INVESTIGATION OF EFFECT OF CUTTING PARAMETERS ON GEOMETRIC RUNOUT 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. Major channels of machined components are produced by CNC machine. CNC machine has got specific capability to produce components meeting both the dimensional and geometric requirements with low processing time. These requirements are to be met with in order to meet the functional requirements by each component as a part of an assembly. 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. Literature Surveys indicates that there is large scope for investigation, which may be useful and produce parts meeting both geometrical and dimensional requirements.

Keywords–Turning, Geometric Dimensioning & Tolerancing, Circular Runout Controls, Total Runout Controls.

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1. 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.

Geometric Dimensioning and tolerancing used with advantage for more tolerances, which translates into lower manufacturing costs for the parts. G.D. &T. allows for the use of MMC modifiers, which results in increased tolerance zones under certain conditions. This results in allowing more functional parts being accepted during inspection. Used 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.

Geometric tolerance characteristics are categorisedas Form, Orientation, Profile, Runout and Location. Form controls are Straightness, Flatness, Circularity and Cylindricity. The form characteristics arealways individual. Profile contains a Profile of line and a Profile of surface. Orientation controls are Angularity, Perpendicularity and Parallelism. Runout controls are Circular runout and Total runout. Location controls are Position, Symmetry and Concentricity. 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 runout control always requires a use of datums.

2. Literature Review

In this study, the effects of cutting edge geometry, work-piece hardness, feed rate and cutting speed on surface roughness and resultant forces in the finish hard turning of AISI H13 steel were experimentally investigated. Four-factor (hardness, edge geometry, feed rate and cutting speed) two-level fractional experiments were conducted and statistical analysis of variance was performed. During hard turning experiments, three components of tool forces and roughness of the machined surface were measured. This study shows that the effects of work-piece hardness, cutting edge geometry, feed rate and cutting speed on surface roughness are statistically significant. Especially honed edge geometry and lower workpiece surface hardness resulted in better surface roughness. Cutting-edge geometry, workpiece hardness and cutting speed are found to be affecting force components [2].

In this study the geometric tolerance of an aluminium piece produced by turning is analysed. The effect of cutting speed, feed and depth of cut were investigated. Experimental work carried out on Aluminium workpiece by using CNC turning machine and measured carried out on Coordinate Measuring Machine. The experiments conducted using Design of experiments (DOE) and Analysis of variance (ANOVA) techniques are used to analyse effect of process variables on responses. Designed Experiments are also powerful tools to achieve manufacturing cost savings by minimizing process variation and reducing rework, scrap, and the need for inspection. The results showed that feed is most significant parameter and speed is less significant parameter and depth of cut did not affect the circularity [3].

In this work, the geometric tolerance and surface quality of an aluminium piece produced by turning is analysed. The effect of the length and diameter of working piece, cutting depth and feed were also investigated. The cutting speed, which is an important machining parameter, was kept constant in this study. Going from past works experience the effect of cutting speed was ignored. Statically method of Taguchi was used in this work in order to obtain more reliable and optimum results. By this method, time and cost savings were made, and the test results were optimized. The results showed that cutting force, surface roughness, cylindricity and vibration were minimized in machining process and production quality was improved [4].

This paper presents the detailed discussions on fabrication of aluminium –silicon carbide (10% by weight of particles) and boron carbide (5% by weight of particles) Hybrid Metal Matrix Composites (Al/SiC/B4C-MMC) using stir casting method. SiC and a B4C particle range from 30 µm to 50 µm. The cylindrical rods of diameter 60 mm and length 250 mm are fabricated and subsequently machined using medium duty lathe of 2 kW spindle power to study the machinability issues of Hybrid MMC using Polycrystalline Diamond (PCD) insert of 1600 grade. Results show that at higher cutting speeds, good surface finish is obtained with faster tool wear. It is concluded that, tool wear and cutting force are directly proportional to the cutting speed, whereas surface roughness is inversely proportional to the cutting speed [5].

This experimental study was conducted to determine statistical models of surface roughness criteria inhard turning of high alloyed steel. Based on 3^3 full factorial design, a total of 27 tests were carried out. The range of each parameter was set at three different levels, namely low, medium and high. Mathematical models were deduced by the software Minitab (multiple regression method) in order to express the influence degree of each cutting regime element on surface roughness. These models would be helpful in selecting cutting variables for the required surface roughness criteria. They can also be used for the optimization of hard cutting process. The result indicates that feed rate is the dominant factor affecting surface roughness, followed by cutting speed. As for the depth of cut, its effect is not very important [6].

3. Selection of Cutting Parameters in Turning

3.1 CuttingSpeed

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

3.2 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 millimetre per revolution.

3.3 Depth of Cut

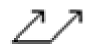
The Depth of Cut is the thickness of the layer being removed from the workpiece or the perpendicular distance measured from the machined surface to the uncut surface of the workpiece. Depth of Cut is expressed in millimetres [1].

4. 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. Therefore, the feature modifiers MMC and LMC are not applicable. 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.

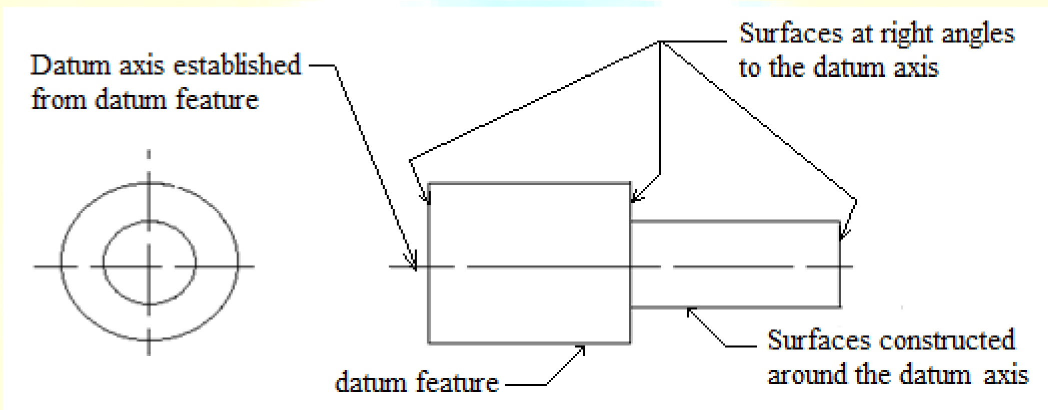


Fig.1 Features Applicable to Runout Tolerances

4.1 Circular Runout

Circular runout is a two dimensional control of circular elements of surface. When applied to surface constructed around a datum axis, 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 of a plane surface, i.e., wobble.Because of the centring of the controlled surface to datum axis, circular runout is a good control for certain aspects of balance for spinning parts.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). In addition, each circular element of the controlled surface must lie between two concentric circles, one with a radius of 0.12 larger than the other. The circles are concentric with centres on the specified datum axis.

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 □ about the datum axis as shown in Fig. 2 [2].

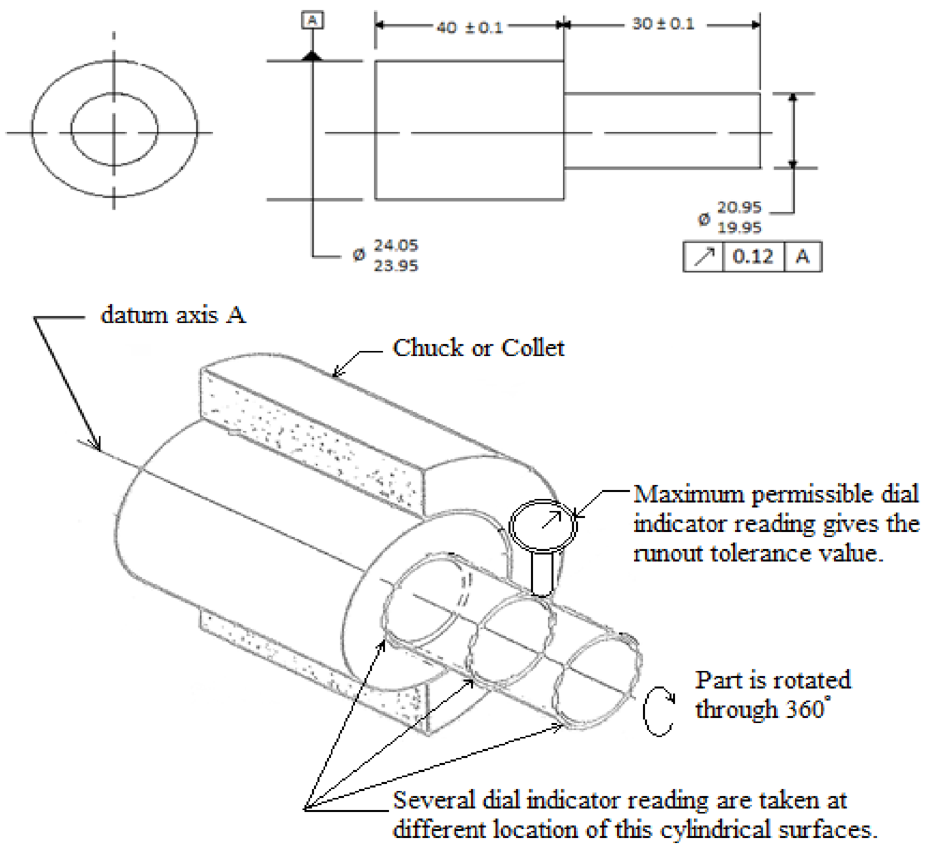


Fig. 2 Circular Runout applied to a diameter& its verification

4.2 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. For features constructed at 90 □ angles to the datum axis, it controls perpendicularity and flatness. 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.

The controlled diameter must meet the size requirements too. When diameter is controlled by total runout tolerance control, its maximum possible axis offset from the specified datum axis is equal to one-half the specified tolerance value. In inspection, the part is rotated 360 □ 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].

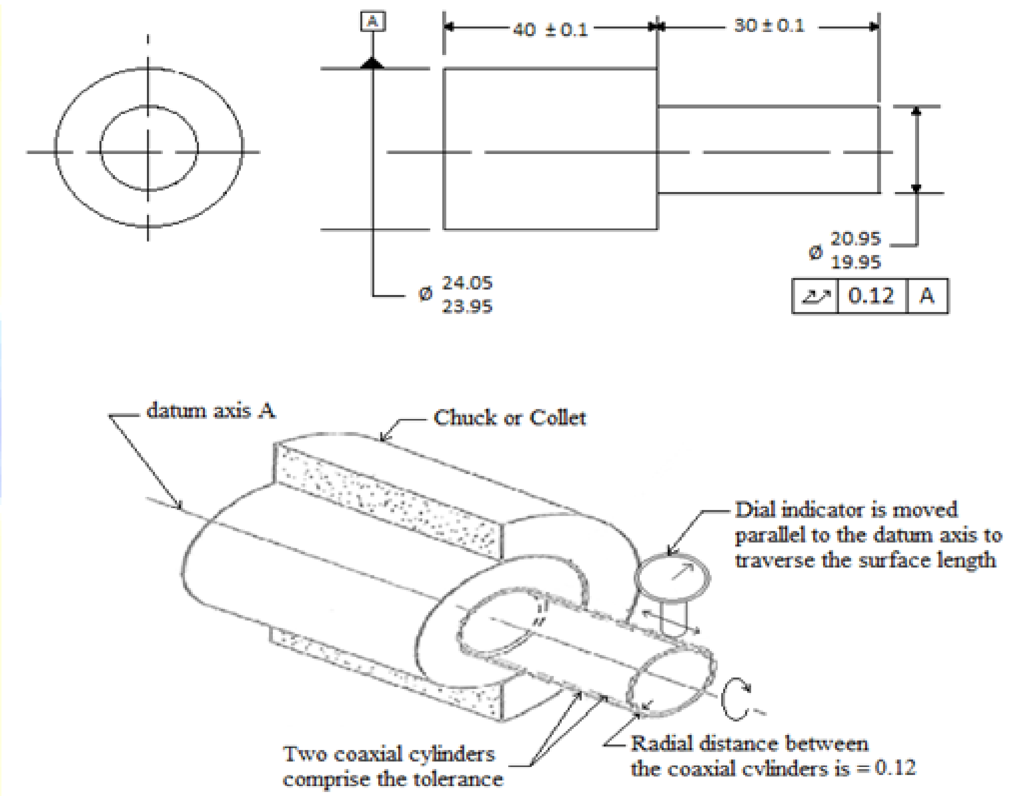


Fig. 3 Total Runout applied to diameter& its verification

5. 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. The current status and demands is that the specific requirement of geometrical and dimensional relation needs to ensure better functioning of part as part of an assembly. 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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