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Effect of Input Cutting Parameters on Geometric Run out Controls – A Review

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***Abstract*—Turning is a widespread machining operation in which a single-point cutting tool removes material from the surface of a rotating cylindrical workpiece. Variables involved in the machining process are the primary factors that directly affect the quality of a product. The geometrical requirements to be met by the components apart from dimensional requirements are: Circularity, Cylindricity, Straightness, Circular Runout, Total Runout etc. The controls considered in this review paper are: Circular Runout, Total Runout. The effect of various cutting parameters on these geometrical parameters are of great significance for effective part functioning.**

***Index Terms*—Turning, Geometric Dimensioning and Tolerancing (GD&T), Design of Experiments (DOE).**

I. INTRODUCTION

Among various cutting processes, turning is one of the most fundamental and most applied metal removal operations in a real manufacturing environment because of its ability to remove material faster giving reasonably good surface quality. It is used in a variety of manufacturing industries including aerospace and automotive sectors, where quality is an important factor in the production of slots, pockets, precision moulds and dies. Greater attention is given to dimensional accuracy and surface roughness of products by the industries in these days [1]. The system of Geometric Tolerancing offers a precise interpretation of drawing requirements. Geometric dimensioning and tolerancing (G.D. &T.) is an international language that is used on engineering drawings (part prints) to describe parts in three mutually perpendicular, dimensions. 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. G.D. &T. is a step ahead to produce parts which are functionally better.

Design of experiment (DOE) is useful method in identifying the significant parameters and in studying the possible effect of the variables during the machining trials. This method also can developed experiment between a ranges from un-controllable factors, which will be introduced randomly to carefully controlled parameters. The factors must be either quantitative or qualitative. The term experiment is defined as the systematic procedure carried out under controlled condition in order to discover an unknown effect, to test or establish a hypothesis or to illustrate a known effect. When analyzing a process experiments are often used to evaluate which process input have a significant effect on the process output. And what target level of those inputs should be to achieve desired results. Experiments can be designed in many different ways to collect this information. Experimental Design can be used at the point of greatest leverage to reduce design costs by speeding up the design process reducing late engineering design changes and reducing product material and labor complexity.

II. SELECTION OF CUTTING PARAMETERS IN TURNING

A .CuttingSpeed

The cutting speed of a tool is the speed at which the metal is removed by the tool from the workpiece. In a lathe it is the peripheral speed of the work past the cutting tool expressed in RPM.

B .Feed

The feed of a cutting tool in a lathe work is the distance the tool advances for each revolution of the work along its cutting path. Feed is expressed in millimeter per revolution.

C. Depth of Cut

The Depth of Cut is the thickness of the layer being removed from the workpiece or the perpendicular distance measured from the machined surface to the uncut surface of the workpiece. Depth of Cut is expressed in millimeters [1].

III. GEOMETRIC RUNOUT CONTROLS

Runout is a composite tolerance control used to control the functional relationship of one or more features of a part to a datum axis. A composite control controls the form, location, and orientation of a part feature simultaneously verified in a single gauge setup reading. These controls are surface to datum axis controls. They are always regardless of feature size. At least one datum feature is required. The Runout specification may be verified with a dial indicator, Coordinate Measuring Machine (CMM) or by other methods. There are two types of Runout Controls: Circular Runout, Total Runout,

Runout tolerances will control surfaces constructed around a datum axis and those constructed at right angles to a datum axis; Fig. 1.Runout may or may not have a plane surface referenced as a datum but must always be referenced to a datum axis.

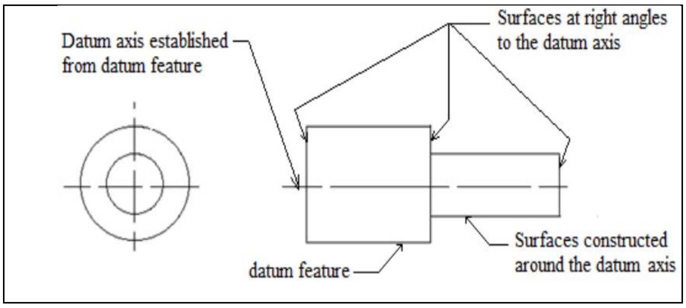

Fig. 1. Features Applicable to Runout Tolerances

A. Circular Runout

Circular runout is a two dimensional control of circular elements of surface. Circular runout may be used to control the cumulative variations of circularity and coaxiality. When applied to surface constructed at right angles to the datum axis, circular runout controls circular elements. The shape of the circular runout tolerance zone applied to a diameter is two concentric circles whose centres are located on the specified datum axis. The radial distance between the circles equals to the tolerance value specified in the feature control frame. The feature must be within the specified limits of size (i.e.19.95/20.05). Circular runout may be verified with a dial indicator, CMM or other methods. If dial indicator is used, each circular cross section of the surface must lie within the specified runout tolerance (i.e.0.12 Full Indicator Movement (FIM)) when the part is rotated 360^0 about the datum axis as shown in Fig. 2 [2].

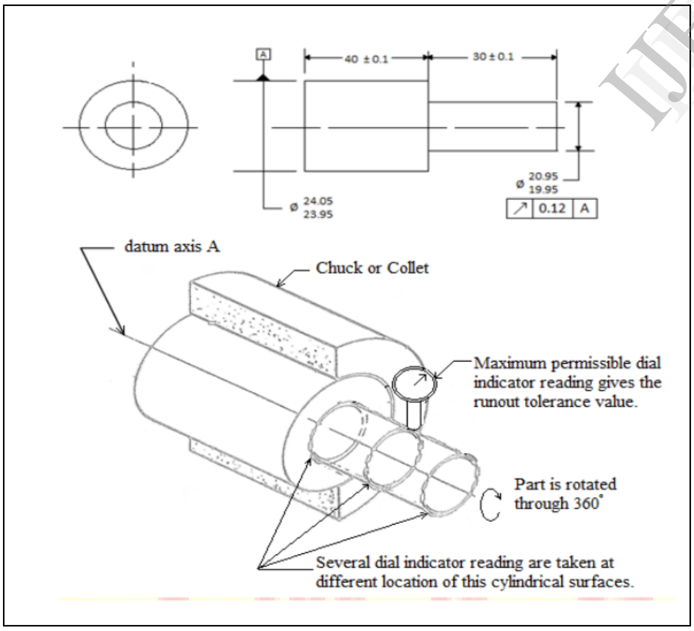

Fig. 2 Circular Runout applied to a diameter& its verification

B. Total Runout

Total runout is a three dimensional composite control of surface elements. When applied to a surface constructed around a datum axis, total runout will control the cumulative variations of Circularity, straightness, coaxiality, angularity, taper and variations in the surface relative to the datum axis specified. When applied to a diameter, the shape of the tolerance zone is the space between two coaxial cylinders whose axes are collinear with the specified datum axis. The distance between the cylinders is equal to the total runout tolerance value, specified in feature control frame. In inspection, the part is rotated 360^0 about the datum axis while an indicator is moved parallel to the datum axis over the entire surface to be controlled; Fig. 3. The FIM may not exceed 0.12 [2].

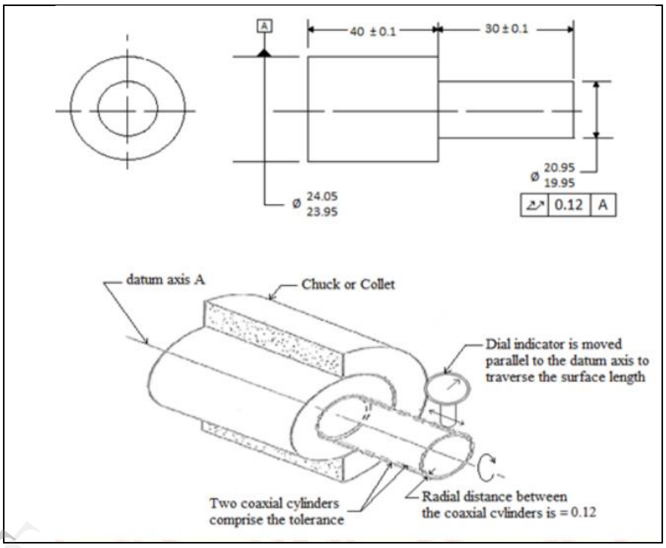

Fig. 3 Total Runout applied to diameter& its verification

IV. LITERATURE REVIEW

Hari Singh [2] et al obtain an optimal setting of turning process parameters (cutting speed, feed rate and depth of cut) resulting in an optimal value of the feed force when machining EN24 steel with TiC-coated tungsten-carbide inserts. The effects of the selected turning process parameters on feed force and the subsequent optimal settings of the parameters have been accomplished using Taguchi's parameter design approach. The results indicate that the selected process parameters significantly affect the selected machining characteristics. The percent contributions of depth of cut (55·15 %) and feed rate (23·33 %) in affecting the variation of feed force are significantly larger (95 % confidence level) as compared to the contribution of the cutting speed (2·63 %).Interaction between cutting speed and depth of cut is significant at 95% confidence level in affecting the mean and variation of feed force, while the interaction between feed and depth of cut affects only the variation in the feed force. Optimal settings of various process parameters for turned parts to yield optimal feed force are: cutting speed=310 m/min; feed rate=0·14 mm/rev; depth of cut=0·70 mm.

Akhyar [3] et al applied taguchi method where Taguchi's parameter design is an important tool for robust design, which offers a simple and systematic approach to optimize a design for performance, quality and cost. Taguchi optimization methodology is applied to optimize cutting parameters in turning Ti-6%Al-4% extra low interstitial with coated and uncoated cemented carbide tools under dry cutting condition and high cutting speed. The turning parameters evaluated are cutting speed of 55, 75, and 95 m/min, feed rate of 0.15, 0.25 and 0.35 mm/rev, depth of cut of 0.10, 0.15 and 0.20 mm and tool grades of K313, KC9225 and KC5010, each at three levels. The analysis of results show that the optimal combination of parameters are at cutting speed of 75 m/min, feed rate of 0.15 mm/min, depth of cut of 0.10 mm and tool grade of KC9225. The cutting speed and tool grade have a significant effect on surface roughness have a contribution are 47.146% and 38.881%, respectively. At optimal condition, contribution of each cutting parameter on surface roughness is reached at 20.47 from tool grade, 21.01 from feed rate, 11.54 from depth of cut and 11.17 from cutting speed.

Mathew A. Kuttolamadom [4] et al examines the achievability of surface roughness specifications within efforts to reduce automotive component manufacture cycle time, particularly by changing cutting feeds. The most widely employed methodologies for surface roughness prediction in terms of machining parameters are the Response Surface Methodology (RSM) and the Taguchi techniques for design of experiments. The factors affecting surface roughness as well as practical techniques for its improvement through optimizing machining parameters are discussed next. Emphasis is placed on portraying the dominance of feed on surface quality over other controllable machining parameters. The most significant machine parameters that have a direct effect on surface roughness are speed, feed, and depth of cut. It is found that surface roughness increases with an increase in the feed rate and depth of cut and a decrease in cutting speed. The effect of increased feed is more pronounced on surface finish than the effect of an increased depth of cut.

M. Kaladhar [5] et al used optimization model based on Taguchi and Utility concept to optimize process parameters, such as speed, feed, depth of cut, and nose radius on multiple performance characteristics, namely, surface roughness (Ra) and material removal rate (MRR) during turning of AISI 202 austenitic stainless steel using a CVD coated cemented carbide tool. Taguchi's L8 orthogonal array (OA) is selected for experimental planning. The experimental result analysis showed that the combination of higher levels of cutting speed, depth of cut, and nose radius and lower level of feed is essential to achieve simultaneous maximization of material removal rate and minimization of surface roughness. The ANOVA and F-tests are used to analyze the results. And from their corresponding ANOVA results, the feed (61.428%) is the most significant parameter followed by cutting speed (20.697%) for Ra, the depth of cut (63.183%) is the most significant parameter followed by cutting speed (20.697%) for MRR response.

Surinder Kumar [6] et al implement the Taugchi's technique for minimizing the surface roughness and maximizing the material removal rate in machining unidirectional glass fiber reinforced plastics (UD-GFRP) composite with a polycrystalline diamond (PCD) tool. Experiments were conducted based on the established Taguchi's technique L18 orthogonal array on lathe machine. The cutting parameters considered were tool nose radius, tool rake angle, feed rate, cutting speed, depth of cut and cutting environment (dry, wet and cooled) on the surface roughness and material removal rate produced. The results indicate that the developed model is suitable for prediction of surface roughness and material removal rate in machining of unidirectional glass fiber reinforced plastics (UD-GFRP) composites. From the experimental results, it is evident that the surface roughness increases as feed rate increases. It is observed that the feed is the most influencing parameter for surface roughness.

Dr. M. Naga Phani Sastry [7] et al investigate that the machining parameters yields the desired surface finish and metal removal rate the proper combination of machining parameters is an important task as it determines the optimal values of surface roughness and metal removal rate. It is necessary to develop mathematical models to predicate the influence of the operating conditions. Mathematical models have been developed to predicate the surface roughness and metal removal rate with the help of Response surface methodology, Design of experiments. The Response surface methodology (RSM) is a practical, accurate and easy for implementation. The study of most important variables affecting the quality characteristics and a plan for conducting such experiments is called design of experiments (DOE). Analysis of variance is employed to verify the validity of the model. RSM optimization procedure has been employed to optimize the output responses, surface roughness and metal removal rate. The minimum surface roughness value was 1.18 µm for Aluminum alloy and2.295 for resin. The maximum metal removal rate was found to be 1377.83mm/min for Aluminum alloy and 182.899mm/min for resin.

Kompan Chomsamutr [8] et al compare the cutting parameters of turning operation the work pieces of medium carbon steel (AISI 1045) by finding the longest tool life by Taguchi methods and Response Surface Methodology. The suitable of response of tool life by both methods will get the suitable values namely depth of cut at 0.5 mm. cutting speed at 150 m/min and feed rate at 0.10 mm/rev. All mentioned values cause the longest tool life at 670.170 min by Taguchi method and 670.230 by RSM respectively.

Durai Matinsuresh Babu [9] et al explains the findings of the experimental results that were obtained to select appropriate cutting parameters that ensure less power consumption in high rate CNC machines. Using Taguchi's technique, experiment was conducted with an extruded aluminium shaft on CNC lathe with cutting speed, feed rate and depth of cut as process parameters. Power consumed(energy), the output characteristic was measured with the help of a data acquisition system. The data were analyzed and appropriate process parameters were selected for minimum energy consumption. From the experimental data, both power and energy are compared with material removal rate(MMR) which shows that, as material removal rate increase power demand and energy consumption decreases.

Jitendra Verma [10] et al focused on the analysis of optimum cutting conditions to get lowest surface roughness in turning ASTM A242 Type-1 ALLOYS STEEL by Taguchi method. Experiment was designed using Taguchi method and L9 array were conducted by this process. The results are analyzed using analysis of variance (ANOVA) method. Taguchi method has shown that the cutting speed has significant role to play in producing lower surface roughness about 57.47% followed by feed rate about 23.46%. The Depth of Cut has lesser role on surface roughness from the tests. The results obtained by this method will be useful to other researches for similar type of study and may be eye opening for further research on tool vibrations, cutting forces etc. The mean S/N ratio for each level of the cutting parameters is summarized and called the S/N response table for surface roughness. The cutting speed is the only significant factor which contributes to the surface roughness i.e. 57.47 % contributed by the cutting speed on surface roughness. The second factor which contributes to surface roughness is the feed rate having 23.46 %. The third factor which contributes to surface roughness is the depth of cut having 16.27%.

Poornima [11] et al investigate that the CNC turning is one among the metal cutting process in which quality of the finished product depends mainly upon the machining parameters such as feed, speed, depth of cut, type of coolant used, types of inserts used etc. Similarly the work piece material plays an important role in metal cutting process. Hard materials such as stainless steel grades, Nickel alloys, and Titanium alloys are very difficult to machine due to their high hardness. While machining these hard materials, optimized machining parameters results in good surface finish, low tool wear, etc. Response surface methodology and Genetic algorithm are used to optimize the process parameters. From RSM are R-Sq. obtained was 99.9% which indicates that selected parameters (speed, feed, depth of cut) significantly affect the response (surface roughness). The Best ranges obtained by using the genetic algorithm approach are Cutting velocity (speed) -119.93 m/min, Feed-0.15 m/min and Depth of cut -0.5mm. Hence the Optimal surface roughness from GA is 0.74 microns.

M. Kaladhar [12] et al investigate the effects of process parameters on surface finish and material removal rate (MRR) to obtain the optimal setting of these process parameters and the Analysis Of Variance (ANOVA) is also used to analyze the influence of cutting parameters during machining. In this work, AISI 304 austenitic stainless steel work pieces are turned on computer numerical controlled (CNC) lathe by using Physical Vapour Deposition (PVD) coated cermet insert (TiCN- TiN) of 0.4 and 0.8 mm nose radii. The results revealed that the feed and nose radius is the most significant process parameters on work piece surface roughness. However, the depth of cut and feed are the significant factors on MRR. Optimal range and optimal level of parameters are also predicted for responses.

Nitin Sharma [13] et al realized that the optimized cutting parameters are very important to control the required surface quality. Taguchi method is used to find the optimal cutting parameters for surface roughness (Ra) in turning. The L-18 orthogonal array, the signal-to-noise ratio & analysis of variance are employed to study the performance characteristics in turning operations of AISI-410 steel bars using TiN coated inserts. The four cutting parameters insert radius, depth of cut, feed & cutting speed are optimized with considerations of surface roughness. The analysis reveals that feed rate has the most significant effect on Ra. In turning, use of greater insert radius, high depth of cut, low feed rate, high cutting speed are recommended to obtain better surface roughness for the specific test range.

Pragnesh. R. Patel [14] et al founds that Problem associated with MMCs is that they are very difficult to machine due to the hardness and abrasive nature of Carbide particles. The main objective is to investigate the effects of different cutting parameters (Cutting Speed, feed rate, Depth of cut) on surface roughness and Power Consumption in turning of 6063 AL alloy TiC (MMCs). PCD tool was used as wear resistive tool in order to achieve desire surface finish. Full factorial Design in design of experiment was adopted in order to planning the experimental runs. Analysis of Variance was used to investigate percentage Contribution of Each process parameters on output Response. Results show that feed rate is significant parameter, which affect on surface roughness and Cutting Speed is effective parameter which affect on power consumption. The increase of feed rate increases the surface roughness. Value of surface roughness is decrease with increase in cutting speed. Power Consumption is increase with increase in cutting speed, feed rate and depth of cut. Cutting speed is most effective parameter on power consumption.

Pankaj Sharma [15] et al find that the The AISI H13, a chromium based hot work tool Steel has a wide variety of applications in aluminum casting and extrusion dies, forging dies, hot nut tools, hot header dies, extrusion mandrels, plastic molds, cores, die holder blocks, hot press dies and specially hot work punches etc. the optimization of two response parameters (Surface roughness and Material Removal Rate) by three machining parameters (cutting speed, feed rate and depth of cut) is investigated in high speed turning of H13 in dry conditions. Taguchi's L'18 orthogonal array and analysis of variance (ANOVA) are used for individual optimization. The simultaneous optimization is done by Grey Relational Analysis approach. The different levels of all machining parameters are used and experiments are done on HMT STALLION-100 HS CNC lathe machine. The optimum condition for combined effects was found V5-F2-D3 and the optimal value of the surface roughness (Ra) comes out to be 1.0828 (μm) and of MRR is 554.0.4 (mm^3/sec).

Krishankant [16] et al perform an optimization of turning process by the effects of machining parameters applying Taguchi methods to improve the quality of manufactured goods. EN24 steel is used as the work piece material for carrying out the experimentation to optimize the Material Removal Rate. The bars used are of diameter 44mm and length 60mm. There are three machining parameters i.e. Spindle speed, Feed rate, Depth of cut. MRR is increased with the increase in spindle speed, MRR is increased with increase in feed rate and MRR is in increased with the increase in depth of cut.

V. CONCLUSION

Turned components represent a vast majority of parts produced in industries. The adherence of the geometrical parameters for attaining the Runout controls on the turned components to meet their functional requirements as part of an assembly is extremely important. This can be ensured by fully understanding the effect of machining parameters on the geometry and dimension irrespective of the machining process used. Hence, the selection of proper cutting parameters for turning process becomes a critical problem so some research is required in this field. Some of the main parameters are cutting speed, Feed rate and depth of cut. For better surface finish & better geometrical and dimension requirements this parameters must be controlled in well manner.

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