ISSN No. 2455-5800
Journal of Scientific Research in Allied Sciences
**Original Research Article**

# OPTIMIZATION OF MILLING MACHINING PARAMETER BY ANOVA ANALYSIS

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Article history:
Submitted on: June 2016
Accepted on: June 2016
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## ABSTRACT

In a machining process, in adjustment to advance machining efficiency, abate the machining cost, and advance the superior of machined parts, it is all-important to baldest the lot of adapted machining conditions. The ambience of machining ambit relies acerb on the operator's experience. It is difficult to advance the accomplished achievement of an apparatus attributable to their getting too abounding adjustable machining parameters. The range of each parameter is set at three different levels, namely low, medium and high. Mathematical models were deduced by software MINITAB in order to express the influence degree of the main cutting variables such as cutting speed, feed rate and depth of cut on cutting force components. The results indicate that the depth of cut is the dominant factor affecting cutting force components. The depth of cut influences tangential cutting force more than radial and axial forces. The cutting speed affects tangential force more than radial and axial forces.

**KEYWORDS: Cutting Force, Material Removal Rate, Full Factorial Design, ANOVA, Milling**

## 1. INTRODUCTION :

The service life of any work piece relies on upon its properties of the force and evacuation rate, in light of the fact that this is with the immediate contact of climate, so the execution of any strength may get influenced as a result of the physical and synthetic change in the surface. There is a popularity of segments of aluminium amalgams of better completing in the aviation commercial enterprises keeping in mind the end goal to expand their execution by evading vicinity of some anxiety concentrators in the surface, for example, miniaturized scale breaks, scratches, or striations created amid machining. The efficiency of any machine device and any machined part is dictated by the nature of the surface delivered by that machine. Henceforth for the great useful conduct of any mechanical parts accomplishing great surface quality is of awesome significance. In today's assembling commercial enterprises quality is one of the noteworthy variables, the main part to impact the client to a level of fulfilment. In every mechanical division surface quality is distinguished by the estimation of powers of the segment.

**Milling Machine**

Milling is a machining process by which a surface is generated by progressive chip removal using a milling cutter. It is a machine tool which removes metal from the work piece as it is fed against the rotating milling cutters.

***Principle of Milling***

Horizontal Knee and Column Milling Machine is shown in Fig. 1. In milling, the work piece is mounted on the machine table. The table can slide both horizontally and vertically. The milling cutter (s) mounted on the machine spindle. The spindle receives power from a motor and hence the cutter rotates about the axis of the spindle in the vertical plane. Based on the requirement, the table (work piece) is moved against the rotating cutter and the desired machining surface is obtained in a single pass of the work piece. Desired depth of cut may be obtained by multiple passes of the work piece. Equally spaced peripheral teeth over the cutter intermittently engage and machine the work piece. This is called interrupted cutting. It enables the cutter teeth to be cooled effectively till they engage the work piece again.

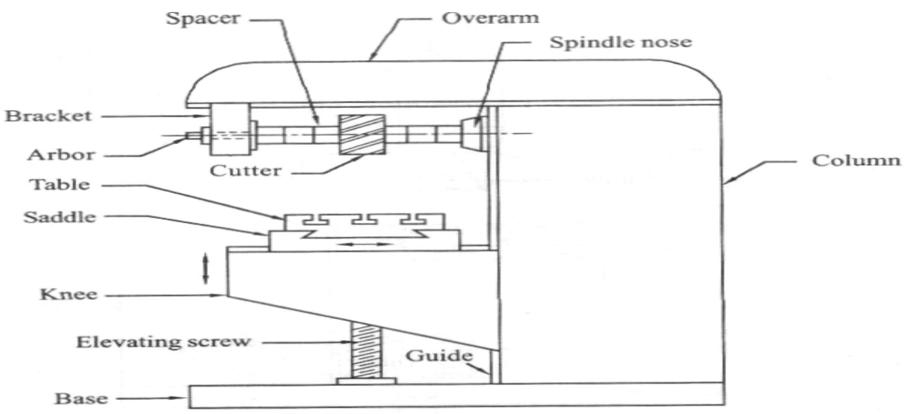


**Fig.1**. Horizontal Knee and Column Milling Machine [3]

***Milling Operation***

The work piece is mounted the table with the help of suitable fixtures. The desired contour, feed and depth of cut for the job are noted down. A suitable milling cutter for the specified job is selected and mounted on the arbour. The knee is raised till the cutter just touches the work piece. The machine is started. By moving the table, saddle and the knee, for the specified feed and depth of cut, the desired job may be finished. The machine may then be switched off.

**METAL CUTTING PROCESS:**

Metal cutting procedure frames the premise of the designing business and is included either specifically or in a roundabout way in the assembling of almost every result of our advanced human progress. The cutting instrument is one of the vital components in understanding the maximum capacity out of any metal cutting operation. Over the years the demands of economic competition have motivated a lot of research in the field of metal cutting leading to the evolution of new tool materials of remarkable performance and vast potential for an impressive increase in productivity. An area of research interest in metal cutting is the analysis of cutting force, as minimum power consumption is a never ending endeavor. Among the Cutting force, Thrust force and Feed force the former prominently influences power consumption and the most common equation available for the estimation of Cutting force is given by (equation 1) 1and Another important parameter of research interest is Material removal rate of the work piece produced is given by equation 2:

$$Fc = kc \times doc \times f \qquad (1)$$

Where, doc = Depth of cut (mm), f = feed (mm/rev), kc = Specific cutting energy coefficient (N/ mm 2). The three dimensions of a machining process:

Cutting speed *v* – primary motion

Feed *f* – secondary motion

Depth of cut *d* – penetration of tool below original work surface

For certain operations, material removal rate can be found as

$$MRR = v\,f\,d \qquad (2)$$

Where $v$ = cutting speed; $f$ = feed; $d$ = depth of cut

Milling process is the most important process for any type of material can be cut. The cutting tool is fed linearly in a direction parallel to the axis of rotation. Milling is carried on milling machine that provides the power to turn the work piece at a given force and feed to the cutting tool at specified rate and depth of cut. Therefore three cutting parameters namely cutting speed, feed rate and depth of cut need to be optimized in a turning operation. Turning operation is one of the most important operations used for machine elements construction in manufacturing industries i.e. Aerospace, automotive and shipping. Milling produces three cutting force components as shown in fig.1a,(the main cutting force i.e. thrust force, (Fz), which acts in the cutting speed direction, feed force, (Fx), which acts in the feed rate direction and the radial force, (Fy), which acts in radial direction and which is normal to the cutting speed).

## 2. OBJECTIVE OF PRESENT WORK

The influence of cutting parameters (speed, feed, and depth of cut) on cutting forces and surface finish has been analyzed, under the different variable with different responses. 27 experiment based Full Factorial design was used to study cutting force (Fx, Fy and Fz) and Material removal Rate (MRR) of mild steel work-piece.

Full Factorial function was taken to optimize the milling process with multiple performance characteristics. The machining parameters setting of were found by using ANOVA for analysis of variance table for maximum cutting force and minimum MRR.

## 3. WORK MATERIAL:

The present work deals with the Milling of hard material such as tool steel. It is an important engineering material employed in manufacturing of components in auto and aerospace industries. Since the present pattern in the manufacturing industry is high speed dry machining, it was applied to evaluate the performance of coated tools in typical manufacturing processes.The work piece material used for the experiments is mild steel of standard dimensions was used for machining with 150 mm square plate. Its chemical composition is given in Table4.1. The experimental setup is shown in Fig.2.

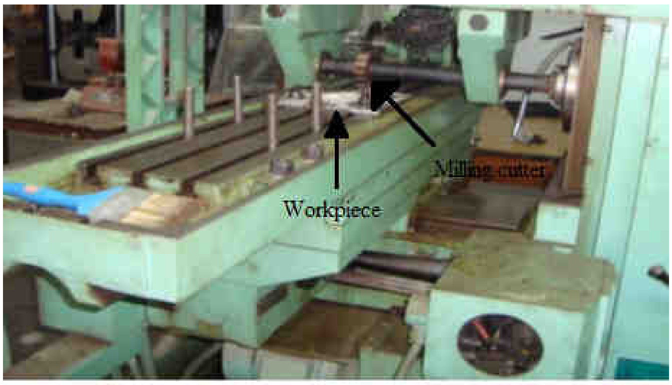


**Fig 2** Tool and work piece [Ref. 3]

**Table.4.1**.The chemical composition of AISI 4340 steel in percentage by weight

| C | Si | Mn | P | S | Cr | Ni | Mo | Fe |
|---|---|---|---|---|---|---|---|---|
| 0.382 | 0.228 | 0.609 | 0.026 | 0.022 | 0.995 | 1.514 | 0.226 | 95.998 |

## 4. MEASUREMENT OF CUTTING FORCE:

The force following up on an apparatus are an essential part of machining for studying the machinability conditions. Knowledge of the cutting forces is expected to appraise the power requirements and ensure that the machine tool elements, tool-holders, and fixtures are adequately rigid and free from vibrations. Estimations of the device strengths are useful in streamlining the apparatus plan. Cutting force is also one of the major criteria for determining the machinability index of any work piece during the machining. The measurement of the cutting forces will help in:

- Determining the power consumption during machining.
- Design (structural) of the machine, fixture and tool system.
- Evaluating the effect of various machining parameters on the cutting forces.

Force components measured in turning tests:

**Fx: Axial component of force**- The effect of feed force during machining is of least significant and is generally 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.

On line measurement of cutting force is carried out using Milling 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 as seen in Fig. 3.

**Fig.3.** Kistler piezoelectric dynamometer [Ref. 3]

## 5. RESULT AND DISCUSSIONS:

Table 2 presents' experimental results of cutting force components (Fx, Fy and Fz) different blends of cutting administration parameters (cutting speed, feed rate and depth of cut) according to $3^3$full factorial design. The outcomes demonstrate that the lower cutting forces were registered at the higher cutting speeds. This can be identified with the temperature increment in cutting zone and leads to the drop of the work piece yield strength and chip thickness. The outcomes additionally demonstrate that cutting forces increase with increasing feed rate and depth of cut because chip thickness becomes significant what causes the growth of the volume of deformed metal. That implies increasing of cutting speed with lowest feed rate and depth of cut leads to decreasing of cutting force components.

**Table 2** Observation table

| Run no. | Center Pt | Blocks | S | F | d | Fx | Fy | Fz | MRR |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 45 | 16 | 0.1 | 957 | 74 | 1041 | 5.42 |
| 2 | 1 | 1 | 90 | 40 | 0.1 | 545 | 215 | 924 | 7.35 |
| 3 | 1 | 1 | 90 | 16 | 0.2 | 178 | 168 | 557 | 6.54 |
| 4 | 1 | 1 | 45 | 40 | 0.2 | 1426 | 89 | 1149 | 5.75 |
| 5 | 1 | 2 | 90 | 16 | 0.1 | 619 | 176 | 511 | 6.68 |
| 6 | 1 | 2 | 45 | 40 | 0.1 | 1170 | 97 | 1257 | 5.94 |
| 7 | 1 | 2 | 45 | 16 | 0.2 | 962 | 49 | 990 | 5.37 |
| 8 | 1 | 2 | 90 | 40 | 0.2 | 178 | 197 | 957 | 6.95 |

**ANALYSIS OF Fx:-**

Fig 4 gives the fundamental element plots for Fx. Axial force Fx appears to be a decreasing function shown in same figure. This figure additionally shows that Fx is an almost linear increasing function of d. But the feed rate f has a little effect on Fx.

The results of analysis of variance (ANOVA) for axial force Fx are demonstrated in Table 3 This table likewise demonstrates the degrees of freedom (DF), F-values means ratio of variance and probability (P-VAL.) each factor and different interactions . A low P-value (≤0.05) indicates statistical significance for the source on the corresponding response (i.e., $\alpha = 0.05$, or 95% confidence level), this indicates that the obtained models are considered to be statistically significant, which is desirable; as it demonstrates that the terms in the model have a significant effect on the response. The other essential coefficient, R-Squared, which is called coefficient of determination in the subsequent ANOVA tables, is characterized as the proportion 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 values.

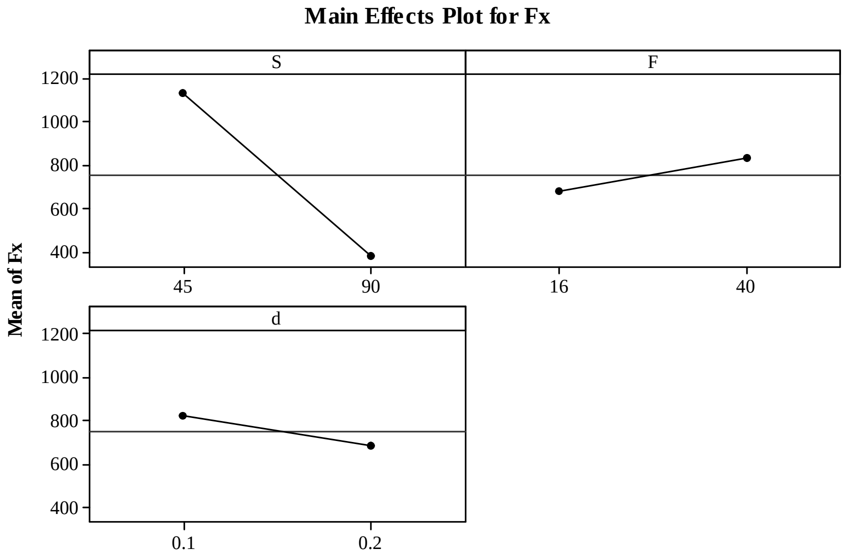


**Fig 4** Main Effect plots for Fx

**Table 3** Analysis of Variances of Fx

| Source | DF | Seq SS | Adj SS | Adj MS | F | P |
|---|---|---|---|---|---|---|
| Blocks | 1 | 3916 | 3916 | 3916 | 0.05 | 0.834 |
| Main Effects | 3 | 1204105 | 1204105 | 401368 | 5.32 | 0.102 |
| S | 1 | 1121253 | 1121253 | 1121253 | 14.85 | 0.031 |
| F | 1 | 45451 | 45451 | 45451 | 0.60 | 0.494 |
| D | 1 | 37401 | 37401 | 37401 | 0.50 | 0.532 |
| Residual Error | 3 | 226548 | 226548 | 75516 | | |
| Total | 7 | 1434570 | | | | |

## 6. CONCLUSIONS

Full Factorial Design method is found to be a successful technique to perform trend analysis of Cutting Force and MRR in metal cutting in milling with respect to various combinations of design variables (cutting speed, feed rate, and depth of cut). 3$^{rd}$ 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 important.

## 7. REFERENCES

[1] Aruna M, Dhanalakshmi V., Response surface methodology in finish turning INCONEL 718, International Journal of Engineering Science and Technology , 2(9) , 4292-4297, (2010).

[2]. Lalwani D.I., Mehta N.K., Jain P.K., Experimental Investigations of Cutting Parameters Influence on Cutting Forces and Surface Roughness in Finish Hard Turning of MDN 250 Steel, Journal of Material Processing Technology , 206(1-3) , 167-179 (2007).

[3] Fnides B, Yallese M A, Aouici H 2008 Hard turning of hot work steel AISI H11: Evaluation of cutting pressures, resulting force and temperature. Mechanika. Kaunas: Technologija, Nr. 3(77): 68–73

[4] Trent E M metal cutting 2nd edition Butterworth's & Co. London, UK, limited, ISBN 0-408- 34-38, (1984).

[5] Nagpal G.R. Machine Tool Engineering Khanna Publishers, New Delhi, 68-71 (1986).

[6] Kalpak Jain S. Manufacturing Engineering and Tecnology, 5thEition. (2000).

[7] Devilleza A., Schneider F, DOminiaka, S. Duzinskia , D. Larrouquereb, D. "Cutting Forces and wear in dry maching of Inconel 718 with coated carbide tools" wear (2007).

[8] Bouacha K., Yallese M.A. Mabrouki T, Rigal J-F 2010 Statistical analysis of surface roughness and cutting forces using response surface methodology in hard turning of AISI 52100 bearing steel with CBN tool. Int. J. Refractory Metals and Hard Materials 28: 349–361.

[9]. Smith, G. T., "Advanced Machining: The Handbook of Cutting Technology", IFS Publications, 1989.

[10]. Soderberg, S., Sjostrand, M., Ljungberg, B., Advances in coating technology for metal cutting tools, Metal Powder Report 56 (2001) 24-30.

[11]. Sahu S., Sahu S.K. and Maity K P Perfomance Evaluation of Uncoated and Multi layer Tin coated carbide tool in Hard Turning,Journal of Basic Applied Science Research (2012) 45-51.