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DEFECT ANALYSIS IN CNC TURNING OF TOP BEARING HOUSING COMPONENTS USING THE 4M APPROACH

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Abstract:

Defect analysis in CNC turning is critical to ensuring high-quality manufacturing, especially for precision components like top bearing housings. This study employs the 4M approach (Man, Machine, Material, and Method) to systematically identify and analyze defects such as dimensional inaccuracies, surface roughness issues, and tool wear.

Keywords — CNC Machine,4M Approach, Tool Holding Device.

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I. INTRODUCTION

CNC machine, or Computer Numerical Control machine, is a computer-controlled machine tool that employs a computer to direct its movements and operations. CNC machines are utilized to cut, shape, and carve materials such as wood, metal, plastic, and foam. A CNC machine is an automated machine tool that executes machining operations such as cutting, milling, drilling, and turning based on programmed instructions.

II. TYPES OF CNC MACHINES

CNC (Computer Numerical Control) machines are automated machining tools controlled by computer programs. Here are the main types of CNC machines:

A. **CNC Milling Machine** – Uses rotating cutting tools to remove material.

B. **CNC Lathe** – Rotates the workpiece while cutting tools shape it.

C. **CNC Router** – Ideal for cutting wood, plastic, and soft metals.

D. **CNC Plasma Cutter** – Uses a high-temperature plasma torch to cut metals.

E. **CNC Laser Cutter** – Uses a laser beam for precise cutting.

F. **CNC Electrical Discharge Machine** – Uses electrical sparks to shape materials

III.DIAGRAM

CNC Machine as shown in Figure 1

IV. ADVANTAGES OF CNC MACHINES

CNC (Computer Numerical Control) machines have a number of advantages over traditional machining processes. These advantages contribute to their popularity in numerous industries, such as aerospace, automotive, manufacturing, and medical fields.

- High Precision and Accuracy
- Increased Productivity and Efficiency
- Repeatability
- Reduced Human Error
- Flexibility in Manufacturing
- Cost-Effectiveness

V. PROBLEM IDENTIFICATION

Identifying problems in CNC machines is crucial to ensuring smooth operations, reducing downtime, and maintaining productivity. Problem identification in CNC machines involves diagnosing issues that affect performance, accuracy, and efficiency. Common problems include tool wear, spindle misalignment, software errors, improper machine calibration, and power supply fluctuations. Mechanical issues such as loose belts, faulty bearings, or lubrication failures can lead to vibrations and inaccurate cuts. Programming errors, incorrect tool offsets, and incompatible G-code can also result in machining defects. Regular maintenance, error diagnostics, and software updates are essential to minimize downtime and ensure precision in CNC operations.

- Mechanical Issues
- Electrical Issues
- Programming Issues
- Sensor and Feedback Issues
- Workpiece and Tool Holding Issues
- Coolant and Lubrication Problems
- Human Errors

VI. SOLUTION APPROACH

A solution approach in CNC (Computer Numerical Control) machines involves optimizing machining processes to enhance precision, efficiency, and productivity. The approach begins with designing CAD models and generating accurate CAM programs, ensuring that toolpaths are optimized for minimal material waste and reduced machining time. High-quality cutting tools and appropriate toolpath strategies, such as high-speed machining or adaptive milling, help improve performance.

- Regular maintenance checks
- Proper training for operators
- Real-time monitoring of sensors
- Using high-quality cutting tools
- Proper machining parameters
- Ensuring stable power supply
- Efficient cooling systems

VII. DEFECTS IN CNC MACHINE

CNC turning is a common machining process that facilitates accurate manufacturing of cylindrical parts. CNC turning can be defective due to several reasons, affecting the quality and productivity of production. The 4M approach (Man, Machine, Material, Method) is a good method to evaluate and prevent defects in CNC turning.

A. Man (Operator/Personnel)

Machine Analysis of Nonconformities (MAN) in CNC turning is a critical process aimed at identifying, categorizing, and mitigating defects that impact machining quality and efficiency. Common defects in CNC turning include dimensional inaccuracies, surface roughness, tool wear, chatter, and geometric deviations, often caused by improper tool selection, incorrect cutting parameters, machine misalignment, or material inconsistencies.

B. Machine

Machine analysis of defects in CNC turning involves the use of automated systems and advanced sensors to detect, classify, and diagnose defects that occur during the machining process. Common defects such as tool wear, surface roughness, dimensional inaccuracies, and chatter can be identified through real-time monitoring using sensors like accelerometers, acoustic emission devices, and vision systems. Machine learning algorithms and data analytics further enhance defect detection by analyzing patterns and deviations from standard machining parameters.

C. Material

Material analysis of defects in CNC turning involves examining the causes and characteristics of imperfections such as tool marks, built-up edges, surface roughness, and chip formation issues. These defects often arise due to factors like improper cutting parameters, tool wear, material properties, and thermal effects. Microstructural analysis using techniques like scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS) helps identify material inconsistencies, inclusions, or metallurgical changes that contribute to defects.

D. Method (Process & Parameters)

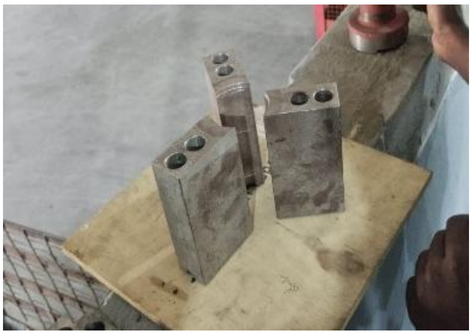
The analysis of defects in CNC turning is crucial for ensuring high-quality machined components and optimizing manufacturing efficiency. Common defects such as surface roughness, dimensional inaccuracies, tool wear, chatter marks, and burr formation can arise due to various factors, including improper cutting parameters, tool misalignment, material inconsistencies, and machine vibrations. A systematic approach to defect analysis involves identifying the defect, determining its root cause, and implementing corrective actions such as adjusting spindle speed, feed rate, or depth of cut, selecting appropriate cutting tools, or improving workpiece clamping.

VIII.TOOL CHUCK IN CNC MACHINE

One of the most commonly used chucks in CNC machines is the three-jaw self-centre chuck, which is ideal for holding cylindrical or round workpieces. This type of chuck automatically centres the workpiece, reducing setup time and improving efficiency. For irregularly shaped objects, a four-jaw independent chuck is preferred, allowing each jaw to be adjusted separately for precise positioning. In high-speed CNC operations, hydraulic and pneumatic chucks are widely used because they provide faster clamping and unclamping actions with uniform pressure, reducing operator fatigue and increasing productivity.

MODEL 1

Failure model 1 in CNC machine is shown in Figure 2,



MODEL 2

Failure model 2 in CNC machine is shown in Figure 3,

MODEL 3

Success model 3 in CNC machine is shown in Figure 4,

IX. COMMON CAUSES OF CHUCK FAILURE IN CNC MACHINES

Chuck failure in CNC machines can result from several common causes, including improper maintenance, excessive wear, and contamination. Insufficient lubrication or the use of incorrect lubricants can lead to increased friction, causing the chuck to seize or operate inefficiently. Wear and tear on chuck components, such as jaws, slides, and actuators, can occur due to prolonged use, improper gripping force, or machining high-hardness materials. Additionally, contamination from coolant, metal chips, or debris can affect the chuck's movement and gripping accuracy. Misalignment or improper installation can also lead to uneven gripping forces, causing premature failure. Regular inspection, proper cleaning, and timely replacement of worn parts are essential to ensuring optimal chuck performance and longevity.

X. CONCLUSION

The defect analysis of CNC-turned top bearing housing components using the 4M approach (Man, Machine, Material, and Method) has provided valuable insights into the root causes of defects and their potential solutions. Through systematic evaluation, it was observed that common defects such as dimensional inaccuracies, surface roughness issues, and chatter marks primarily stem from improper tool selection, worn-out inserts, machine misalignment, and inconsistencies in raw material properties. Addressing these issues requires a multi-faceted approach. Proper training and skill development of operators (Man) can significantly reduce manual errors and enhance process efficiency.

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