ISSN 2348 - 7968

OPTIMIZATION OF MACHINING CHARACTERISTIC OF D2 STEEL UNDER DIFFERENT IN TURNING CONDITION

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Abstract: D2 Steel (Tool Steel) is one of the most widely used materials due to its unique high strength that is maintained at the elevated temperature and its exceptional wear resistance.D2 steel possessing high strength and toughness is usually known to create major challenges during its machining. Turning is the process known for its capabilities in providing machining efficiency in terms of higher machining rate and low tool wear apart from reasonably good surface quality. Turning is the traditional machining method that could be effectively used for the cost effective machining of D2 Steel. However, there is a critical lack of evidence regarding the application of turning process for the machining of a material like tool steel in the literature available till now. Hence the study was aimed to investigate the machining characteristics of D2 Steel under different process conditions. The machining characteristics investigated are; Thrust force, Feed force, Radial force, Surface roughness, and Material removal rate. The results showed that the response variables were strongly influenced by the control factors (input parameters).
Keywords: D2 Steel, ANOVA, S/N Ratio, Cutting Speed

1. INTRODUCTION

1.1 METAL CUTTING PRINCIPLE: Metal cutting is one of the most important methods of removing unwanted material in the production of mechanical components (Groover and Mikell, 1996).

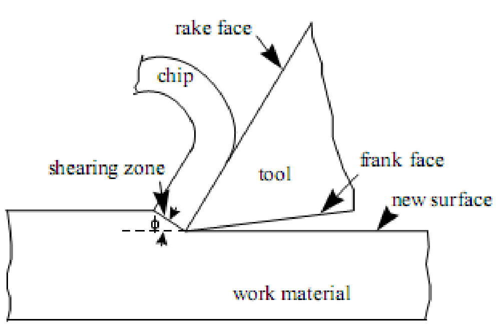


Figure 1.1 Basic of metal cutting

Metal cutting is the process of producing a job by removing a layer of unwanted material from a given workpiece. Figure 1.1 shows the schematics of a typical metal cutting process in which a wedge shaped, sharp edged tool is set to a certain depth of cut and moves relative to the workpiece. Under the action of force, pressure is exerted on the workpiece metal causing its compression near the tip of the tool. The metal undergoes shear type deformation and a piece or layer of metal gets repeated in the form of a chip.If the tool is continued to move relative to workpiece, there is continuous shearing of the metal ahead of the tool. The shear occurs along a plane called the shear plane. All machining processes involve the formation of chips; this occurs by deforming the work material on the surface of job with the help of a cutting tool. Depending upon the tool geometry, cutting conditions and work material, chips are produced in different shapes and sizes. The type of chip formed provides information about the deformation suffered by the work material and the surface quality produced during cutting.

The following parameters were selected for this study based on the avialability of these parameters on the machine.

1. Cutting Tool
2. Cutting Fluid
3. Spindle Speed
4. Feed
5. Depth of Cut

The others paramerters were made to be fixed during the experimentaion based on the literaure survay.The workpiece material for this experimentation was selected as a pure Tool Steel (D2 Steel) .

1.2 CUTTING SPEED: A cutting speed for mild steel, of 100 ft/min (or approx 30 meters/min) is the same whether it is the speed of the (stationary) cutter passing over the (moving) work piece, such as in a turning operation, or the speed of the (stationary) work piece moving past a (rotating) cutter, such as in a milling operation.

Table 1.1 Cutting speeds for various materials

Cutting speeds for various materials using a plain high speed steel cutter		
Material type	**Meters per min**	**Surface feet per min (SFM)**
Steel (tough)	15 - 18	50 – 60
Mild steel	30-38	100-125
Cast iron (medium)	18-24	60-80
Alloy steels (1320 - 9262)	-	65-120
Carbon steels (C1008-C1095)	-	70-130
Free cutting steels (B1111-B1113 & C1108-C1213)	-	115-225
Stainless steels (300 & 400 series)	-	75-130
Bronzes	24-45	80-150
Leaded steel (Leadloy 12L14)	-	300
Aluminum	75-105	250-350
Brass	-	600+ (Use the maximum spindle speed)

2. RESULTS AND DISCUSSION

2.1 INRODUCTION: After conducting the experiments with different settings of the input factors i.e. cutting tool, cutting fluid, spindle speed, feed and depth of cut, the value of output variables (cutting forces, MRR, surface roughness) were recorded and plotted as per Taguchi's design of experiments methodology. The analysis of the results obtained has been performed according to the standard procedure recommended by Taguchi. The detailed description of analysis is given as under.

2.2 ANALYSIS

2.2.1 Evaluation of S/N Ratio: The S/N ratio is obtained using Taguchi methodology. Here the term 'signal' represents the desirable value (Mean) and the 'noise' represents the undesirable value (standard deviation). Thus, the S/N ratio represents the amount of variation present in the performance characteristic. Here the desirable objective is to optimize the response variable (thrust force, feed force, radial force, MRR and surface roughness).Hence, smaller –the –better type S/N ratio was applied for transforming the raw data for cutting forces as smaller value of cutting force is desirable. For Thrust Force, (smaller-the-better) S/N ratio, corresponding to different experimental runs has been tabulated in table 1.2 along the Mean value of the thrust force.

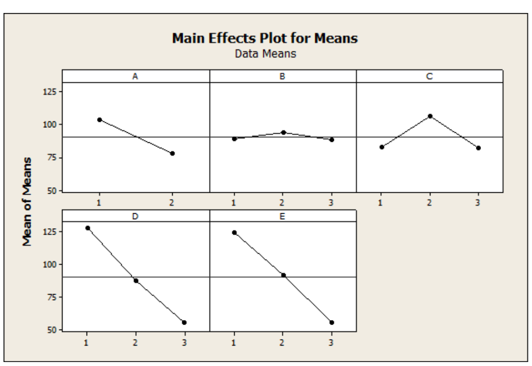
4.2.2 Main effect due to parameters: The main effect can be studied by the level average response analysis of Mean data and S/N ratio. The analysis is done by averaging the Mean and/or S/N data at each level of each parameter and plotting the values in graph. The level average response from the Mean data helps in analyzing the trend of performance characteristics with respect to the variation of the factor under study. The level average response plots based on the S/N data helps in optimizing the objective function under consideration.

2.2.3 Analysis of Variance (ANOVA): The percentage contribution of various process parameters on the selected performance characteristic can be estimated by performing analysis of variance test (ANOVA). Thus, information about how significant the effect of each controlled parameter is on the quality characteristic of interest can be obtained. The ANOVA (general linear model) for Mean and S/N data have been performed to identify the significant parameters to quantify their effect on the performance characteristics. The most favorable condition or optimal levels of process parameters have been established by analyzing response curves of S/N ratio associated with the raw data. The pooled ANOVA S/N data are given in tables 1.3 and 1.4.

ISSN 2348 - 7968

Table 1.2 Test data summary for thrust force

Exp. No.	Thrust Force(Kg.)			Thrust Force Mean Value (Kg)	Thrust Force S/N Ratio (dB)
	R1	R2	R3		
1	157	138	137	144	-43.18
2	86	78	88	84	-38.49
3	3	6	3	4	-12.55
4	160	147	137	148	-43.42
5	127	120	122	123	-41.80
6	98	85	84	89	-39.01
7	130	148	82	120	-41.81
8	90	105	90	95	-39.57
9	136	97	136	123	-41.89
10	22	12	20	18	-25.34
11	227	187	216	210	-46.47
12	57	45	123	75	-38.32
13	23	19	21	21	-26.47
14	88	82	76	82	-38.29
15	96	90	114	100	-40.04
16	49	31	58	46	-33.50
17	45	42	42	43	-32.67
18	98	105	103	102	-40.17
Average				90.38	-36.83
Max.	227	187	216	148	-12.55
Min.	3	6	3	4	-46.47



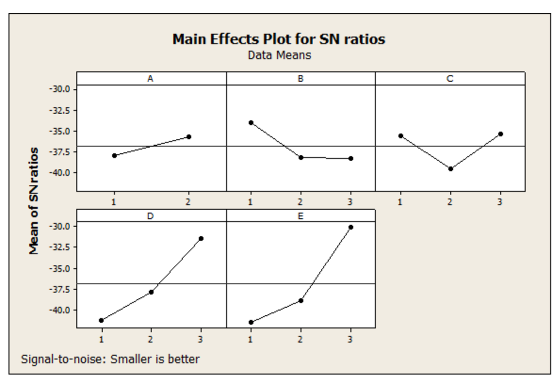
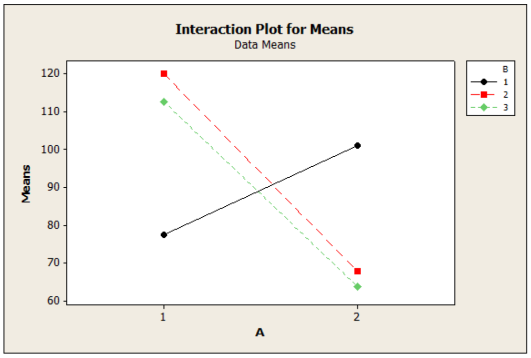


Figure 1.2 Effects of process parameters on thrust force -raw data and S/N ratio

Optimal Combination: $A_2B_3C_3D_3E_3$



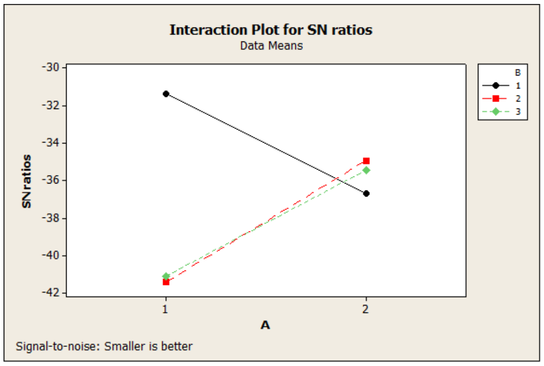


Figure 1.3 Effect of interaction (A×B) on thrust force-raw data and S/N ratio

Table 1.3 ANOVA results for thrust force (S/N Ratio)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
A	1	23.22	23.22	23.22	0.71	0.424
B	2	69.25	69.25	34.62	1.06	0.391
C	2	66.62	66.62	33.31	1.02	0.404
D	2	303.26	303.26	151.63	4.64	0.046*
E	2	425.82	425.82	212.91	6.51	0.021*
Error	8	261.65	261.65	32.71		
Total	17	1149.82				

S = 5.71895 R-Sq = 77.24% R-Sq(adj) = 51.64%

Oder of significance: 1. Feed rate 2.Depth of cut

* Significant at 5% level

Table 1.4 ANOVA results for thrust force (raw data)

Source	DF	Seq SS	Adj SS	Adj MS	F	P	% contribution
A	1	9048	9048	9048	9.84	0.003*	6.15
B	2	329	329	165	0.18	0.837	0.22
C	2	6725	6725	3363	3.66	0.034*	4.57
D	2	47314	47314	23657	25.72	0.000*	32.19
E	2	43080	43080	21540	23.42	0.000*	29.31
Error	44	40473	40473	920			
Total	53	146971					

S = 30.3290 R-Sq = 72.46% R-Sq(adj) = 66.83%

Oder of significance:1.Feed rate 2.Depth of cut 3.Cutting tool 4.Spindle speed

* Significant at 5% level

3. DISSCUTION OF THE RESULTS

3.1 The effect on the thrust force: As it can be observed from the figure 1.2 both feed and depth of cut affect the thrust force very significantly. Moreover the different input parameters used in the experimentation can be ranked in order of increasing effect as cutting fluid, cutting tool, spindle speed, depth of cut, and feed rate. From figure 1.3 optimum thrust force has been recorded at lowest value of both feed rate as well as depth off cut at level 3 while cutting tool and spindle speed are also highly significant factors and cutting. Cutting fluid is insignificant factor with regard to the thrust force.

In order to estimate the contribution of the each factor towards the variation of machining performance (in terms of thrust force) in turning of D2 Steel, analysis of variance test was conducted on the results obtained from the experimentation. The ANOVA test summery for thrust force has been recorded for both average response as well as S/N response. The ANOVA results show that feed and depth of cut are the most significant factor.

The percentage contribution of feed force is 32.19% and depth of cut is 29.31% so these are the most significant factors. The percentage contribution of cutting tool is 6.15% and spindle speed is 4.57% so these are the less significant factors. The cutting oil is insignificant factor with percentage contribution of 0.22%. With regarding to the S/N response the value of S/N ratio have been found to highest for those factor levels that corresponds to the highest average response. Hence these factor levels can be termed as optimum for point of view of average response as well as S/N response (Tables 1.3-1.4). As S/N response takes into account both the magnitude as well as variation in a response, the factor level that corresponds to highest S/N ratio are termed as optimum. The analysis of results showed that “$A_2B_3C_3D_3E_3$” is the optimal parameter setting for the optimization of the thrust force. Hence it can de concluded that form this discussion that input parameter setting of cutting tool as carbide, cutting condition as dry, spindle speed at 192 rpm, feed at 0.05 mm/rev and depth of cut at 0.2 mm has given the optimum results for the thrust force when D2 Steel (tool steel) was turned on lathe.

4. SCOPE FOR FUTURE WORK

1. In the present investigation, only five parameters viz. cutting tool, coolant oil, spindle speed, feed rate and depth of cut were include as input factors. Study of other parameters such as work material properties, cutting tool geometry can be included.

2. The study can be extended to other grades of steel as EN 31,A1S1 420, A1S1 430 and other tougher and harder materials such as nickel alloys, titanium alloys etc.

5. REFERENCES

1. Feng C and Hu Z (2001), “A comparative study of the ideal and actual surface roughness in finish turning”, *International Journal of Advanced Manufacturing Technology*, **Vol 2,** Number 1.
2. Manna A and Bhattacharyya B (2004), “Investigation for optimal parametric combination for achieving better surface finish during turning of Al/SiC-MMC”, *International Journal of Advanced Manufacturing Technology*, **Vol 23,** pp 658-665
3. Mahapatra S, Patnaik A and Prabina K (2006), “Parametric Analysis and Optimization of Cutting Parameters for Turning Operations based on Taguchi Method”, Proceedings of the International Conference on Global Manufacturing and Innovation, pp. 27-29.
4. Chang-Xue and Feng (2001), “An Experimental Study of the Impact of Turning Parameters on Surface Roughness”, Paper No. 2036, Proceedings of the Industrial Engineering Research Conference.
5. Thomas M, Beauchamp Y, Youssef A and Masounave J (1995), “Effect of tool vibrations on surface roughness during lathe dry turning process”, *Computers and Industrial Engineering*, **Vol 40,** pp. 637–644.
6. Ozel T, Hsu T and Erol Z (2005), “Effects of cutting edge geometry, workpiece hardness, feed rate and cutting speed on surface roughness and forces in finish turning of hardened AISI H13 steel”, *International Journal of Advanced Manufacturing Technology*, **Vol 25**, pp.262–269.
7. Singh H and Kumar P (2006), “Optimizing feed force for turned parts through the Taguchi technique “, Sadhana **Vol. 31**, Part 6, pp. 671–681.
8. Barker (1986) “Quality engineering design: Taguchi Philosophy”, Quality Progress, **Vol 12**, pp. 33-42.