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Investigating the Surface Characteristics during Rough Turning of External Cylindrical Surfaces Using Different Tool Path Approaches

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Abstract
CNC (Computer Numerical Control) lathe is a metal cutting machining method performed on CNC lathe machines to shape raw materials into desired products. It is achieved through the coordinated movement of the workpiece and the cutting tool. The primary motion involves the rotational movement of the workpiece, creating the cutting motion. This is coupled with the translational movement, both longitudinally and laterally, of the cutting tool. All processes are automatically controlled through commands programmed on a computer. In CNC turning, the procedural steps are executed to uphold machining precision and enhance process efficiency, thus yielding economic advantages. The residual material left for subsequent processes profoundly affects overall productivity. Despite employing identical technological parameters, the selection of toolpath strategies significantly impacts the remaining stock, especially in rough machining. This study delves into an examination and comparative analysis of the remaining stock during the rough turning process of external cylindrical surfaces, considering various prevalent toolpath strategies in CNC turning.
Keywords: *CNC, Lathe, CNC Machining.*

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I. Introduction.

CNC machining is a manufacturing process based on computer programs to remove material from a workpiece and produce desired components or parts. This process involves creating a 3D CAD model of the component or part to be machined before converting it into G-code using computer-aided manufacturing (CAM) software. Subsequently, the G-code automates the operation of cutting tools and the workpiece to shape it precisely as intended.

Advantages of CNC Machining

High Precision and Repeatability: CNC lathes ensure high precision and repeatability in machining, guaranteeing products with high accuracy and smoothness. They can easily machine details with cylindrical or conical shapes in 2D and 3D planes.

Reduced Setup Time and Machine Calibration: Machining programs can be reused multiple times, significantly reducing setup time after the first machining. Changes in techniques and program adjustments take less time.

Simplified Tools and Component Positioning: Specialized cutting tools designed for digital applications entirely replace multi-step cutting tools in traditional lathing. Chucks and component positioning aid in keeping components rigid and fixed in place during machining.

Fast and Stable Machining Time: CNC lathes eliminate time barriers, ensuring stable cutting cycles synchronized with production schedules and consistent allocation for each tool.

Increased Machining Productivity: CNC lathes operate automatically and continuously, drastically reducing production time. Improved productivity and high-quality product assurance.

These advantages make CNC lathes flexible in the machining process, allowing for easy transitions between different products without extensive setup times.

In CNC turning, the cutting mode is a crucial aspect of the machining process, influencing the quality of the product and the performance of the lathe. Below are some important cutting modes to consider:

Cutting Speed**:** This is the speed at which the cutting tool moves across the material surface. Excessive cutting speed can generate high temperatures, affecting the tool's durability and the surface quality of the product.

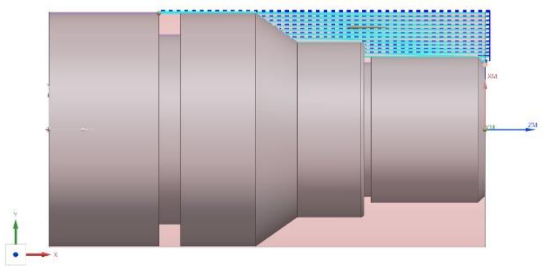
Feed Rate**:** It is the speed at which the lathe tool advances through the material. The feed rate is adjusted to achieve the desired size and quality of machining.

Depth of Cut: This is the amount of material removed in each cutting cycle. A larger depth of cut can increase efficiency rapidly, but it also needs to ensure that the lathe can handle it without issues.
***Cutting Tool Material*:** The material of the cutting tool also affects cutting performance. Cutting tools made from materials like tungsten carbide are often preferred for their durability and sharpness.
Adjusting these cutting modes often requires careful consideration to achieve a balance between increased productivity and ensuring the quality of machining

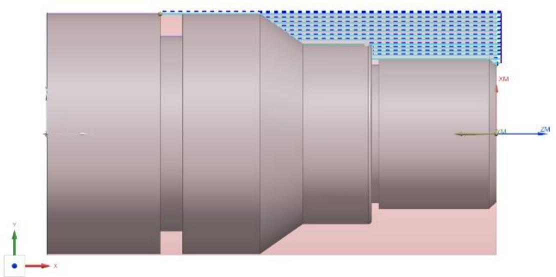
II. Research Methodology.

CAD models integrated with CAM data extraction significantly enhances production efficiency. CAD models empower designers to effortlessly manage, modify, and test designs without incurring substantial prototyping expenses. Meanwhile, CAM data facilitates the swift and convenient connection and utilization of numerically controlled machine tools, ensuring high accuracy and consistency [1-3]. In CNC machining, numerous parameters influence productivity and surface quality. In the context of large-batch machining, the machining time significantly impacts production efficiency. Therefore, optimizing the machining time for each operation and stage is paramount for achieving optimal efficiency.

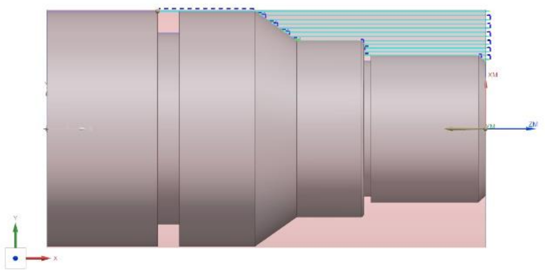
In CNC turning, a toolpath refers to the trajectory that the cutting tool follows to shape the workpiece. This path is determined by the CNC program, which is usually generated using Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) software [4-5]. The toolpath is crucial in defining the tool's movement, depth of cut, and other parameters during the turning process [6-7]. There are different types of toolpaths used in CNC turning, and the selection depends on factors such as the geometry of the part, material properties, and machining requirements. Common toolpaths include:
Roughing Toolpath: This involves removing the bulk of material quickly, leaving behind a stock allowance for subsequent finishing passes.
Finishing Toolpath: This is focused on achieving the final dimensions and surface finish. It involves precise movements of the cutting tool to refine the workpiece.
Grooving Toolpath: Used for creating grooves or recesses in the workpiece.
Threading Toolpath: Generates threads on cylindrical parts.
Facing Toolpath: Used to create a flat surface on the end of the workpiece.



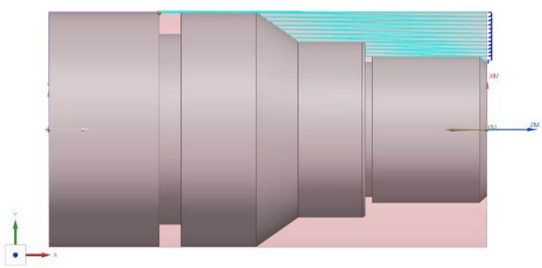
Ramping Zig



Ramping ZigZag



Linear Zig



Linear ZigZag

Fig 1. Some common toolpath types in CNC turning

The efficiency of the CNC turning process, in terms of both time and quality, is closely tied to the optimization of these toolpaths. Skillful programming and toolpath optimization contribute to minimizing cycle times, reducing tool wear, and enhancing the overall productivity of CNC turning operations.

In mechanical machining, machining allowance is a crucial concept in the manufacturing and machining of mechanical components. Machining allowance refers to the surplus or reserve material that is retained to ensure that, after the machining process, the component can achieve the desired final dimensions and shape. When machining in mechanical engineering, components are often designed with larger dimensions and shapes than the final desired ones. This allowance is added to ensure that, after the machining process, the component can be adjusted and perfected to the exact desired dimensions and shape. The machining allowance can vary depending on the type of material, machining method, and precision requirements of the component. Proper management of machining allowance is essential to ensure high and consistent quality in mechanical production.

To examine the residual material remaining after rough turning, we simulate and model the rough turning process on the external cylindrical surface of the component. The choice of technological parameters also affects the residual amount and surface quality of the part after rough machining.

One of the important parameters with great influence is the geometrical parameters of the cutting tool. In this study, we use an external turning insert tool with the geometrical parameters as shown in the table 1

Table 1. *Cutting tool parameters*

Isert	*Insert position*	*Nose radius*	*Nose angle*	*Orient angle*	*Cutting length*
Iso insert shape (C80)	*Topside*	*1.2*	80^0	5^0	*15*

Choosing cutting parameters involves determining the cutting depth, number of tool passes, tool engagement, cutting speed, and required power under specific machining conditions. The cutting parameters need to be calculated and tested directly on the machining tool to determine the most reasonable cutting parameters. This involves ensuring that the cutting parameters meet the technical requirements of the workpiece, are compatible with the capabilities of the machine and cutting tools, and, most importantly, generate high machining productivity and cost-effectiveness under specific conditions of the machining unit. To select the most reasonable and optimal cutting parameters for machining, it is essential to choose the right tool structure, calculate the geometric parameters of the cutting part, determine the correct tool setting and workpiece clamping, assess the CNC machine's quality, and equip it with a structurally sound technology. Additionally, factors such as the chemical composition, microstructure, and crystal lattice of the raw material, as well as the machining method, also have some influence on the cutting parameters.

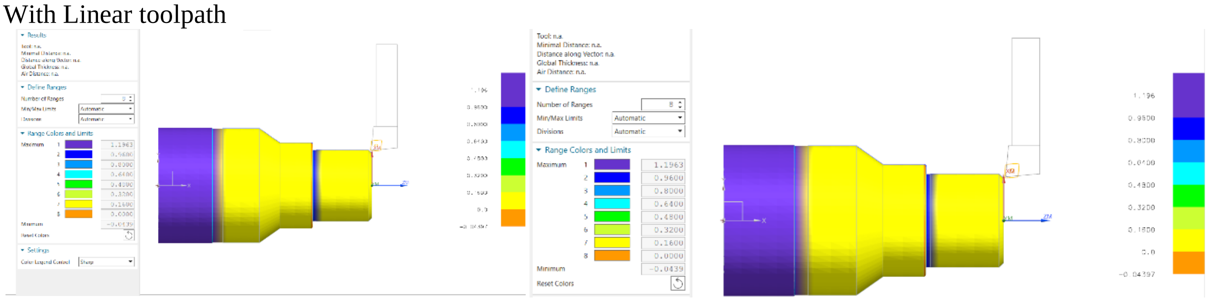
Table 2. *The cutting parameter*

Speed	Feed rate	Depth of cut
2000 (rpm)	0.8 (mm/rev)	0.8(mm)

III. Result And Disscustion.

Results of the simulation process of rough turning of the outer cylindrical surface with the investigation of the remaining amount for the finishing operation

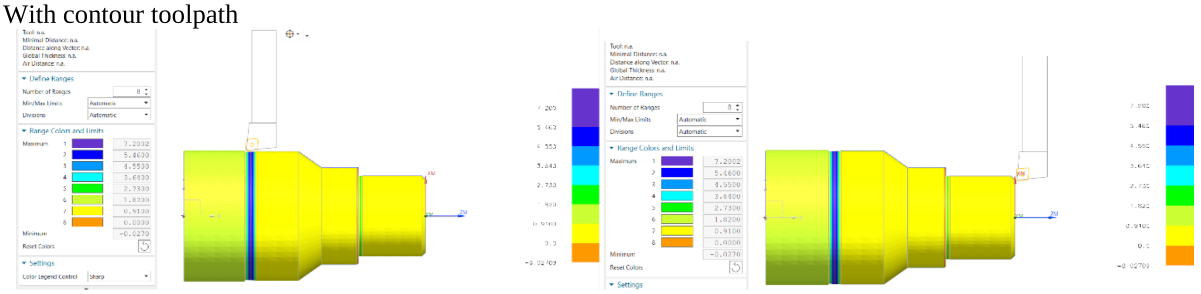
With Linear toolpath



a. Linear zig *b. Linear Zigzag*

Fig 2. Residual amount remaining after rough machining

With contour toolpath



a. Contour zig *b. Contour Zigzag*

Fig 3. Residual amount remaining after rough machining in contour toolpath

The maximum residual value determined on the outer cylindrical surface excluding the groove area of the tool path types is as follows

Table 3. *The maximum residual value*

Toolpath types	Linear zig	Linear Zigzag	Contour zig	Contour Zigzag
Stock left	0.16	0.16	0.91	0.91

The simulation outcomes indicate that the selection of toolpath geometry significantly influences surface quality, precision, and residual stock remaining for finishing operations. Given a particular technological mode and cutting tool, the specified parameters will vary based on machining conditions and workpiece material. This finding serves as a guide for opting for the suitable toolpath geometry when defining the process parameters for rough turning the outer cylindrical surface.

Acknowledgment

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References

[1]. Kunwoo Lee, Tae Ju Kim* and Sung Eui Hong - Generation of toolpath with selection of proper tools for rough cutting process - Computer-Aided Design, 26(11), 822–831.

[2]. F. Y. Han, D. H. Zhang, M. Luo & B. H. Wu - Optimal CNC plunge cutter selection and tool path generation for multi-axis roughing free-form surface impeller channel - The International Journal of Advanced Manufacturing Technology volume 71, pages1801–1810 (2014).

[3]. Z.Y. Zhao, C.Y. Wang, H.M. Zhou, Z. Qin - Pocketing toolpath optimization for sharp corners - Journal of Materials Processing TechnologyVolumes 192–193, 1 October 2007, Pages 175-180.

[4]. V. Giri, D. Bezbaruah, P. Bubna, A. Roy Choudhury - Selection of master cutter paths in sculptured surface machining by employing curvature principle - International Journal of Machine Tools and ManufactureVolume 45, Issue 10, August 2005, Pages 1202-1209.

[5]. Jinting Xu, Yukun Ji, Yuwen Sun, Yuan-Shin Lee - Spiral Tool Path Generation Method on Mesh Surfaces Guided by Radial Curves – Journal of Manufacturing Science and Engineering Jul 2018, 140(7): 071016 (13 pages).

[6]. Yu-an Jin, Yong He, Jian-zhong Fu, Wen-feng Gan , Zhi-wei Lin - Optimization of tool-path generation for material extrusion-based additive manufacturing technology - Additive ManufacturingVolumes 1–4, October 2014, Pages 32-47.

[7]. James E. Bobrow - NC machine tool path generation from CSG part representations - Computer-Aided DesignVolume 17, Issue 2, March 1985, Pages 69-76.