To Predict The Significant Factor of Turning Operation And Analysis MRR In Lathe Machine

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Abstract- *The main objective of this work is to study and analysis the effect of speed, depth , and feed of cutting on metal surface and cutting force in machining mild steel using high speed steel cutting tool.. The fluency demand for higher productivity of product quality probes for superior understanding and control of machining processes by reducing machining time with the increase of cutting force and material removal rate (MRR).The present work performance of machining of hardened steel (AISI 4340 steel) under high speed lathe turning. The influence of cutting parameters (speed, feed, and depth of cut) for surface finish . Under the different cutting conditions . Cutting force and MRR are mostly affected by speed and feed.Conducted Experiment on lath tool with influence of cutting parameter was studied using analysis of variance (ANOVA) based on adjusted approach. Based on the most effects plots obtained through Full Factorial approach, a complete of 27 tests is administered , optimum level for MRR and cutting force from the three levels of cutting parameters considered. The range of each parameter is set at three different levels, namely low, medium and high*

Keywords- Cutting Force , MRR, Full Factorial, ANOVA, Design Expert

I. INTRODUCTION

The layers on the cutting tools through various chemical reactions is take place . Deposit of thin layers method on the cutting tools through physical techniques, mainly sputtering and evaporation .The cutting tools majority uses today employ chemical vapor deposition (CVD) or physical vapor deposition (PVD) hard coatings. The wear resistance and chemical stability of extraordinary hardness of these coatings offer proven benefits in terms of tool life and machining performance. The first technique is the CVD.AISI 4340 is a heat treatable , low alloy steel containing , chromium and molybdenum. Coated hard metals have caused tremendous increase in productivity since their introduction. Since then coatings have also been applied to high speed steel and particularly to HSS drills.. Coatings used are extremely hard for the compounds which make very abrasion resistant. Emblematic constituents of coating are Titanium Carbide(TiC), Titanium Nitride (TiN) .All these compounds have low solubility in iron and they enable inserts to cut two le at much higher rate than is or multi-layer.

Procedure of Metal cutting arrangements and is involved either directly or indirectly in the manufacture of nearly every product of our modern civilization. An area of research interest in metal cutting is that the analysis of cutting force . Prominently influences power consumption Cutting force, Thrust force and Feed force on former most common equation available for the estimation of Cutting force parameter of research interest is Material removal rate of the work piece produced..

Important conventional machining process are turning in which a single point cutting tool removes unwanted material from the surface of a work piece. Turning operation is one of the most important operations used for machine elements construction in manufacturing industries i e. aerospace, automotive and shipping. Turning produces three cutting force components as shown in fig.1a,(the main cutting force i.e. thrust force, (FZ), which acts within the cutting speed direction, feed force, (FX), which acts within the feed rate direction and therefore the radial force, (FY), which acts in radial direction and which is normal to the cutting speed).

Application of Metal:

Metal removal by coating tool from work piece in the form of chips in order to obtain high MRR and finished product with desired size , shape and surface finish. Producing sectors are virtually example for automobiles, railways, aircraft manufacture, consumer electronics etc. one finds large shops with many thousands of machining

Challenges in Metal Cutting:

Metal cutting with coating tools are complex because of the highly nonlinear nature of between deformation and temperature fields, a complete understanding of the mechanics of metal cutting is still lacking and is thus the subject of batch of current research. Also the power requirement rises since amount of cutting force is involved.. Any machining operation which involves the removal of metal by a cutting action requires that the fabric used for cutting will get up to the trials of that cutting action. The main properties which any cutting material must possess so as to hold out its function are:

- Hardness to overcome wearing action
- Hot strength to overcome the heat involved
- Sufficient toughness to withstand vibration

In general, increasing hardness brings with it a discount in toughness then those materials within the higher hardness region of the list will fail by breakage if used for heavy cuts, particularly with work pieces which have holes or slots in them which produce to interruption it the cut.

Work Material:

In this part of unit detail methodology of the experiment has been described. The detail aspect of machine tool used, equipment facilities, work piece material, cutting tool and machining parameters has been discussed. The work deals with the turning of hard material such as AISI 4340 steel. g, it was applied to evaluate the performance of tools in typical manufacturing processes.The work piece material used for the experiments is of standard dimensions was used for machining with 45 mm diameter, 175 mm long and Its chemical composition is given in table 1

Table.1The chemical composition of AISI 4340 steel in percentage by weight

C	Si	Mn	P	S	Cr	Mo	Fe
0.380 - 0.430	0.15 - 0.30	0.75 - 1.0	0.035	0.040	0.80 - 1.10	0.15 - 0.25	Balance

Cutting Parameters:

The machining operation was carried out under variable cutting speeds of 120, 210 and 310rpm for the feed rates of 0.1, 0.2 and 0.3 mm/rev and at constant depth of cut 0.1, 0.3 and 0.5 mm in dry environment i.e. without use of any coolant or cutting fluid.

II. PARAMETER SELECTION

The present work deals with the turning of hard material such as Mild steel. The parameters which of their individual level are selected on the basis of past literature which confirm that these condition are efficient in different responses. Based on some preliminary experiment selection parameters are following process selected for the present work: a) Cutting speed (A), b) Feed rate – (B), c) Depth of cut – (C), given in table –2

Table-2 Factors and their Levels

Factor	Level 1	Level 2	Level 3
A: Speed (rpm)	150	210	270
B: Feed (mm/rev)	0.1	0.15	0.2
C Depth 0fCut (mm)	0.3	0.5	0.7

Specification of the Lathe Machine & W/P Setup:

Turning experiments were carried out at four different cutting speeds which were 150, 210 and 270 m/min(*v*) and Feed rates were 0.1, 0.15, 0.2 mm/rev (*f*) and depth of cut (*d*) was kept constant at 0.3, 0.5, 0.7 mm throughout the experiments. This small depth of cut was used for finish turning. The lathe used for machining operations is Royal Machine Tool Centre Lath are shown in Figure 1 and their specification listed in table

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Fig 1 Center Lath

The photographic view of the experimental setup is shown in Fig

Fig..2 Work piece Setup

III. MEASUREMENT OF CUTTING FORCE

Cutting force is also one of the major criteria for determining the machine index of any work piece during the machining. Fx: axial component of force-The effect of feed force during machining is of least significant and is usually harmless.

Fy: radial component of force- This force is of lower magnitude but it actuates vibration during machining and dimensional accuracy of machined surface produced.

Fz: tangential component of force -This force accounts for large proportion of the resultant force and is used for determination of cutting power consumption

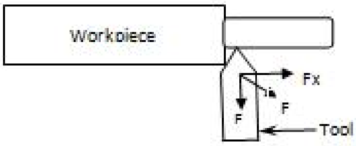

Figure 3 Cutting force component

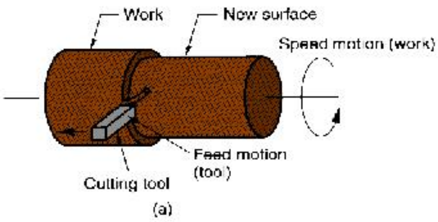

Fig 4 Turning

On line measurement of cutting force is carried out using Lath Tool Dynamometer (Kistler-9257B) mounted on the lathe. The charge signal generated at the dynamometer was amplified using charge amplifiers (Kistler Type 5814B1).The dynamometer is capable of measuring feed force (Fx), thrust force (Fy) and main cutting force (Fz) which occurs during turning operations .

Material Removal Rate (MRR)Measurement:

The challenge of modern machining industries is mainly focused on the achievement of high quality, in terms of work piece dimensional accuracy, high surface finish, high production rate, MRR of the machined chip is an important quality measure in metal cutting, and it is important to monitor and control during the machining operation. MRR = Weight of Chips/ [Density of material (p) × Time(t)]

Design of experiment:

The present experimental investigation deals with the analysis of the experiment by the Full Factorail methodology. Based on Full Factorial design, a total of 27 tests were carried out , optimum level for MRR and cutting force were chosen from the three levels of cutting parameters considered 3^3 27 experiments of settings were done to analyse the response that is the Cutting force and Material removal rate. Experiments with combination of different cutting parameters were randomly repeated

The table 3 given below

the 3^3 Full Factorial design which is used for the experiments.

S.L.No	Speed (rpm)	Feed (mm/rev)	DOC (mm)
1	150	0.1	0.3
2	150	0.1	0.5
3	150	0.1	0.7
4	150	0.15	0.3
5	150	0.15	0.5
6	150	0.15	0.7
7	150	0.2	0.3
8	150	0.2	0.5
9	150	0.2	0.7
10	210	0.1	0.3
11	210	0.1	0.5
12	210	0.1	0.7
13	210	0.15	0.3
14	210	0.15	0.5
15	210	0.15	0.7
16	210	0.2	0.3
17	210	0.2	0.5
18	210	0.2	0.7
19	270	0.1	0.3
20	270	0.1	0.5
21	270	0.1	0.7
22	270	0.15	0.3
23	270	0.15	0.5
24	270	0.15	0.7
25	270	0.2	0.3
26	270	0.2	0.5
27	270	0.2	0.7

Influences on Force Measurement:

The results indicate that the lower cutting forces were registered at the higher cutting speeds. This can be related to the temperature increase in cutting zone and leads to the drop of the work piece yield strength and chip thickness.Table presents experimental results of cutting force components (Fx, Fy and Fz) for various combinations of cutting parameters (cutting speed, feed rate and depth of cut) according to 3^3 full factorial design. The results also show that cutting forces increase with increasing feed rate and depth of cut

Minimal values of cutting forces were obtained at Vc = 270 rpm, f = 0.1 mm/rev and d = 0.3 mm (test number 13). That means increasing of cutting speed with lowest feed rate and depth of cut leads to decreasing of cutting force components. Maximal values of cutting force components (Fx, Fy and Fz) were registered at Vc= 150 m/min and f = 0.15 mm/rev and d= 0.5 mm (test number 23). In order to achieve better machining system stability, the highest level of cutting speed, 270 m/min, the lowest level of feed rate, 0.1 mm/rev, the lowest level of depth of cut, 0.3 mm, should be recommended.

Analysis of Fx :-

The results of analysis of variance (ANOVA) for axial force Fx are shown in table This table also shows the degrees of freedom (df), F-values means ratio of variance and probability each factor and different interactions . A low Probability -value (≤0.05) indicates statistical significance for the source on the corresponding response (i.e., α = 0.05, or 95% confidence level), this indicates that the obtained models are considered to be statistically significant, as it demonstrates that the terms in the model have a significant effect on the response. The other important coefficient, R-Squared, which is called coefficient of determination in the resulting ANOVA tables, is defined as the ratio of the explained variation to the total variation and is a measure of the fit degree. When R-Squared approaches to unity, it indicates a good correlation between the experimental and the predicted

Table 4 - Experimental results

Run	S	F	D	Fx	Fy	Fz	MRR
1	150	0.1	0.3	116.30	74.44	88.00	6.42
2	150	0.1	0.5	38.14	61.26	84.00	6.25
3	150	0.1	0.7	87.45	67.59	109.00	6.94
4	150	0.15	0.3	87.56	52.73	114.00	5.25
5	150	0.15	0.5	65.02	76.23	136.00	6.28
6	150	0.15	0.7	44.99	77.36	56.00	6.74
7	150	0.2	0.3	112.45	49.26	66.03	5.37
8	150	0.2	0.5	82.60	86.00	59.73	6.55
9	150	0.2	0.7	42.54	57.80	99.63	6.87
10	210	0.1	0.3	69.69	54.00	107.61	6.09
11	210	0.1	0.5	47.91	74.00	74.45	5.96
12	210	0.1	0.7	51.82	87.80	121.38	5.88
13	210	0.15	0.3	66.45	86.45	87.13	5.05
14	210	0.15	0.5	40.58	78.00	140.91	5.31
15	210	0.15	0.7	116.53	66.00	89.56	6.61
16	210	0.2	0.3	87.46	112.00	54.87	6.74
17	210	0.2	0.5	42.54	87.00	80.28	5.76
18	210	0.2	0.7	51.57	44.01	124.97	6.09
19	270	0.1	0.3	96.50	106.42	101.45	7.72
20	270	0.1	0.5	59.14	76.00	64.20	7.59
21	270	0.1	0.7	58.90	106.72	90.98	5.7
22	270	0.15	0.3	84.78	112.00	105.16	5.77
23	270	0.15	0.5	51.08	54.85	219.41	6.67
24	270	0.15	0.7	116.30	54.50	110.43	6.16
25	270	0.2	0.3	38.14	46.34	112.52	5.9
26	270	0.2	0.5	87.45	60.67	113.32	7.13
27	270	0.2	0.7	87.56	59.78	121.97	6.74

Table 5. -Analysis of variance table Fx

Source	DF	Seq SS	Adj SS	Adj MS	F	P
S	2	3407.7	3247.6	1623.8	3.26	0.041
F	2	258.8	267.4	133.7	0.27	0.068
D	2	2116.5	2116.5	1058.3	2.12	0.147
Residual Error	19	9472.7	9472.7	498.6		
Total	25	15255.7				

The analysis of variance of first order model is shown in table .The "Model P-value" of 0.041 implies the model is significant relative to the cutting speed. For the linear model, the p-value for lack of fit is 0.041 is significant with the lack of fit and the f-statistic is 3.26.This implies that the model could fit and it is adequate Non-significant lack of fit is good we want the model to fit.This result shows that depth of cut has the most significant effect on the cutting force, followed by cutting speed and feed rate. A negative "Pred R-Squared" implies that the overall mean is a better predictor of your responsethan the current model.

Effect graphs of the main cutting regime on Fx

Figure , gives the main factor plots for Fx. Axial force Fx appears to be a decreasing function shown in fig. This figure also indicates that Fx is an almost linear increasing function of d. But the feed rate f has a little effect on Fx, in this case lower the better term is used to predict the parameters level. Finally predicting the parameter for Fx direction is cutting speed is 3.10, feed is 0.3 and depth of cut is 0.5.

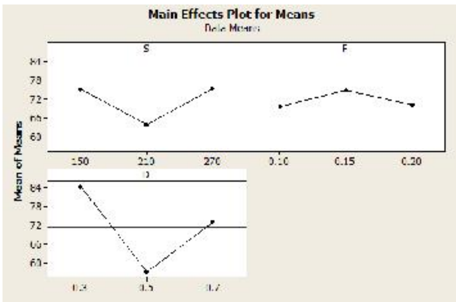

Fig. 4 Mean effect plot of Fx

Analysis of Fy:

Table 6 Analysis of variance table for Response Fy

Source	DF	Seq SS	Adj SS	Adj MS	F	P
S	2	5185.0	5142.2	2571.1	3.47	0.052
F	2	1638.4	1637.3	818.6	1.10	0.042
D	2	594.0	594.0	297.0	0.40	0.676
Residual Error	19	14095.8	14095.8	741.9		
Total	25	21513.2				

The analysis of variance of second order model is shown in table 5.3 The "Model P-value" of 0.042 implies the model is significant relative to the feed. There is a 42% chance that a "Model F-value" this large could occur due to noise.For the linear model, the p-value for lack of fit is 0.42 significant with the lack of fit and the f-statistic is 1.10.This implies that the model could fit and it is adequate Non-significant lack of fit is good we want the model to fit.This result shows that cutting speed has the most significant effect on the cutting force, followed by feed rate and depth of cut.The second response model is more precise than first order model, because the predicted result is much more accurate than the first response model.

To understand the hard turning process in terms of axial force Fy, mathematical model was developed using Classical sum of squares method. However, this model is built using only the main cutting variables (cutting speed, feed rate and depth of cut) and their significant interactions.

Effect graphs of the main cutting regime on Fy

Fig shows the main factor plots for Fy. Radial force Fy appears to be a decreasing function of V. This figure also indicates that Fy is an almost increasing function of F . But feed rate is more significant factor in this graph. This graph follow lower the better function in each level. The prediction parameter for Fy cutting speed is 310, feed is 0.2 and depth of cut is 0.1.

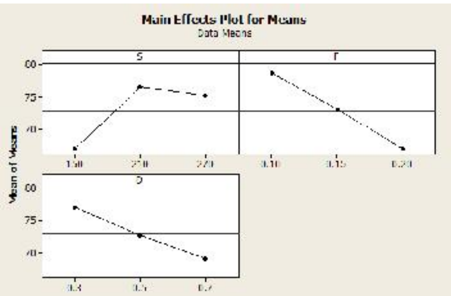

Fig. 5 Mean effects plot of F

Analysis of Fz:

Table 7 Analysis of variance table Fz

Source	DF	Seq SS	Adj SS	Adj MS	F	P
S	2	1628	1330	664.9	0.77	0.476
F	2	1627	1699	849.5	0.99	0.392
D	2	9655	9655	4827.4	5.60	0.012
Residual Error	19	16379	16379	862.1		
Total	25	29289				

The analysis of variance of response Fz model is shown in table 6

The Model P-value of 0.012 implies the model is significant. In this case D is significant model terms.The "Lack of Fit F-value" of 5.60 implies the Lack of Fit is significant relative to depth of cut. This model can be used to significant the design. It can be noted that the depth of cut is the dominant factor affecting tangential cutting force Fz.

Effect graphs of the main cutting regime on Fz

Fig highlights the main factor plots for Fz. Tangential cutting force Fz appears to be an almost decreasing function of V. This figure also indicates that Fzis an almost linear increasing function of D respectively.

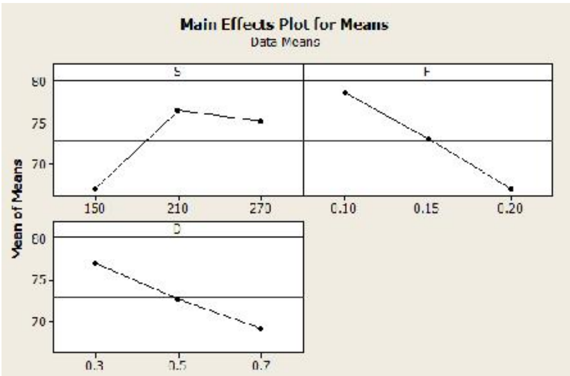

Fig. 6 Mean effect plot of

FzAnalysis of MRR:

Table 7 Analysis of variance table MRR

Source	DF	Seq SS	Adj SS	Adj MS	F	P
S	2	1.8680	1.4209	0.71045	8.46	0.02
F	2	8.1469	8.0850	4.04251	8.13	0.01
D	2	0.1231	0.1231	0.06156	0.73	0.494
Residual Error	19	1.5960	1.5960	0.08400		
Total	25	11.7339				

ANOVA results for MRR are indicated in table 7.

The Model P-value of 0.02 and 0.01 implies the model is significant. There is only a 0.01% chance that a "Model F-Value" this large could occur due to noise. Values of "Prob > F" less than 0.0500 indicate model terms are significant.In this case A, B are significant model terms. . A ratio greater than 4 is desirable. This model can be used to navigate the design space. It can be noted that the feed is the dom inant factor affecting MRR.

Effect graphs of the MRR

Fig highlights the main factor plots for MRR. MRR appears to be an almost linear decreasing function of Feed. This figure also indicates that MRR is an almost linear increasing function of f and d respectively.

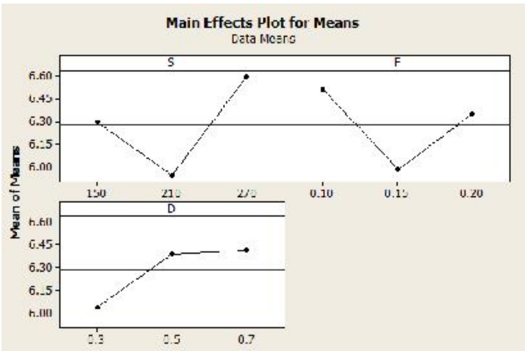

Fig. 6 Effect plot of MRR

IV. CONCLUSION

Based on the experimental results, the following conclusions can be drawn:

1) Full Factorial Design method is found to be a successful technique to perform trend analysis of Cutting Force and MRR in metal cutting with respect to various combinations of design variables (metal cutting speed, feed rate, and depth of cut).

2) Response model for Fz is more precise than first Response model for Fx and second Response model for Fy in predicting the power consumption and significant during machining

A. Thus, to get good machining system stability, we must use the highest level of cutting speed, 270 m/min, the lowest level of feed rate, 0.1 mm/rev and the lowest level of depth of cut, 0.3 mm.
B. The depth of cut influences cutting forces in a considerable way
C. This study reveals that in dry hard turning of this steel and for all cutting conditions tested, the principal force is not always the radial force. The tangential cutting force becomes the major force followed by radial and axial forces.
D. The second factor affecting cutting force is feed. Its contributions on Fy in P value is lower its effect is important
E. Statistical models deduced defined the degree of influence of each cutting regime element on cutting force components. They can also be used for optimization of the hard cutting process.

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