of S/N ratio calculated in table 7. the final results for temperature is present in table 8, in which rank is identified for present study.

Table 8 rank identification for temperature

Level	material	Feed	Speed	DOC
1	-42.96	-42.89	-42.94	-42.91
2	-42.78	-42.91	-42.79	-42.92
3		-42.81	-42.88	-42.77
Delta	0.18	0.10	0.15	0.15
Rank	**1**	**4**	**3**	**2**

The same result is present in figure 5, the table 8 show the rank for temperature. The first ranked parameter is material and least ranked factor is feed rate of the machine. Figure 5 help to find the optimal solution for cutting time which present in table 9 for temperature.

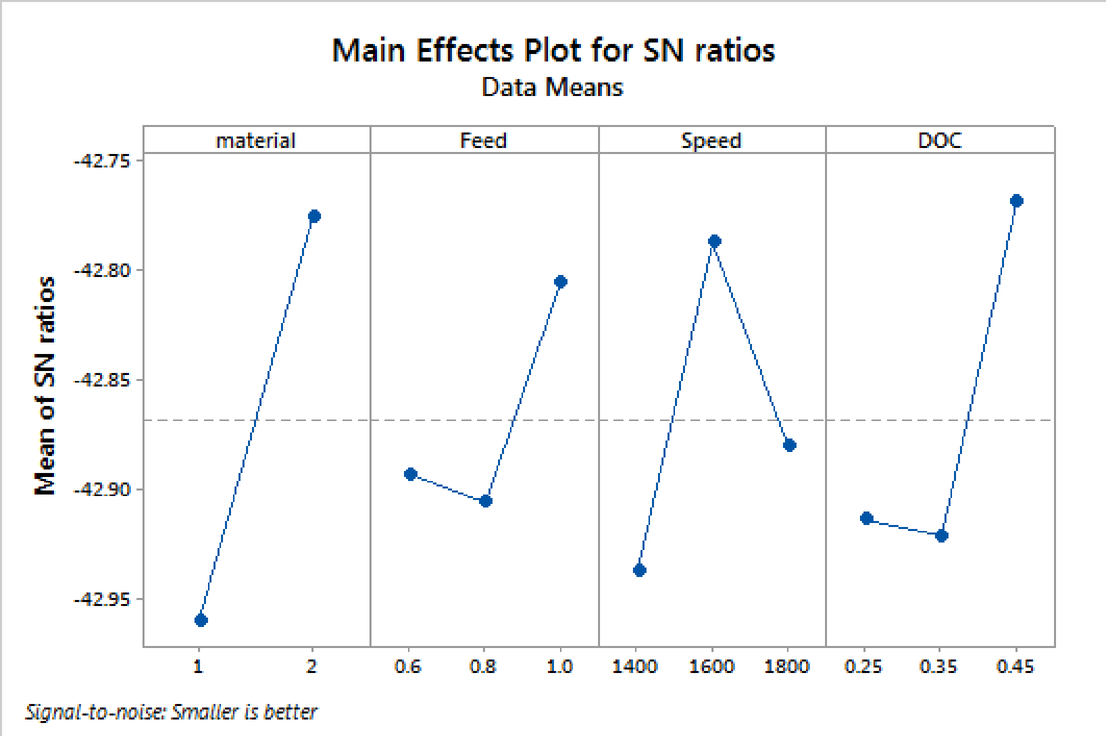

Figure 5 S/N ratio analysis for Temperature

Optimal Solution for Temperature

Table 9 Optimal solution for cutting time

material	Feed	Speed	DOC
D3	1	1600	0.45

Conclusion

Rank identification using S/N ratio analysis is performed for two responses to find the rank among all three factors which are present here.

Response	Material	Feed	Speed	DOC
CT	2	1	3	4
Temperature	1	4	3	2

Optimal solution for both response parameters are present here

Response	material	Feed	Speed	DOC
CT	D3	1	1600	0.25
Temperature	D3	1	1600	0.45

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