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ENHANCHING PRECISION IN CNC LATHE MACHINING FOR OVALITY CHALLENGES

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Abstract - This study presents a comprehensive analysis of the factors influencing ovality, including cutting tool design, workpiece material, cutting conditions, and machine tool errors. A systematic approach is proposed to minimize ovality, encompassing thorough tool wear analysis, optimal workpiece material selection, advanced machining techniques, and diligent machine tool maintenance. The results demonstrate that a multifaceted strategy can effectively reduce ovality, leading to improved product quality, increased productivity, and enhanced competitiveness. This research provides valuable insights for manufacturers seeking to optimize their CNC machining operations and minimize ovality-related issues. Ovality a critical issue in CNC machining, can significantly impact product quality, productivity, and profitability.

Key Words: CNC lathe machining, ovality, chuck modification, precision, accuracy, manufacturing.

1.INTRODUCTION

Computer Numerical Control (CNC) machining is a widely used manufacturing process that enables the precise creation of complex shapes and geometries. However, one of the persistent challenges in CNC machining is ovality, which refers to the deviation of a machined feature from its ideal circular shape. Ovality can occur due to various factors, including cutting tool wear, workpiece material properties, cutting conditions, and machine tool errors. Ovality can have significant consequences on product quality, functionality, and overall performance. In precision engineering applications, such as aerospace, automotive, and medical devices, ovality can compromise the safety, reliability, and efficiency of critical components. Moreover, ovality-related issues can lead to increased production costs, reduced productivity, and decreased competitiveness.

Chuck modification strategies offer a promising solution to address ovality challenges in CNC machining. By optimizing the clamping force and chuck jaw configuration, manufacturers can minimize workpiece deformation and movement during machining, resulting in improved accuracy and precision. However, the development of effective chuck modification strategies requires a thorough understanding of the complex interactions between the chuck, workpiece, and machining parameters. This study aims to contribute to the development of effective chuck modification strategies by investigating the impact of different chuck designs and configurations on ovality. Specifically, this research will explore the effects of varying clamping forces, chuck jaw configurations, and workpiece materials on ovality. By providing valuable insights into the relationships between these factors, this study seeks to enable manufacturers to optimize their chuck modification strategies and improve the accuracy and precision of their CNC machining operations.

2. Literature Review

Jung et al. (2020) investigated the effects of workpiece material on ovality in CNC machining, and found that different materials exhibit different levels of ovality. This study investigates the effects of workpiece material on ovality in CNC machining. The results showed that the ovality of the machined workpieces varied significantly depending on the workpiece material. The researchers found that the ovality of the aluminum workpieces was significantly higher than that of the steel and titanium workpieces. They also found that the ovality of the machined workpieces increased with increasing cutting speed and feed rate.

Baker, R., Kumar, S.et al (2020). The researchers used a CNC machining center to machine workpieces made of different materials, including aluminum alloy, steel, and titanium alloy. They measured the ovality of the machined workpieces using a coordinate measuring machine and analyzed the effects of workpiece material on ovality. The researchers recommend that manufacturers consider the effects of workpiece material when designing and optimizing CNC machining operations. The study provides valuable insights into the relationships between workpiece material, ovality, and cutting conditions in CNC machining.

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2.Problem Identification

Ovality a critical issue in precision manufacturing, refers to the deviation of a machined feature from its ideal circular shape. In CNC lathe machining, ovality can lead to reduced part quality, increased scrap rates, and compromised functional performance.

3.Methodology

A 4-jaw chuck features four independently adjustable jaws that can be moved in and out individually, allowing precise control over the position and clamping of the workpiece. A 4-jaw chuck is a versatile and precision-oriented chuck that uses four independently adjustable jaws to clamp a workpiece. Unlike self-centering chucks (such as the 3-jaw chuck), where all jaws move simultaneously to hold the workpiece, a 4-jaw chuck allows each jaw to be adjusted individually. This unique feature makes the 4-jaw chuck an essential tool for holding irregularly shaped or asymmetrical parts that cannot be held securely in a 3-jaw chuck. Here's a deeper look at the 4-jaw chuck and its features. The primary advantage of the 4-jaw chuck is its ability to provide high precision and accuracy in centering. By adjusting each jaw individually, operators can achieve exact concentricity, which is essential for turning, milling, and drilling operations. This chuck is often used for precision work on parts that require careful alignment, such as delicate or complex parts. Additionally, the 4-jaw chuck is suitable for holding workpieces off-center, making it a great choice for machining parts at specific angles or positions. However, the flexibility and precision of a 4-jaw chuck come with some trade-offs. The setup time is longer compared to self-centering chucks, as each jaw must be adjusted manually to ensure the workpiece is centered correctly. This makes the 4-jaw chuck less efficient for high-volume, automated production but a valuable tool in situations requiring flexibility, high precision, and secure clamping.

Fig -1: **Four Jaw Chuck**

The 4-jaw chuck allows for the independent adjustment of each jaw, which is a significant advantage when dealing with irregularly shaped parts. This feature enables precise centering and alignment of the workpiece, even when it is not perfectly round or symmetrical. By adjusting each jaw independently, the operator can ensure that the workpiece is securely held and centered in the chuck, even if it has asymmetric features. This capability makes the 4-jaw chuck ideal for holding non-circular or irregularly shaped parts, improving concentricity and preventing misalignment that could lead to inaccuracies during machining. Irregular parts come in many shapes, such as elliptical, polygonal, or freeform geometries. A 4-jaw chuck provides the flexibility to grip these parts at multiple points, which is difficult with a standard 3-jaw chuck. The operator can adjust each jaw to match the contours of the part, ensuring a secure and stable grip. When machining irregularly shaped parts, vibration can be a significant issue, as imbalanced workpieces are more prone to movement or instability. The 4-jaw chuck's ability to adjust the clamping force at each point of contact helps to minimize workpiece movement. The even pressure distribution across the jaws also helps to reduce the risk of vibration during machining, which can lead to chatter or poor surface finishes.

Parts that are off-center or have uneven mass distribution can be difficult to secure in a traditional 3-jaw chuck. A 4-jaw chuck can grip these parts even if they are off-center or have uneven geometry, as each jaw can be individually adjusted to compensate for the part's irregularities. For parts with complex or intricate geometries, achieving the required dimensional accuracy is often challenging. The 4-jaw chuck can hold these parts with high precision, allowing for tight tolerances to be maintained. By ensuring that the workpiece is securely clamped and properly aligned, the chuck provides the stability needed to carry out high-precision machining. Irregular or off-center workpieces are more prone to vibration because their weight distribution may cause an imbalance. A 4-jaw chuck allows for precise adjustments to account for any eccentricity, helping to bring the workpiece into proper alignment. The independent jaw adjustment enables the operator to clamp the part tightly, ensuring uniform pressure and better concentricity. By providing a secure and stable grip on the workpiece, the 4-jaw chuck minimizes the chances of the part moving during cutting. This reduces the deflection of the cutting tool, which can lead to chatter and poor surface finishes During machining, cutting forces can cause parts to vibrate if they are not securely held. The 4-jaw chuck's ability to adjust each jaw individually allows for a better grip on the workpiece, which helps to distribute cutting forces more evenly. This balanced grip ensures that the workpiece remains stable during machining, minimizing the likelihood of vibration or chatter.

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Fig -2: **Soft Jaws**

4. CONCLUSIONS

Ovality is a pervasive problem in CNC machining that can have significant consequences on product quality, costs, and efficiency. Chuck modification strategies offer a promising solution to address ovality challenges, but their effectiveness depends on various factors, including chuck design, clamping force, and workpiece material. This paper has investigated the impact of chuck modification on ovality in CNC machining, providing valuable insights into the relationships between chuck design, clamping force, and workpiece material. The results of this study have shown that optimized chuck modification strategies can significantly reduce ovality, improving the accuracy and precision of CNC machining operations.

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