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Static and dynamic characteristics modeling for CK61125 CNC lathe bed basing on FEM

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Abstract

The lathe bed characteristics are directly effect on the machining accuracy. Firstly, based on finite element analysis method, the static and dynamic structural are modeled for CK61125 CNC lathe. The results show that the maximum stress is 100.98MPa, the maximum strain is 0.615μm/mm, the maximum deformation is 0.1455mm. Secondly, the modal is analyzed based finite element analysis method, the results show that the first-order resonance frequency is 271.63Hz, the second-order resonance frequency is 290.41 Hz, the third- resonance frequency is 305.88Hz.

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Keywords: lathe bed; static; dynamic; FEM.

1. Introduction

Machine tool is the main manufacturing equipment, and the computer numerical control (CNC) machine tool has high-precision, high-efficiency automated production equipment. It is widely used in automotive, aviation, aerospace, marine, rail, wind, hydroelectric power and other fields. With the growing demand for complex precision parts, it made the CNC machine tools preferment development to efficiency, reliability, precision level developed[1-2].

The lathe bed dynamic and static performances have an important impact on the performance of the machine. The structural characteristics of the bed are related to the machine's machining accuracy and quality, as well as the machine's operating stability. So the designer must study the bed dynamic and static performance.

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With the development of computer technology and the analysis method, the digital manufacturing is realized gradually to information technology and manufacturing technology[3-6]. Among those methods, the finite element analysis method is an advanced and effective design method because the finite element analysis method can get the stress, distribution, deformation, stress easily and accurately. And the internal stress of components can be calculated. This makes the design of structure more targeted. Tyalor[7] based the theory of quality, drilling machine has carried basing the finite element modeling. The analysis result is reliable. However, due to ignoring the influence of joint stiffness and damping coefficient, the dynamic characteristics of machine tool was not true. Jiang[8-9] proposed mathematical model to simulate the machine tool connection structure method using finite element analysis. Machine tool spindle to the position and number of connection of CNC machine tools is optimized. Yeh [10-11] established the modal for movable milling machine bed machine tool bed, head frame and column used finite element method. And modal analysis was done for each part. He[12] modeled the solid model of CA6140 machine bed by using UG software，then the solid model was imported into the ANSYS software in order to process its modal analysis. The spacing, thickness and structure of the ribs were looked as the design variables. The correspondence was established between the bed natural frequency and stiffness, and got the optimal results. Wang[13], based on the dynamic optimization principle of structure and the variable analysis method of finite element method, the dynamic characteristics of the bed structure of precision machine tools are analyzed. Two structural optimization schemes for the bed structure are proposed basing the results of the meta-structure analysis. Abuthakeer[14] is to improve the stiffness, natural frequency and damping capability of machine tool bed using a composite material containing welded steel and polymer concrete. A machine tool bed made of sandwich structures and polymer concrete are designed and manufactured. Modal and static analyses were conducted numerically and experimentally to determine the modal frequencies, damping ratio, deformation and strain.

In this paper, as the research object of CK61125 horizontal CNC lathe, the CNC lathe bed unit are modeled and analyzed based the finite element analysis method in analyzing structure and working characteristics of the lathe bed deeply. The lathe bed working stress, strain and the modal parameters are calculated.

2. The static, dynamic characteristics analysis principle

The static and dynamic finite element modeling of machine lathe bed is set up the finite element digital model, which can reflect the engineering practice through the analysis of its performance. The basic ideas are: to discrete the continuous structure into a finite number of units, and set a finite number of nodes in each unit, to make continuum as only in the node connected to a set of assembly unit, to select the node value as the basic unknown quantity, to assume an approximate interpolation function in each unit to represent the unit midfielder function distribution, using the mechanics principle such as variation principle and virtual work principle to solve the unknown node finite element equation, which will be a continuous domain of infinite degrees of freedom into the limited degree of freedom of discrete domain problems.

2.1. Static characteristic analysis

Used the principle of elasticity mechanics, elastic body under the load of external force, any point the stress, strain, deformation respectively are:

$$\{\sigma\} = \left[\sigma_x \ \sigma_y \ \sigma_z \ \tau_{xy} \ \tau_{yz} \ \tau_{zx}\right]^T \tag{1}$$

$$\{\delta\} = \left[u \ v \ w\right]^T \tag{2}$$

$$\{\varepsilon\} = \left[\varepsilon_x \ \varepsilon_y \ \varepsilon_z \ \gamma_{xy} \ \gamma_{yz} \ \gamma_{zx}\right]^T \tag{3}$$

For isotropic linear elastic material, the relationship between the stress and strain vector is: