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RESEARCH ARTICLE

Effect of process parameters on concentricity in CNC turning operation using design of experiment

P.L. Parmar*, **P.M. George**

Abstract

A major channel of machined components is produced by CNC and VMC machines. These machines have got specific capability to produce components meeting both the dimensional and geometric requirements. These requirements are to be met in order to meet the functional requirements of each component as a part of an assembly. This work is an effort in this direction, especially in the content of location control. Here, concentricity is taken as a response to be studied as a geometry of part. Greater attention is given to geometry in addition to the dimensional accuracy and surface characteristics of products by industries these days. In order to produce parts that are more functional and ensure ease of assembly, in this work, the design of experiment is carried out to investigate the effect of machining parameters on concentricity. How this concentricity behaves under the different combinations of machining parameters is the objective of this work. Experimental work carried out on mild steel (AISI 1020) work piece on a CNC turning center. The turning operation was performed on a mild steel round bar. AISI 1020 steel can be largely utilized in all industrial sectors in order to enhance weldability or machinability properties. It is used in a variety of applications due to its cold-drawn or turned and polished finish property. The current status and demands is that the specific requirements of geometrical and dimensional relation need to ensure better functioning of a part while assembling. Economic and efficient manufacturing is also required apart from creating a product that satisfies the customer more.

Keywords: GD&T, Concentricity, DoE, ANOVA.

Introduction

Turning operation is one of the most basic machining processes. That is, the part is rotated while a single-point cutting tool is moved parallel to the axis of rotation. Turning is a form of machining, a material removal process, which is used to create rotational parts by cutting away unwanted material. The turning process requires a turning machine or lathe, work piece, and cutting tool. Turning is used to produce rotational, typically axis-symmetric, parts that have many features, such as holes, grooves, threads, tapers, various diameter steps, and even contoured surfaces.

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Geometric requirements that part must possess after the turning process are cylindricity, circularity, circular runout, total runout, concentricity of features etc., within the specified limits of sizes. Process variables like cutting tool geometry, cutting tool material, speed, coolant type, feed, depth of cut etc., are affect the geometric requirements of parts.

Geometric dimensioning and tolerancing (GD&T) is a system for defining and communicating engineering tolerances pertaining geometric shape of components. Geometric dimensioning and tolerancing (GD&T) is used to define the nominal (theoretically perfect) geometry of parts and assemblies, to define the allowable variation in form and possible size of individual features, and to define the allowable variation between features. The plus and minus system of dimensioning and tolerancing is insufficient to consistently convey design intent. If one part is made in one geographic location and mating part in another, even though both were made as per drawing specifications, when brought together the parts would not always mate in assembly. ASME Y14.5-2009 is the accepted geometric dimensioning and tolerancing standard superseding ANSI Y14.5M-1994 used within the USAs and ISO 1101-2004 is used outside of the USA. It allows as the repeatability of part

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orientation, interchangeability of part, etc. Allows a designer to express his/her thoughts and design requirements in a clear, concise manner.

Literature Review

So far as work in the study of behavior of geometry of feature as a function of machining parameter is concern we find least amount of literature. Some of the research paper related to the same is discussed below.

In studies with three-factor, two-level factorial design was used to determine the effects of the cutting speed, feed and depth of cut on geometric tolerances in CNC turning of Aluminium 6061(size 25 mm dia x 100 mm length). A hexagon CMM machine was used to measure the data for circularity. The study shows that the circularity error is minimum at 800 rpm, 0.1 mm/rev. and depth of cut 0.75 mm, for 23 Design. From the circularity model feed is the most significant parameter and speed is the less significant parameter and depth of cut does not affect the circularity (Tadvi, P. M., *et al.,* 2012). Experimental and statistical methods were used. The parameters determined at the experimental design stage and the parameters necessary for improving the dimensional precision of the workpiece were consistent. Thus, the study was successfully completed. In short, independent variables estimated for the dependent variables solved the problem. The minimum surface roughness value was 0.831 µm. The minimum cutting force was 94 N. The minimum work piece cylindricity error was 0.019 mm (Mustafa, A.Y. *et al*., 2011). The application of RSM to study the surface roughness of ground components. With this technique, the number of tests required to develop a surface roughness predicting equation can be significantly reduced. Three independent variables, i.e., work speed, traverse feed and depth of cut or in feed, are selected to investigate in this work and based on the carefully planned and conducted experiments, surface roughness predictive equations have been developed (Jivani, R.G. *et al*., 2011). reviewed the influence of machining parameters on geometric form and orientation control. The form and orientation controls considered in this paper are: Parallelism, straightness and flatness. The effect of various cutting parameters on these geometrical parameters are of vital consequence for effective part functioning. The influence of these cutting parameters on the geometrical features are to be studied and an empirical model could be developed that may be used by process planners for creating components that can function better, can be assembled without any problem as well as produce most economically (Vora, N.A., *et al*. 2011).

Experiments of drilling using VMC on CFRP composites with various tools like HSS, solid carbide (K20) and poly crystalline diamond insert drills were used to perform the experiments. A predictive model was developed to predict the thrust force during drilling operations. The results showed that moderate cutting speed and feed rate are desired for getting optimum thrust forces irrespective of the type of drills used (Madhavan, S., *et al*., 2012).

The Taguchi methodology was used to perform experiments on mild steel. The response parameters are surface finish and MRR. Spindle speed is found as significant parameter during the study (Tyagi, Y., *et al*., 2012).

Analyzed effect of machining parameters in the Micro-drilling operations. The taguchi-based method along with analysis of variance (ANOVA) and design of experiments (DOE), is implemented for an optimized result. The analysis concluded that the spindle speed and feed rate increases material removal rate. The nominal diameter and tool point angle had not significant effect. An engineering drawing of a production part conveys information from the designer to the manufacturing and inspection. It must contain all information necessary for the part to be correctly manufactured and inspected. The system of geometric tolerancing offers a precise interpretation of drawing requirements. Geometric dimensioning & tolerancing is an international system of symbolic language and is simply another tool available to make engineering drawings for communication from design through manufacturing & inspection. It uses a series of internationally recognized symbols rather than words to describe the part shape. These symbols are applied to the features of a part and provide a very concise and clear definition of the design intent. GD&T is a step ahead in producing parts which are functionally better. Geometric tolerancing controls geometric characteristics of part features (Bharti A., *et al*., 2013).

WCB is widely used in manufacturing valves due to its lower cost. 23 full factorial designs with four center points are selected to perform reliable experiments. Here, the response parameters selected are surface roughness and flatness, a form control of GD&T. The values of flatness and surface roughness affect a lot during leakage testing of dual plate check valves. To achieve the desired value of flatness and surface roughness machining parameters need to be controlled. The right selection of process parameters can be achieved through a predictive model. ANOVA has been carried out to know the significance of input parameters. The values predicted from the model and experimental values are very close to each other (Sheth, S., *et. al*., 2016).

By performing experiments by using rotary tools in face milling analysis says that the use of such types of tools may increase productivity when the machining is performed on "difficult- to - machine" materials. The paper also showed that the cutting forces were highly affected by spindle speed, feed and depth of cut. Even chip characteristics were also studied by varying the stated parameters along with inclination angle (Patel, KM, *at el*.,2006). Machining of high-performance work pieces, which combine two or more materials to one compound, using face milling. The compounds are made of polyurethane, cast iron and aluminum. The use of compounds, due to its lightweight, drastically increased in the automotive and aircraft industry. A model to predict the surface finish for such kind of compounds is developed (Denkena, B, *at el*., 2015). After studying the face milling operation in two aspects, the experimental and numerical analysis of the face milling operation, a predictive tool wear model was developed using FEM (Rao, B, *at el*., 2011). Comparing the cost of manufacturing using surface grinding and face milling of hardened steel flat surfaces for dies and moulds is also required. Technological considerations like surface roughness, dimensional tolerance, and component geometry are taken into account. They derived that face milling operation is sometimes a competitive process with compared to surface grinding (Vila, C, *at el*., 2012).

The effect of drilling parameters such as speed, feed and point angle on MRR and surface roughness with face cantered CCD design was used to perform the experiments. Aluminum matrix composites and hybrid aluminum matrix composites are used as materials during analysis (Chaudhary, G, *at el*., 2014). Researched on the effect of face mill wear, speed and feed on the surface roughness of steel 45 shows that the roughness grows from 15 to 30% with the increase in the flank wear from 0 to 3.14 mm. The increase in the speed reduces the surface roughness by 7-15% while increase in the feed reduces the roughness by 28-48% (Pimenov, DY, *at el*., 2014). By using RSM the evaluated surface roughness in turning operation by varying machining parameters results showed that, minimum surface roughness value was 1.18 μm for Aluminum alloy and 2.295 μm for resin. The maximum metal removal rate was found to be 1377.83 mm/min for Aluminum alloy and 182.899 mm/min for resin (Sastry, M, *at el*., 2012). The experiments on carbon steel using DOE were performed by face milling operation to analyze the effect of process parameters on the surface roughness the regression and ANN models were developed. The simplex optimization algorithms were used to found out the minimum value of surface roughness (Bajic, D, *at el*., 2008). Mathematical models for predicting MRR, Tool Wear Ratio (TWR) and surface roughness (Ra) during EDM machining by varying current, pulse-on time and voltage. CCD was employed to perform the experiments. ANOVA was performed, to know the significance of the process parameters (Shabgard, M, *at el*., 2010).

Geometric tolerance characteristics are categorized as form, orientation, profile, runout and location. Different types of geometric characteristic symbols are used to specify the drawing. Form contains flatness, straightness, circularity and cylindricity. The form characteristics are always individual (not related to datums). In other words, features that are flat, round, straight or cylindrical are not compared to other features but are compared only to perfect geometric counterparts of themselves. Profile contains profile of a line and profile of a surface. The profile characteristics may, but are not require the use of datums. Orientation contains perpendicularity, parallelism and angularity. They require the use of datums. Runout contains total runout and circular runout. They require the use of datum. Location contains position, symmetry and concentricity. This also requires the use of datums.

Advantages of Geometric Dimensioning & Tolerancing

The system of geometric tolerancing offers a precise interpretation of drawing requirements. Following are some advantage of using GD&T control:

- Plus and minus system results in a "Square or Rectangular" tolerance zone for hole location. This results in less tolerance being available for hole, which in turn results in higher manufacturing costs for part. Whereas, geometric tolerancing results in a cylindrical tolerance zone for the hole location. This results in 57% more tolerance for hole location, which translates into lower manufacturing costs for the parts and higher profits.
- Plus and minus tolerancing always results in a tolerance zone of fixed size. This results in some otherwise functional parts being scrapped during inspection. Due to the higher resulting scrape rate, the operating costs go higher. Whereas, geometric tolerancing allows for the use of MMC modifier, which results in increased tolerance zones under certain conditions. This results in allowing more functional parts being accepted during inspection.
- Use of G. D. & T. results in improved product designs. Also it takes into consideration the part function at the design stage and makes use of functional dimensioning philosophy to establish part tolerances based upon functional requirements.
- Use of G. D. & T. results in improved communications, at all levels, by providing a common language to design, manufacturing, and quality control. It enforces uniformity in drawing specifications and interpretation, and results in reduced controversy, guess work and assumptions.
- Location of part features are more accurately defined from specified datums for repeatability.
- Interchangeability of parts.

Concentricity Tolerancing

Concentricity is a three dimensional type of location control. It controls opposed points to an axis. Concentricity is the condition where the median points of all diametrically opposed elements of a feature of revolution (or correspondingly located elements of two or more radially disposed features) are congruent with the axis of a datum feature. A median point is the mid-point of a two point measurement. These median points/elements coincide exactly in all their parts with the datum axis. This tolerance zone generated is cylindrical or spherical and coaxial with the datum axis or center point. Concentricity will control location and can have some effect on the form and orientation of the feature. Figure 1 will gives very clear idea about the concentricity control.

Concentricity is applied to circular feature, and the parts which are having operating like turning, drilling, boring etc are required to have concentricity within specified tolerance zone. In industry concentricity control is used in few unique applications, where a primary consideration is precise balance of part, equal wall thickness and another functional requirement that's call equal distribution of mass.

Turning Operation

The process of Turning has been long considered an art due to the tremendous amount of variability and subjectivity involved. The quality of turning differs from operator to operator and the results are highly inconsistent. The surface roughness, geometric tolerances depend on the proper control of turning parameters such as cutting speed, feed rate, depth of cut, work piece material, coolant type, cutting tool material and geometry etc. To attain the desired outcomes, it is imperative to select proper values for the turning control parameters. Moving the art of turning into a science and quantifying the results can solve many of the above problems.

Factorial designs have been found to be most efficient for experiments that involve the study of the effects of two or more factors, which is the case here. Thus, in this research, the experiments were designed using factorial design concepts.

Operator's variability and environmental factors may be considered random variations in conducting the experiments or say uncontrollable parameters. And there are some controllable parameters which we can keep constant during process or can vary to study effect of the same. For this study workpiece material, workpiece dimension and

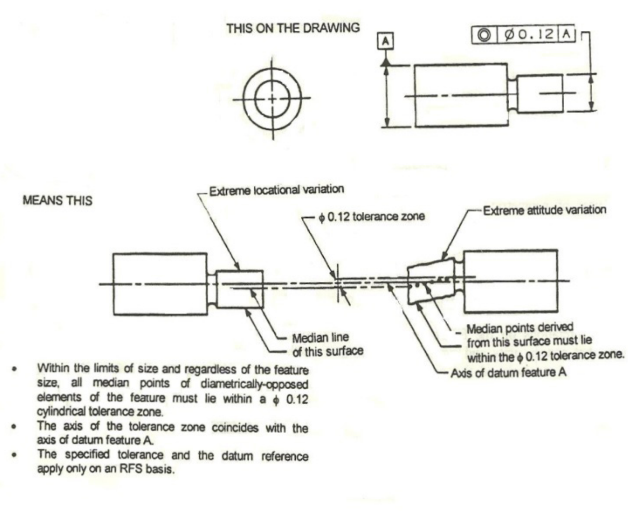

Figure 1: Concentricity definition

Table 1: Controllable & response parameters

Controllable Parameters	Cutting speed, Feed, Depth of cut, Coolant type, Cutting tool material and geometry, workpiece material, etc.
Uncontrollable Parameters	Geometric tolerances, surface roughness.

cutting material are kept constant during process. As a variable parameter speed, feed and depth of cut are taken. According to tool material and work piece material following data were taken using reference:

Many experiments involve the study of the effects of two or more factors/variables on various responses. In general factorial designs are the most efficient for this type of experiments. The effect of factor is defined to be change in response produced by a change in the level of the factor. This is frequently called main effect because it refers to the primary factor of interest in the experiment.

The advantage of factorial design is that it is more efficient than one factor at a time experiments. It is necessary when interaction may be present to avoid misleading conclusion. Moreover, factorial designs allow the effects of a factor to be estimated at several levels of the other factors, yielding that are valid over a range of experimental conditions.

The 3^3 Design

The three-level design is written as a 3kfactorial design. It means that k factors are considered, each at 3 levels. These are (usually) referred to as low, intermediate and high levels. These levels are numerically expressed as 0, 1, and 2. One could have considered the digits -1, 0, and +1, but this may be confusing with respect to the 2-level designs since 0 is reserved for center points. Therefore, we will use the 0, 1, 2 scheme. The reason that the three-level designs were proposed is to model possible curvature in the response function and to handle the case of nominal factors at 3 levels. A third level for a continuous factor facilitates investigation of a quadratic relationship between theresponse and each of the factors.

Unfortunately, the three-level design is prohibitive in terms of the number of runs, and thus in terms of cost and effort. For example a two-level design with center points is much less expensive while it still is a very good (and simple) way to establish the presence or absence of curvature.

Now suppose there are three factors A, B and C, under study, and each factor is at three levels arranged in a factorial experiment. This is a 3^3 factorial design, and the experimental layout and treatment combination notation where shown in Figure 2. The 27 treatment combinations have 26 degrees of freedom. Each main effect has 2 degrees of freedom, each two factor interaction has 4 degrees of freedom, and the three factor interaction has 8 degrees of freedom. If there are n replicates, there are $n3^3$-1 total

Table 2: Factors and Their levels

Factors/ Levels	*Low*	*Medium*	*High*
Speed(RPM)	2000	2500	3000
Feed(mm/rev)	0.10	0.15	0.20
Depth of Cut (mm)	0.1	0.3	0.5

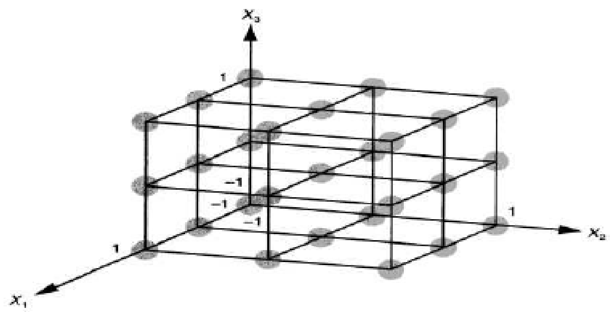

Figure 2: 3^3 factorial experiment design

degrees of freedom and 3^3(n-1) degrees of freedom for error.

The sums of squares may be calculated using the standard methods for factorial designs. In addition, if the factors are quantitative the main effects may be partitioned into linear and quadratic components, each with a single degree of freedom. The two factor interaction may be decomposed into linear x linear, linear x quadratic, quadratic x linear and quadratic x quadratic effects. Finally, the three factor interaction ABC can be partitioned into eight single degree of freedom components corresponding to linear x linear x linear, linear x linear x quadratic, and so on. Such a breakdown for the three factor interaction is generally not very useful. Table 3 depicts a 3^3 design with three levels and three factors.

Table 3: 3^3 Design with factors and number of runs

S. No.	*X1*	*X2*	*X3*
1	-	-	-
2	-	-	0
3	-	-	+
4	-	0	-
5	-	0	0
6	-	0	+
7	-	+	-
8	-	+	0
9	-	+	+
10	0	-	-
11	0	-	0
12	0	-	+
13	0	0	-
14	0	0	0
15	0	0	+
16	0	+	-
17	0	+	0
18	0	+	+
19	1	-	-
20	1	-	0
21	1	-	+
22	1	0	-
23	1	0	0
24	1	0	+
25	1	+	-
26	1	+	0
27	1	+	+

Where X1, X2, X3are factors of 3 levels and signs (- , +, 0) indicates low, high and mean values. Here 3^3 design = 3 x 3 x 3 = 27 runs.

DoE for Turning

The surface roughness, geometric tolerances depend on the proper control of turning parameters such as cutting speed, feed rate, depth of cut, work piece material, coolant type, cutting tool material and geometry etc. To attain the desired outcomes, it is imperative to select proper values for the turning control parameters. Moving the art of turning into a science and quantifying the results can solve many of the above problems.

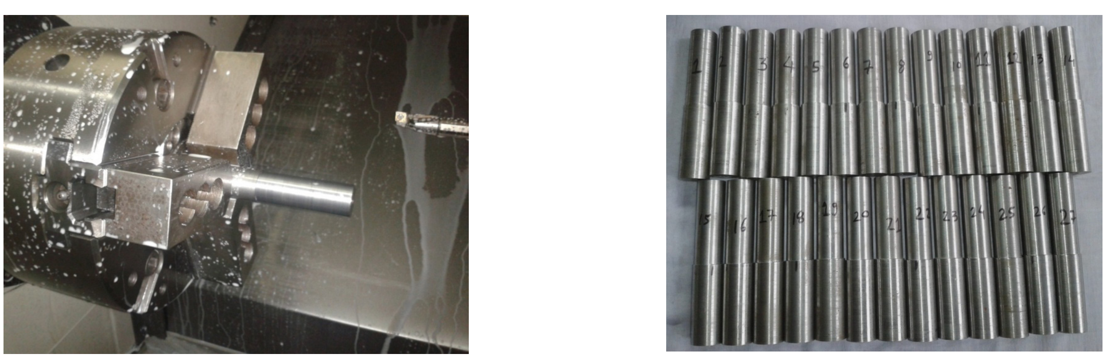

Figure 3: Step making operation holding datum in chuck and 27 component after turning operation

Table 4: 3^3 Design for concentricity control

S. No.	*Speed (RPM)*	*Feed (mm/rev),*	*Depth of Cut (mm),*
Factors	*A*	*B*	*C*
1	2000	0.10	0.1
2	2000	0.10	0.3
3	2000	0.10	0.5
4	2000	0.15	0.1
5	2000	0.15	0.3
6	2000	0.15	0.5
7	2000	0.20	0.1
8	2000	0.20	0.3
9	2000	0.20	0.5
10	2500	0.10	0.1
11	2500	0.10	0.3
12	2500	0.10	0.5
13	2500	0.15	0.1
14	2500	0.15	0.3
15	2500	0.15	0.5
16	2500	0.20	0.1
17	2500	0.20	0.3
18	2500	0.20	0.5
19	3000	0.10	0.1
20	3000	0.10	0.3
21	3000	0.10	0.5
22	3000	0.15	0.1
23	3000	0.15	0.3
24	3000	0.15	0.5
25	3000	0.20	0.1
26	3000	0.20	0.3
27	3000	0.20	0.5

Experimentation Work

In experimentation work turning operation was carried out on AISI 1020 material. Figure 3 shows turning operation.

Turing operation gives following component. Concentricity of this component was measured. Here bigger diameter step is function as datum because same we have hold in chuck, with respect to it we have to measure the concentricity of smaller diameter step.

Measurement of concentricity was carried out at Microflat Datums Pvt. Ltd. using high precision concentricity measuring set up. Here it is visible that datum is rotational axis created by the V– block and the larger diameter. Concentricity of smaller diameter is measured with respect to datum. Figure 4 shows the same. Concentricity value was measured at 5 different cross section in the length of small diameter step and average of the same was taken as concentricity value for that component for the choosen combination of process parameters. The 3^3 model for concentricity control with measured response is given in Table 6.

ANOVA table for 3^3 design is given in Table 7.

Model Summary

S R-sq R-sq(adj) R-sq(pred)

0.0059355 83.48% 46.30% 0.00%

Regression Equation

Concentricity (mm) = 0.02906 - 0.00367 A_2000 - 0.00117 A_2500 + 0.00484 A_3000
- 0.00426 B_0.10 - 0.00086 B_0.15 + 0.00512 B_0.20 - 0.00384 C_0.1
- 0.00083 C_0.3 + 0.00466 C_0.5 - 0.00323 A*B_2000 0.10 + 0.00224 A*B_2000 0.15 + 0.00099 A*B_2000 0.20 + 0.00040 A*B_2500 0.10
- 0.00190 A*B_2500 0.15 + 0.00149 A*B_2500 0.20 + 0.00283 A*B_3000 0.10
- 0.00034 A*B_3000 0.15 - 0.00249 A*B_3000 0.20 + 0.00171 A*C_2000 0.1

Figure 4: Final workpiece ready to measure concentricity

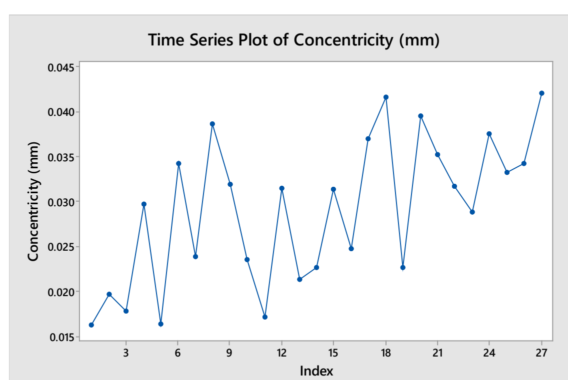

Figure 5: Time series plot of concentricity

Table 6: Experimental results for concentricity control (3^3 Design)

S. No. / *Factors*	*Speed (RPM), A*	*Feed (mm/rev), B*	*Depth of cut (mm), C*	*Concentricity (mm)*
1	2000	0.10	0.1	0.0162
2	2000	0.10	0.3	0.0197
3	2000	0.10	0.5	0.0178
4	2000	0.15	0.1	0.0297
5	2000	0.15	0.3	0.0164
6	2000	0.15	0.5	0.0342
7	2000	0.20	0.1	0.0239
8	2000	0.20	0.3	0.0387
9	2000	0.20	0.5	0.0319
10	2500	0.10	0.1	0.0235
11	2500	0.10	0.3	0.0171
12	2500	0.10	0.5	0.0315
13	2500	0.15	0.1	0.0213
14	2500	0.15	0.3	0.0227
15	2500	0.15	0.5	0.0314
16	2500	0.20	0.1	0.0248
17	2500	0.20	0.3	0.0370
18	2500	0.20	0.5	0.0417
19	3000	0.10	0.1	0.0226
20	3000	0.10	0.3	0.0395
21	3000	0.10	0.5	0.0353
22	3000	0.15	0.1	0.0317
23	3000	0.15	0.3	0.0288
24	3000	0.15	0.5	0.0376
25	3000	0.20	0.1	0.0333
26	3000	0.20	0.3	0.0342
27	3000	0.20	0.5	0.0421

+ 0.00037 A*C_2000 0.3 - 0.00209 A*C_2000 0.5 - 0.00085 A*C_2500 0.1
- 0.00146 A*C_2500 0.3 + 0.00231 A*C_2500 0.5 - 0.00086 A*C_3000 0.1
+ 0.00109 A*C_3000 0.3 - 0.00023 A*C_3000 0.5 - 0.00020 B*C_0.10 0.1
+ 0.00146 B*C_0.10 0.3 - 0.00126 B*C_0.10 0.5 + 0.00320 B*C_0.15 0.1
- 0.00474 B*C_0.15 0.3 + 0.00154 B*C_0.15 0.5 - 0.00301 B*C_0.20 0.1
+ 0.00328 B*C_0.20 0.3 - 0.00027 B*C_0.20 0.5

Main effect plot for concentricity control is shown in Figure 5.

Table 7: Analysis of variance

Source	*DF*	*Adj SS*	*Adj MS*	*F-value*	*p-value*
Model	18	0.001424	0.000079	2.25	0.122
Linear	6	0.001085	0.000181	5.13	0.019
A	2	0.000344	0.000172	4.89	0.041
B	2	0.000406	0.000203	5.76	0.028
C	2	0.000334	0.000167	4.75	0.044
2-Way interactions	12	0.000339	0.000028	0.8	0.647
A*B	4	0.000110	0.000028	0.78	0.568
A*C	4	0.000053	0.000013	0.38	0.820
B*C	4	0.000176	0.000044	1.25	0.364
Error	8	0.000282	0.000035		
Total	26	0.001706			

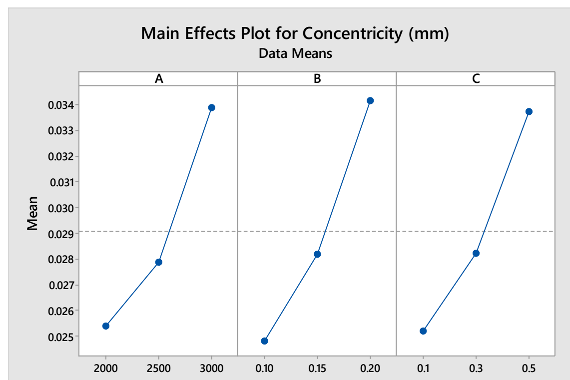

Figure 6: Main effect plot of concentricity vs speed, feed & depth of cut

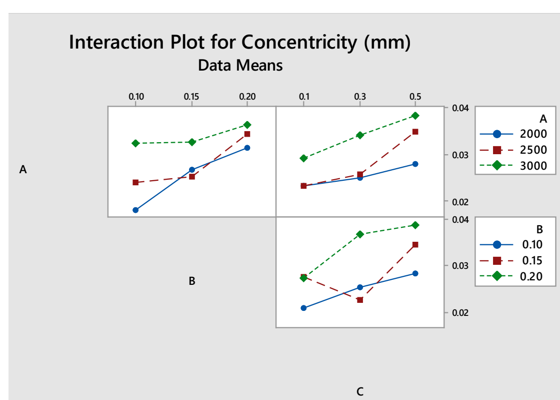

Figure 7: Interaction plot of factor A, B and C

Surface Plot

Figures 9, 10 and 11 depicts the surface plot for concentricity control. And Figures 12, 13 and 14 shows the contour plot of concentricity vs speed and feed, feed and depth of cut, speed and depth of cut.

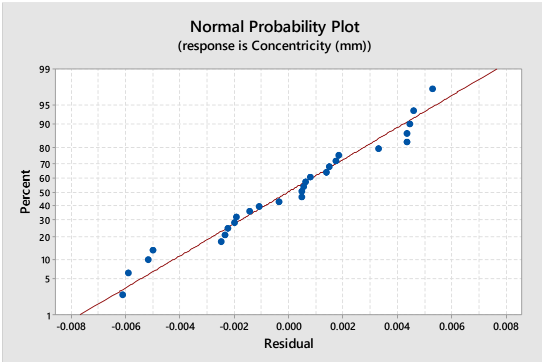

Figure 8: Normal probability plot of concentricity

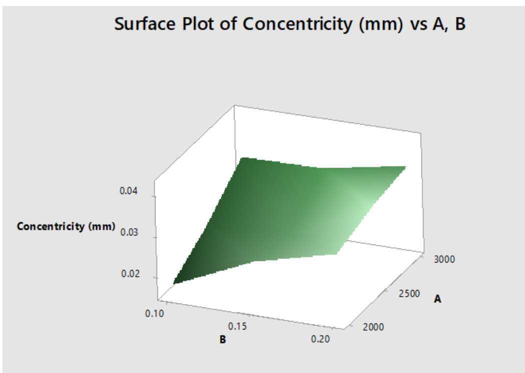

Figure 9: Surface plot for concentricity vs speed & feed

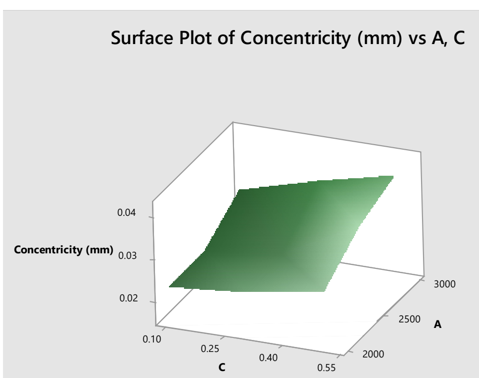

Figure 10: Surface plot for concentricity vs speed & depth of cut

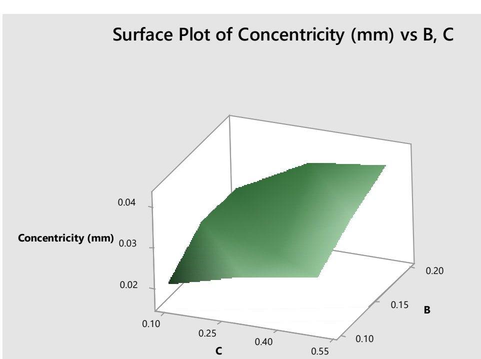

Figure 11: Surface plot for concentricity vs depth of cut & feed

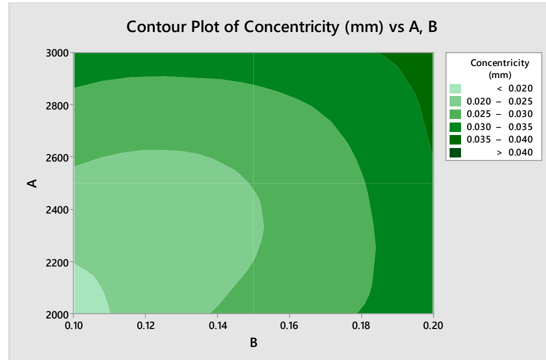

Figure 12: Contour plot of concentricity vs factor A and B

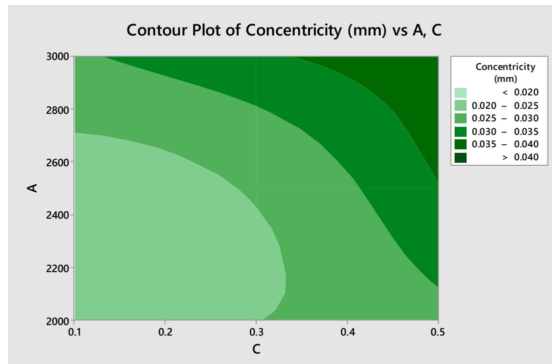

Figure 13: Contour plot of concentricity vs factor A and C

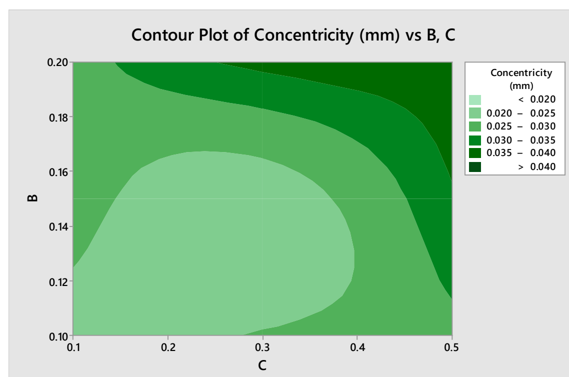

Figure 14: Contour plot of concentricity vs factor B and C

Conclusion

This work is meant to evaluate the effects of different machining parameters in turning operation where in concentricity is the major concern. From Figure 6 (Main effect plot of concentricity vs. speed, feed & depth of cut) it is understood that for the concentricity, error increase with increase in the speed, feed as well as depth of cut. From figure 9,10 and 11 it can be conclude that as speed, feed and depth of cut increase the concentricity error also increases, and we get lower concentricity error at the lower level of this process parameters. From Table 7 (Analysis of Variance) also we can conclude that the *p-value* for speed, feed and depth of cut is less than the confidence level (i.e.

95%). And from *p-value* concept also we can say that the more significant parameter affecting the concentricity is speed having *p-value* of 0.05.

References

A. Y. Mustafa and T. Ali, "Determination and optimization of the effect of cutting parameters and work piece length on the geometric tolerances and surface roughness in turning operation", International Journal of the Physical Sciences Vol. 6(5), pp. 1074-1084, 4 March, 2011.

Bajic D, Lela B, Zivkovic D, (2008), Modeling of machined surface roughness and optimization of cutting parameters in face milling, Metalurgija 47, 4, pp. 331-334.

Bharti A, Moulick S.K., (July-2013), Parametric optimization of multi response factors in micro drilling operation, International Journal of Scientific & Engineering Research, Volume 4, Issue 7, ISSN 2229-5518, pp. 1157-1163.

Chaudhary G, Kumar M, Verma S, Srivastav A, (2014), Optimization of drilling parameters of hybrid metal matrix composites using response surface methodology, Procedia Materials Science, 6, pp. 229-237.

Denkena B, Hasselberg (2015) 'Influence of the cutting tool compliance on the workpiece surface shape in face milling of workpiece compounds', Procedia 15th CIRP Conference on Modelling of Machining Operations, 31, pp. 7-12.

Jivani RG, George P.M. and Patel B.S. (2011) 'Design of experiments and response surface method in context to grinding process', at National Conference on Recent Trends and Technology, organized by B.V.M. Engineering College, V.V.Nagar, Gujarat, ISBN NO: 978-81-921558-4-7.

Madhavan S, Prabu SB, (Aug.2012), Experimental investigation and analysis of thrust force in drilling of carbon fiber reinforced plastic composites using response surface methodology, International Journal of Modern Engineering Research, Vol.2, Issue.4, ISSN: 2249-6645, pp. 2719-2723.

P. M. Tadvi, R. S. Barot, V. H. Chaudhari, Dr. P. M. George," Analyze Effect of Cutting Parameters on Geometric Tolerances in CNC Turning using Design of Experiment (2^3 and 3^3 Design) National Conference on Thermal, Fluid and Manufacturing Science January 20 – 21, 2012.

Patel KM, Joshi SS, (2006), Mechanics of machining of face-milling operation performed using a self- propelled round insert milling cutter, Journal of material processing technology, 171, pp. 68-76.

Pimenov DY, (2014), Experimental research of face mill wear effect to flat surface roughness, Journal of Friction and Wear, 35 (3), pp. 250-254.

Rao B, Dandekar CR, Shin YC, (2011), An experimental and numerical study on the face milling of Ti-6Al-4V Alloy: Tool performance and surface integrity, Journal of material processing technology, 211, pp. 294-304.

Sastry MNP, Devi KD, Reddy KM, (2012), analysis and optimization of machining process parameters using design of experiments, Industrial Engineering Letters, ISSN 2224-6096, Vol. 2, No.9, pp. 23-32.

Saurin Sheth, George P. M., (2016), Experimental Investigation and Prediction of Flatness and Surface Roughness During Face Milling Operation of WCB Material, Procedia Technology, Volume 23, 2016, Pages 344-351.

Shabgard MR, Shotorbani RM, (2010), Mathematical modeling of machining parameters in electrical discharge machining of FW4 welded steel, International Journal of Aerospace and Mechanical Engineering, pp. 172-178, 4:3.

Tyagi Y, Chaturvedi V, Jyoti V, (August 2012), Parametric optimization of CNC drilling machine for mild steel using Taguchi design and signal to noise ratio analysis, International Journal of Engineering Science and Technology, Volume 4, No.08, ISSN: 0975-5462, pp. 3758-3766.

Vila C, Siller HR, Rodriguez CA, Bruscas GM, Serrano J, (2012), Economical and technological study of surface grinding versus face milling in hardened AISI D3 steel machining operations, International Journal of Production Economics, 138, pp. 273-283.

Vora NA, George P.M. and Joshi SP (2011) ' ffect of machining parameters on geometric form control and orientation control – A review', at National Conference on Recent Trends and Technology, organized by B.V.M. Engineering College, V.V.Nagar, Gujarat, ISBN NO: 978-81-921558-4-7.