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Parametric Optimization of Drilling Machining Process of M.S.Material by Using Factorial Regression Method

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Abstract**—** This thesis presents a method for finding the most influential factor amongst the Feed Rate, Speed of the Spindle and Depth of Cut to get the highest removal rate of material and superior surface finish using multi-factor Anova analysis. In any manufacturing industry, it is important that the input parameters are optimized to get the desired output in say minimum time, minimum cost and with high quality. In a metal turning or milling shop the most important input parameters are usually Feed Rate, Speed of the Spindle and Depth of Cut. The common desired outcomes are high Removal Rate of Material (MRR) and good Finish of Surface. Hence to optimize the input parameters, number of experiments were conducted at different spindle speeds, feed rates & depth of cuts and outputs in terms of MRR and surface finish were measured. These outputs were then analyzed using multi factor factorial analysis using Minitab Software. The observation were that, the Depth of cut had significant authority on the Material Removal Rate, however feed rates and spindle speed had comparatively less effect on it. As far as the Surface Roughness was concerned, both the Speed of Spindle and Depth of Cut had significant share of significance on the Surface Roughness values.

Keywords-*Material removal rate, Anova, Minitab Software*

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I. INTRODUCTION

In this research work, material removal rate (MRR) and surface roughness of the work piece prepared by CNC drilling milling operation are to be studied procedure tried on the change us a test and find out the solution. The Drilling machine highly used in a industry for metal removal operation. It is, therefore, essential to optimize quality and productivity simultaneously. .

Productivity can be interpreted in terms of material removal rate in the machining operation and quality represents satisfactory yield in terms of product characteristics as desired by the customers.

The quality of design can be improved improving the quality and productivity in companywide activities Quality and productivity are two importance's inter elation with each other in any machining operation Taguchi parameter design offer a systematic method for optimization techniques of various parameters with the regarding to performance quality and cost. Taguchi methodology optimized drilling parameter a drilling machine. The drilling machines are two importance aspect surface roughness and material removal rate. The personnel industry as well as in research and development is required maintain surface roughness and MRR. Milled steel is extensive used us a main engineering material in various industry such as air craft and aerospace. Impact of drilling parameter industry such as spindle speed (600,800,1000) in rpm ,feed rate (20,30,40) mm/min ,depth of cut (2,5,7) in mm. the drilling tool diameter is constant in 8 mm. The tool angle is fixed 180º .The find out the MRR and SR. The drilling hole used work piece in mild steel material. The tool is made by the high speed steel material. A series of experiment based on L9 orthogonal array are conducted using machining centre. The experimental result is collected analyzed used by multi factor factorial analysis.

Nouari et al. (2003)he studied the important factor which affect the quality of hole. He recognise that speed , feed rate , Temperature as well as parameter of geometry directly affect the quality of hole & also recommended that when large cutting & low feed rate gives better surface finish & accurate dimension of hole.

Azlan Abdul Rahman(2009) He examined that When taking drill bit size 0.5 to 1 mm, influence speed, feed rate & diameter of drill on MRR & roughness of surface. He has experiment doing on roughness of surface &MRR as well as hole accuracy.& those result are specified when increasing the speed & feed that influence on drill wear & edges of drill.

Dipaolo g, kapoor Gand devor He research on the crack growth occurrence through drilling unidirectional carbon fiber resin as well as fiber reinforced composite material. He has doing the experimental set up on crack growth occurrence by way of drill appear from the workpiece exit side.

Wen-Chou Chen He understands the factor of delamination (Max. Dia/hole dia.)& they perform the experimental set up of drilling operation of variation of cutting forces with or without start of delamination & they analyzed the effect on CFRP(carbon fiber reinforced plastic) material of tool geometry & drilling parameter with the help doing experimental set up.

S. C. Lin, I. K. Chen He analyzed that , when increasing the cutting speed & cutting force will quicken the tool wear. He observed that in CFRP material, drill wear as the most important problem in drilling operation of high speed. Drastically tool geometry are change due to drill wear & cutting force as increasing when increasing the cutting speed that will effect on quality of hole.

Anil Jindal, Dr. V. K. Singla139Research Cell:2011 He considered the theory of fracture mechanics & recommended for acute cutting & thrust force in drilling operation & monitors the crack growth formation. He applied the network & understands the thrust force & feed rate.

J. Mathew, N.Ramakrishnan and N. K. Naik They observed that thrust is a main factor & they direct effect on delamination & which is influenced by rate of feed & geometry of tool . In this study they use the trepanning tool & observe that while drilling hole on thin laminated material give the minimum thrust. They developed the mathematical model correlation between the torque & thrust.

II. MATERIAL

Drilling operation performed on mild steel.workpiese.mild steel are soft, ductile and easily machined. Experiments were performed using a CNC vertical drilling machine. One of our tools for the CNC drilling operation will be the high speed steel. High speed steel (HSS)are used for making drilling tools, we used tool diameter 8mm in the drilling machine and point angle is118º This property allows HSS to drilling faster than high carbon steel, hence the name high speed steel.

Table No.1Workpiece Material

Material	M.S.
Size	10mm x 75mm x 8mm
Carbon	0.05% to 0.3%
Young's modulus	210GPa
Poisson's Ratio	0.29
Density	7.8 g/cm^3
Melting point	140^o C
Modulus of elasticity	200GPa
Bulk Modulus	140GPa

Table No.2 Tool Material

Tool Material	**High Speed steel**
Diameter	8mm
carbon	0.6%to0.75%
tungsten	14%to20%
Chromium	3%to5%
vanadium	1%to1.5%
Cobalt	5%to10%
Iron	Remaining

Table No.3Working Condition

Work Condition	**Description**
Workpiece Material	Mild Steel(100x75x8mm)
Spindle speed	600-1000 rpm
Feed	20-40mm/min
Depth of cut	2-7mm
Lubricant	Servo pat
Coolant	Holy Oil
Tool Diameter	8mm

III. EXPERIMENT& METHODOLOGY

The experimental layout for the machining parameters using the L9 orthogonal array (OA) design the machine was used for the drilling operation in this study. The surface and MRR are two essential part of a product in any drilling machining operation The theoretical surface roughness is generally dependent on many parameter such as the tool geometry, tool material and work piece material. The array having a three control parameter and three levels as shown in table 4 In the present study spindle speed (N,rpm) depth of cut (D,mm) feed rate(f,mm/rev) have been selected as design factor. while other parameter have been assumed to be constant over the Experimental domain This Experiment focuses the observed values of MRR and SR were set to maximum, intermediate and minimum respectively. Each experimental trial was performed with three simple replications at each set value. Next, the optimisation of the observed values was determined by Multiple regression method.& Comparing with the response surface regression method. The surface roughness is measured with the help of Handy Surf E-MC-35B Instrument.

Observation Table No.4

No. of Trial	Control Parameters			Results					
	Spindle speed (rpm)	Feed rate (mm/mi)	Depth of cut(mm)	MRR(cm^3/min)x 10^{-3}			SR(Ra)		
				1	2	3	1	2	3
1	600	20	2	1.0	1.5	2	0.5	0.51	0.7
2	600	30	5	1.1	1.53	2.3	0.51	0.52	0.71
3	600	40	7	1.3	1.41	2.12	0.52	0.5	0.7
4	800	20	2	1.2	1.43	2.2	0.4	0.6	0.7
5	800	30	5	1.15	1.45	2.32	0.41	0.61	0.72
6	800	40	7	1.22	1.52	2.13	0.42	0.62	0.73
7	1000	20	2	1.12	1.54	2.3	0.5	0.52	0.62
8	1000	30	5	1.3	1.52	2.14	0.52	0.52	0.64
9	1000	40	7	1.41	1.52	2.34	0.54	0.53	0.62

General Factorial Regression: MRR in cm^3/m versus Spindle Speed, Feed Rate and Depth of Cut

Table No.5 Factor Information

Factor	Levels	Values		
Spindle Speed in RPM	3	1	2	3
Feed Rate in mm per min	3	1	2	3
Depth of Cut in mm	3	1	2	3

Table No6Analysis of Variance

Source	**DF**	**Adj SS**	**Adj MS**	**F-Value**	**P-Value**
Model	18	4.98202	0.27678	25.32	0
Linear	6	4.89591	0.81599	74.65	0
Spindle Speed in RPM	2	0.04887	0.02443	2.24	0.169
Feed Rate in mm per min	2	0.02809	0.01404	1.28	0.328
Depth of Cut in mm	2	4.81896	2.40948	220.44	0
2-Way Interactions	12	0.08611	0.00718	0.66	0.754
Spindle Speed in RPM*Feed Rate in mm per min	4	0.02838	0.00709	0.65	0.643
Spindle Speed in RPM*Depth of Cut in mm	4	0.01051	0.00263	0.24	0.908
Feed Rate in mm per min*Depth of Cut in mm	4	0.04722	0.01181	1.08	0.427
Error	8	0.08744	0.01093		
Total	26	5.06947			

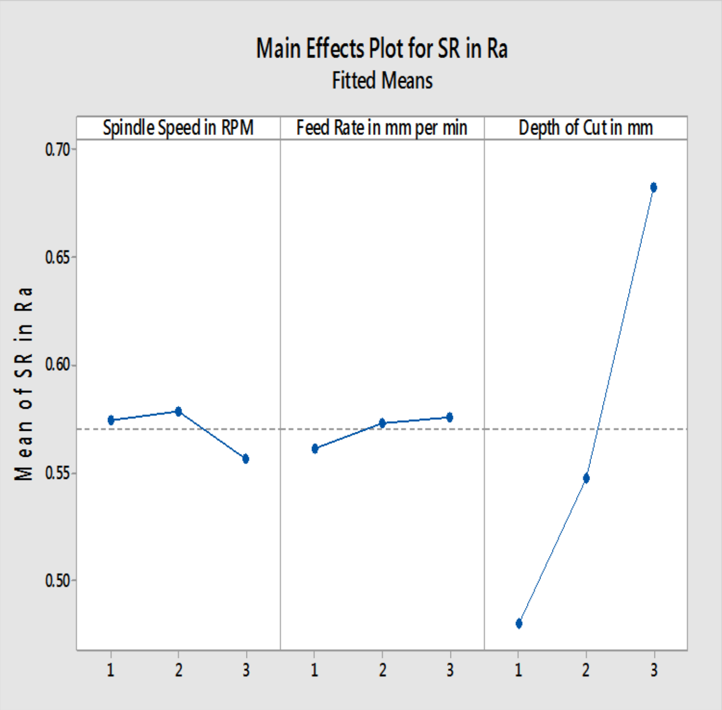
General Factorial Regression: SR in Ra versus Spindle Speed, Feed Rate in, Depth of Cut

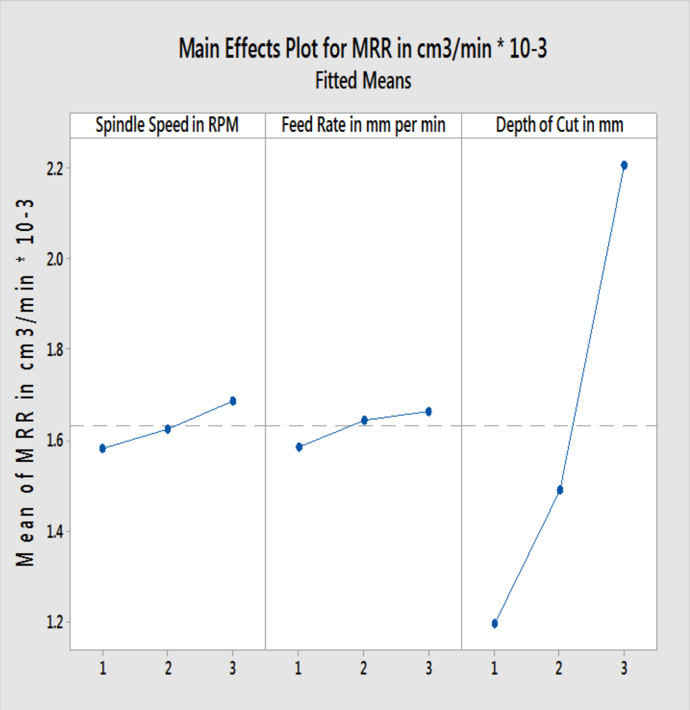
Table No.7 Factor Information

Factor	Levels	Values		
Spindle Speed in RPM	3	1	2	3
Feed Rate in mm per min	3	1	2	3
Depth of Cut in mm	3	1	2	3

Table no.8Analysis of Variance

Source	**DF**	**Adj SS**	**Adj MS**	**F-Value**	**P-Value**
Model	18	0.246667	0.013704	205.56	0
Linear	6	0.194267	0.032378	485.67	0
Spindle Speed in RPM	2	0.002489	0.001244	18.67	0.001
Feed Rate in mm per min	2	0.001089	0.000544	8.17	0.012
Depth of Cut in mm	2	0.190689	0.095344	1430.17	0
2-Way Interactions	12	0.0524	0.004367	65.5	0
Spindle Speed in RPM*Feed Rate in mm per min	4	0.000356	0.000089	1.33	0.337
Spindle Speed in RPM*Depth of Cut in mm	4	0.051556	0.012889	193.33	0
Feed Rate in mm per min*Depth of Cut in mm	4	0.000489	0.000122	1.83	0.216
Error	8	0.000533	0.000067		
Total	26	0.2472			





Response Surface Regression

Table No.10MRR in cm versus Spindle Speed, Feed Rate, Depth of cut

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	9	4.92349	0.54705	63.71	0
Linear	3	4.62885	1.54295	179.69	0
TV Spindle Speed in RPM_1	1	0.0488	0.0488	5.68	0.029
TV Feed Rate in mm per min_1	1	0.02991	0.02991	3.48	0.079
TV Depth of Cut in mm_1	1	4.55014	4.55014	529.9	0
Square	3	0.58042	0.19347	22.53	0
TV Spindle Speed in RPM_1*TV Spindle Speed in RPM_1	1	0.00082	0.00082	0.1	0.762
TV Feed Rate in mm per min_1*TV Feed Rate in mm per min_1	1	0.0024	0.0024	0.28	0.604
TV Depth of Cut in mm_1*TV Depth of Cut in mm_1	1	0.5772	0.5772	67.22	0
2-Way Interaction	3	0.02758	0.00919	1.07	0.388
TV Spindle Speed in RPM_1*TV Feed Rate in mm per min_1	1	0.00003	0.00003	0	0.951
TV Spindle Speed in RPM_1*TV Depth of Cut in mm_1	1	0.00089	0.00089	0.1	0.751
TV Feed Rate in mm per min_1*TV Depth of Cut in mm_1	1	0.02666	0.02666	3.1	0.096
Error	17	0.14598	0.00859		
Total	26	5.06947			

Model Summary			
S	**R-sq**	**R-sq(adj)**	**R-sq(pred)**
0.0926653	97.12%	95.60%	91.78%

Response Surface Regression: SR in Ra_ versus Spindle Speed, Feed Rate, Depth of Cut

Table No.11MRR Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	9	0.199435	0.022159	7.89	0
Linear	3	0.186058	0.062019	22.07	0
TV Spindle Speed in RPM_1	1	0.001024	0.001024	0.36	0.554
TV Feed Rate in mm per min_1	1	0.001012	0.001012	0.36	0.556
TV Depth of Cut in mm_1	1	0.184022	0.184022	65.5	0
Square	3	0.018199	0.006066	2.16	0.13
TV Spindle Speed in RPM_1*TV Spindle Speed in RPM_1	1	0.001067	0.001067	0.38	0.546
TV Feed Rate in mm per min_1*TV Feed Rate in mm per min_1	1	0.00015	0.00015	0.05	0.82
TV Depth of Cut in mm_1*TV Depth of Cut in mm_1	1	0.016983	0.016983	6.04	0.025
2-Way Interaction	3	0.005169	0.001723	0.61	0.616
TV Spindle Speed in RPM_1*TV Feed Rate in mm	1	0.000133	0.000133	0.05	0.83

per min_1					
TV Spindle Speed in RPM_1*TV Depth of Cut in mm_1	1	0.00479	0.00479	1.7	0.209
TV Feed Rate in mm per min_1*TV Depth of Cut in mm_1	1	0.000246	0.000246	0.09	0.771
Error	17	0.047765	0.00281		
Total	26	0.2472			

Model Summary			
S	R-sq	R-sq(adj)	R-sq(pred)
0.0530064	80.68%	70.45%	51.05%

IV. CONCLUSION

- .It can be observed that the effect of Depth of Cut on the MRR value is significant since the P value is below 0.05 value, this can also be verified from the main effects plot. It can also be observed that there is no significant interaction between different parameters on the response value i.e. the MRR.
- It can be observed that the effect of Depth of Cut as well as spindle speed on the SR value is significant since the P value is below 0.05 value, this can also be verified from the main effects plot. It can also be observed that there is significant interaction between spindle speed and depth of cut on the response value i.e. the SR as can be observed from interaction plot. No other significant interaction can be seen.

V. FUTURE SCOPE

- To investigate the same process for enhancing process parameters and level by introducing different cutting tools, different cutting fluids.
- In this research Anova method and General Factorial Regression method are used to find out the control of parameters such as spindle speed, feed rate and depth of cut on surface roughness and material.

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