

Optimization of process parameters of “CNC Drill Machine” for mild steel using Taguchi design and Single to Noise ratio Analysis

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Abstract - In this paper signal-to-noise ratio method is applied to find optimum process parameters for finishing operation of mild steel with the help of CNC milling machine and high speed steel tool used. The signal-to-noise ratio applied to find optimum process parameter for CNC finishing machining. A L9 orthogonal array and analysis of variance (ANOVA) are applied to study the performance characteristics of machining parameter (spindle speed, feed, depth, width) with consideration of high surface finish and high material removal rate (MRR). The surface finishing and material removal rate have been identified as quality attributes and assumed to be directly related to productivity improvement. Results obtained by Taguchi method and signal-to-noise ratio match closely with (ANOVA) and the feed is most effective factor for MRR. And spindle speed is the most effective factor for surface roughness. Multiple regression equation are formulated for estimating predicted value surface roughness and material removal rate

Key Words: CNC milling machine, surface roughness, material removal rate (MRR), Taguchi method, ANOVA, S/N Ratio MRR&SR.

1. INTRODUCTION

Taguchi's parameter design offers a procedural approach for utilization of various parameters with respect to performance quality and cost. The quality is most important factor to improve productivity of the any industries. The quality and cost are basic requirement to the customer and satisfy the customer demand. For this purpose quality of a product and productivity should be high and cost should be low. Design optimization for quality was carried out and single to noise ratio and analysis of variance (ANOVA) were employed using experiment result to confirm effectiveness of this approach. The signal to noise ratio in Taguchi methodology have been widely used in engineering design to find the optimal parameter for material removal rate and surface roughness in finishing operation based experimental results done on mild steel work piece and high speed steel tool. The personnel industry as well as in research and development is required maintain surface roughness and MRR. Mild steel is extensive used us a main engineering material in various industry such as air craft and aerospace industry impact of finishing parameter such as speed (200,1000,2000) in rpm. Feed rate (200,1000,2000) mm/minute, depth of cut (.01,.05,.1) in mm and width of cut (0.1,0.2,0.4) in mm. The finishing tool diameter is constant in 6 mm. The Taguchi optimization methodologies to optimize the finishing parameter in CNC milling machining use mild steel and tool is high speed steel. Authors analysed the data using ANOVA with the help of commercial software package Minitab-16. A series of experiment based on the Taguchi L9 orthogonal array is utilized for experimental planning for CNC milling machining. Taguchi designs provide a powerful and efficient method for designing processes that operate consistently and optimally over a variety of conditions. In this paper the finishing of mild steel with parameters of finishing at three levels and four factor each. The main objective of Taguchi methodology to find a specific range and interaction to achieve the lowest surface roughness value and highest material removal rate.

2.Experimental Processes

Work piece Material

Finishing operation will be performed on Mild steel work piece .Mild steel are soft, ductile and easily machined The composition of mild conation carbon (0.05%to0.3%) and small quantities of manganese(Mn), silicon(Si), phosphorus (P) sulphur(S)

) are material related properties. Experiments were performed using a CNC vertical Milling machine. A rectangular mild steel plate of size 100 mm ×76mm ×12mm in shaping machine for performing CNC drilling machine. Holy oil was used as the coolant fluid in this experiment .Young's Modulus (210GPa), Poisson's Ratio (0.29) Density (7.8g/cm³), Melting Point (140°C) Modulus of elasticity (200GPa) Bulk Modulus (140GPa).

2.1.High speed steel:-

One of our tools for the CNC finishing operation will be the high speed steel. High speed steel (HSS)are used for making finishing tools, we used tool diameter 6 mm in the milling machine and point angle is 118^o This property allows HSS to finishing faster than high carbon steel, hence the name high speed steel. At room temperature, in their generally recommended heat treatment, HSS grades generally display high hardness The composition of high speed steel are carbon (0.6%to0.75%) tungsten (14%to20%),Chromium (3%to5%) vanadium (1%to1.5%), Cobalt (5%to10%) and remaining is iron.

2.2.Plan of experiment:-

The plan of experiment is taken A rectangular mild steel plate of size 100 mm ×76mm ×12mm. In this plate finishing operation are perform with 6 mm diameter of tool. The experiments were conducted according to taguchi orthogonal array. Which helps in reducing the number of experiment. In this paper four parameter and three levels considered for experimental runs. Optimization for quality was carried out with signal to noise ratio and analysis of variance (ANOVA).



Figure 1- Image of Experimental workpiece.

Machining process Calculating mass of each plate by the high precision digital balance meter before machining operation and before machine process CNC machine part programs for particular tool path of particular commands using various levels of spindle speed, feed rate, depth of cut and width of cut. The performing finishing machining operation .After that calculating mass of each work pies plate again by the digital balance meter. The MRR values were measured three times of each specimen and then, the material removal rate Values were average. The Ra values also measured three times on each specimen and the surface roughness (Ra) is measured with a mitutoyo surfest SJ-201 series 178 portable surface roughness tester instrument. Machining experiments for determining the optimal machining parameter were carried out by setting of spindle speed in the range of 200-2000 rpm, feed in the range of 200-2000 mm/min, depth of cut in the range of .01-.1 mm, width of cut in the range of .1-.4 mm and Essential parameter of the experiment are given in table .

Work condition	Description
Work piece	Mild steel , Rectangular shape (100x76x10mm)
Spindle speed	200 to 2000 rpm
Feed	200 to 2000 mm/min
Depth of cut	.01 to .1 mm
Width of cut	.1 to .4 mm
Coolant	Holy oil
Lubricant	Servo pat
Tool Diameter	6 mm



Fig. 2 - Image of working Tool

3.3.Data Analysis

In this paper, analysis based on the taguchi method is done by Signal to noise ratio(MINI-TAB-16Software) to determine the main effects of the process parameters, to perform the analysis of variance(ANOVA) and to establish the Signal to noise ratio optimum conditions. The main effects analysis is used to study the trend of the effects of each of the factors, as shown in figures 4 and 5. The machining performance (ANOVA-rank factor) for each experiment of the L9 can be calculated by taking the observed values of the MRR as an example from table 3. The taguchi analysis parameter for spindle speed (A) feed (B) depth of cut(C) and width of cut(D). The response table6 for MRR use in the signal to noise ratio larger is the better and response table7 for mean effects plot for S/N ratio the spindle speed is less in level (3) compare to the other level .the feed is the high at level (1) and depth is minimum at level (2) all this case the MRR is maximum .the surface roughness is calculated by the same procedure.table8&9 for Signal to Noise Ratios Smaller is better and Means Main Effects Plot for S/N ratios. The surface roughness is minimum at high spindle speed, low feed rate and also low depth of cut.

Table 3 - L9 table and observed value

No. Of trial	Control parameter				Result /observed value					
	Spindle Speed	Feed	Depth of Cut	Width Of cut	MRR (g/min.)			SR (Ra)		
					1	2	3	1	2	3
1	200	200	0.01	0.1	0.98	0.96	0.96	4.22	4.02	4.02
2	200	1000	0.05	0.2	0.93	0.97	0.96	3.88	3.88	3.83
3	200	2000	0.1	0.4	0.86	0.87	0.90	3.96	3.96	3.83
4	1000	200	0.05	0.4	0.89	0.90	0.91	3.85	3.85	3.83
5	1000	1000	0.1	0.1	0.90	0.92	0.90	3.83	3.82	3.86
6	1000	2000	0.01	0.2	0.83	0.86	0.85	3.12	3.21	3.30
7	2000	200	0.1	0.2	0.85	0.83	0.83	3.00	3.12	3.23
8	2000	1000	0.01	0.4	0.97	0.95	0.93	3.20	3.00	3.25
9	2000	2000	0.05	0.1	0.90	0.91	0.88	3.25	3.24	3.22

Table 4 -S/N Ratio for MRR (Larger is Better)

No. Of trial	1	2	3	Average Response Value	SNRA	MEAN
1	0.98	0.96	0.96	0.9667	-0.29417	0.9667
2	0.93	0.97	0.96	0.9533	-0.41541	0.9533
3	0.86	0.87	0.90	0.8767	-1.14298	0.8767
4	0.89	0.90	0.91	0.9000	-0.91515	0.9000
5	0.90	0.92	0.90	0.9067	-0.85073	0.9067
6	0.83	0.86	0.85	0.8467	-1.44541	0.8467
7	0.85	0.83	0.83	0.8367	-1.54860	0.8367
8	0.97	0.95	0.93	0.9500	-0.44553	0.9500
9	0.90	0.91	0.88	0.8967	-0.94706	0.8967

No. Of trial	1	2	3	Average Response value	SNRA	MEAN
1	4.22	4.02	4.02	4.0867	-12.2275	4.0867
2	3.88	3.86	3.83	3.8567	-11.7243	3.8567
3	3.96	3.80	3.83	3.8633	-11.7392	3.8633
4	3.85	3.85	3.83	3.8433	-11.6941	3.8433
5	3.83	3.82	3.86	3.8367	-11.6792	3.8367
6	3.12	3.21	3.30	3.2100	-10.1301	3.2100
7	3.00	3.12	3.23	3.1167	-9.8739	3.1167
8	3.20	3.00	3.25	3.1500	-9.9662	3.1500
9	3.25	3.24	3.22	3.2367	-10.2020	3.2367

Table 5 - S/N Ratio for SR (Smaller is Better)

4.Hole data

All data regarding the holes is stored inside a collection (named "Holes") of instances of a dedicated data structure (named "Hole"). The data structure contains geometrical information - inputted with respect to a specified coordinate system - and other non-geometrical specifications. Table 1 presents in tabular form an example of hole data, with sample values for the most important fields.

Table 6 -. hole data main fields .

N o	X	Y	Z	Dep lh	Typ e	Dia- met -er	Obser- vation -s
1	25. 4	32. 5	0	10	R	5	Regula rhole, -
2	34. 2	32. 5	0	5	T	6	.-'-0.1
3	65. 4	32. 5	-5		P	1 0	Metric lhmid
							Precisi m hole

The notations used in Table 6 are explained below:

X, Y — plane coordinates of the hole:

Z — the altitude of the upper limit of the hole. The reference coordinate system is assumed to have the origin at the top of the work piece, making the Z coordinate zero or negative. In practice, in order to avoid user input errors Z is treated as a positive parameter, the sign being resolved in the postprocessing phase; Depth — actual depth of hole (starting from Z); Type — type of hole, belonging to one of the categories defined. In the example above: R — regular hole, with no specific exigences; T — threaded hole; P — precision hole, finished with a reamer.

Hole information represents the initial data of the process. Starting from it, the programmer technologist, assisted by the program, needs to group the hole drilling operations in sets of identical properties. Each hole in a set is processed by the same tool in a single step.

5.Sets data

We define a set as the collection of holes that can be processed with the same tool and the same milling parameters. As a consequence each set has a specific tool attached: drill, tap, reamer. Starting from initial data, the CNC programmer prepares the sets to be processed in chronological order, in accordance with the designed

technological operations. This activity is aided by the program. The application proposes the sets of holes based on the rules governing the categories to which each hole belongs but the user has full control over the set-up and can edit it in any way as long as the final result is in accordance with the rules.

The first set is always dedicated to the centering operation (performed with a dedicated tool - the center drill) and is composed of all the holes in the job. This is due to the fact that all other operations have a mandatory precedence rule on the centering operation. The configuration of the next sets depends on the chosen technology, according to the initial data specified for the holes: type of hole (regular, precision, thread, etc.), diameter, etc.

Because each hole will probably be part of several sets, the relation between these two concepts is not one of inclusion. Instead, the sets hold references (handles) to the holes they contain, while the holes also retain handles to all the sets they belong to. Running through all the sets referenced by a hole reflects all the technological operations involved in the manufacturing of that specific hole, from centering to the end result

Table 7 - Sets main data fields.

No.	Category	G-code	Tool	Diameter	Rot. Speed	Feed rate	holes	Observations
1	Centering	GSI	T1	-	800	60	1-23	All holes
2	Drilling	G82	T6	5	60	50	1 2.6	-

5.1.Application GSG-01

The methodology proposed here and described above is currently being implemented in an application called “GSG-01”. The application was designed with a full OOP approach and is developed using Visual Basic .NET [9]. The application is intended to assist the technologist in creating programs for the machining of drill holes in a timely and safely manner. The streamlined user interface and power of the underlying system and data model make the job of the engineer much easier, allowing fast creation of error-free CNC programs.

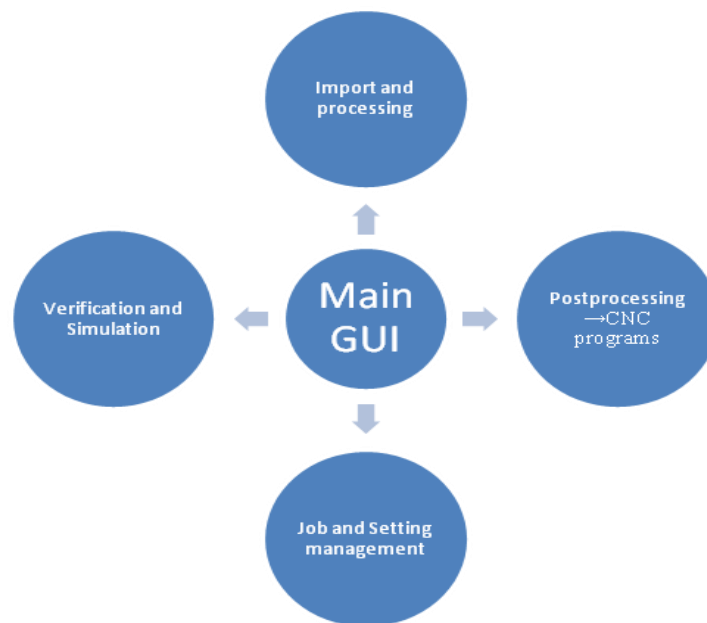


Fig. 3 – Main GUI Process

Application Schematic Diagram

6.Results and Discussion

6.1. Material Removable Rate

In case of MRR the most significant parameter is feed which is having rank 1 in table 6 and with the analysis of S/N Ratio graphs the predicted optimal parameter setting for maximum MRR at spindle speed (A1, 200), feed (B2,1000), depth of cut (C1, 0.01) and width of cut (D1,0.1). According to this procedures' optimal parameter sets confirmation test is done and found MRR is (0.98g/min). Which shows the successful implementation of taguchi methodology in CNC drilling machine.

6.2. Surface Roughness

In case of SR the most significant parameter is spindle speed which is having rank 1 in table 8 and with the analysis of S/N Ratio graphs the predicted optimal parameter setting for minimum SR at spindle speed (A3, 2000), feed (B3,2000) and depth of cut (C1,0.01) and width of cut (D2,0.2). According to this procedures' optimal parameter sets confirmation test is done and found SR is (3.05Ra). Which shows the successful implementation of taguchi methodology in CNC drilling machine.

7.Conclusion

This paper has discussed the feasibility of machining Mild Steel by (CNC finishing machine) With a HSS Tool. The signal to noise ratio has been used to determine the main effects significant factors and optimum machining condition to the performance of finishing operation in mild steel based on the results presented here in. We can conclude that, the Spindle Speed of finishing machine Tool mainly affects the SR. The Feed Rate largely affects the MRR

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References

- [1] Ghani, J.A., Choudhury, I.A., Hasan, H.H. Application of Taguchi Method in Optimization of End Milling Parameters, Journal of Materials Processing Technology (2004) 145: 84-92.
- [2] Zhang, J.Z., Chen, J.C., Kirby, E.D. (2007). Surface roughness optimization in an end milling operation using the Taguchi design method. Journal of Materials Processing Technology, vol. 184, no. 1-3, p. 233-239, DOI:10.1016/j.jmatprotec.2006.11.029
- [3] Ross PJ, Taguchi techniques for quality engineering, (McGraw-Hill International Editions, Singapore, 1996)
- [4] Ghani. J .A.. Choudhury. I.A.. Hasan. H.H. Application of Taguchi Method in Optimization of End Milling Parameters. Journal of Materials Processing Technology (2004) 145: 84-92.
- [5] Yang. J.L.. Chen. J .C' . (2001). A systematic approach for identifying optimum surface roughness performance in end-milling operations. Journal of Industrial Technology. vol. 17. no. 2.p. 1-8.
- [6] Zhang. J.Z.. Chen. J.C.. Kirby. E.D. (2007). Surface roughness optimization in an end milling operation using the Taguchi design method. Journal of Materials Processing Technology. vol. 184. no. 1-3. p. 233-239. DOI:10.1016/j.jmatprotec.2006.11.029 .