

Abstract

Linear servo motion, an important manufacturing unit technology, is one of the most important motion types used in manufacturing systems. Because of backlash, bearing deformation and wear, the common used ball, screw devices can not meet the requirements needed in high speed, high frequency, and high efficiency situations. It is an important method to use directly driven linear servo unit to solve these problems. Based on the application background of noncircular machining and elliptical piston turning, this thesis describes the linear servo unit with small stroke in a manufacturing system. In this study, three aspects are researched. The structure of the linear actuator and the engineering designing method for the magnetic circuit; repetitive control and nonlinear feedback control and their applications; DSP-based Non-hardware-Dependent (NHD-DSP) controller and the Extracted Computer Numerical Controlled (ECNC) system. The system for research and the application of the Voice Coil Motor (VCM) is fully established by combining the above three aspects. It has the characteristics of being open and independent and can be used in PC-based open architecture CNC system. This thesis puts stress on the following objectives:

1. Considering the problems in traditional linear servo unit, a combination driving structure for the linear servo unit and an engineering optimized designing method for NdFeB magnet have been proposed. Many problems such as out force, motor volume and magnet machining with the single magnetic circuit can be solved by this method. A new optimized objective for designing the magnetic circuit which has the smallest magnetic volume as well as the smallest magnetic area has been set compared with the traditional way in which the magnet volume is only considered. So the best ratio value of performance and price of the actuators can be found easily. A structure coefficient designing method has been proposed to get the new designing objective.

2. The model of the linear servo unit has been made based on theory, analyses and experiment. Repetitive control and nonlinear feedback control have been used for the design of the controller and a nonlinear learning control algorithm has been presented to increase the system robustness and the tracking performance.

3. A Non-hardware-Dependent (NHD) hardware structure for the linear servo unit based on Digital Signal Processor (DSP), as well as its fulfillment method, has been proposed to solve the proprietary problem in old linear drive system. With NHD structure, the linear servo unit is independent from other devices and easy to use. Therefore, it is suitable for open architecture CNC system and is also easy to be manufactured as a product.

4. Based on the application of linear servo unit in noncircular CNC turning, the conception of Extracted CNC (ECNC) system, extracted designing method, and extracted structure have been proposed. This was deduced from the experiment and application of the linear actuator. The developing period for the new CNC system is greatly decreased, and so to the price with this designing method. Also the stability of the new developed CNC system is increased compared to the traditional designing method.

5. The new developed linear servo units under research have been used in Guangzhou Machine-tool Factory and Anyang Machine-tool Factory to verify their performance. Three kinds of linear servo units have been developed in the laboratory and two of them with 300N and 800N out force respectively have been produced in small volume.

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Key words: Manufacturing system, Linear servo unit, Combination structure, Elliptical pistons, Noncircular turning