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The Study of Design Method for Robotic Drill End Effector

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Abstract

The drill end effector is a key sub-system to flexible robotic drilling system, which performance will have an effect on drilling quality and efficiency. As a highly-integrated small electro-mechanical system, the design of drill end effector should be based on the robot and the process. The effect of the stiffness, the payload and the accuracy of the robot, the mounted configuration of the end effector, the technological process, and the orbital drilling technique were analyzed. And according to the analysis results, the design method of the drill end effector is established.

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Keywords: robot; drill end-effector; process; design method

1. Introduction

The robotic drilling system have good programmability and motion dexterity, which can quickly adapt itself to product change, and it does not increase the enterprise investment excessively, so the system accords with the lean principals. In recent years, the intelligent manufacturing equipment has been widely used in the aircraft industry. The drill end effector is a key sub-system to the robotic drilling system, which performance will affect the hole quality and productivity. At present, there is only a very few companies provide mature production in the technology area. For example, the Electroimpact in the USA and the Novator in the Sweden. The former develops a

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series of drill end effector (as shown in Fig.1), which main characteristic is multiple process tool integration. The latter invents the orbital drill technology, and the company integrates the technique into the drill end effector. The drill end effector is a non-standard equipment, which function design and structural design strongly depend on the product form and manufacture process of the aviation enterprise. In China, the case study of the drill end effector has been developed, but the systematic design method of the drill end effector is lacking. Moreover, these studies are more concentrated in the university, and the product remains in the prototype stage.

(a)Year 2002 (Hanging configuration) (b)Year 2007 (Side configuration) (c)Year 2009 (Hanging configuration)

Fig.1. The Electroimpact's drill end effector[1-3]

Nomenclature

e	eccentricity
E	max eccentricity

2. The effect of the robot on the design of the drill end effector

Robotic technology (involving positional accuracy, payload capability, stiffness and position compensation, offline programming, and simulation tools) fast development and cost continuous reduction make the robot become an effective flexible motion platform.

2.1. The stiffness of the robot

The 6-axis articulated arm industrial robot is a serial mechanism, so its drawback is related to high compliance, which causes deformations or perturbations in machining applications. In drilling process, the thrust force can induce the intense vibration due to the elasticity of the joints in serial industrial robots. The problem can be solved by means of the structure design, which makes the clamp force couple with the thrust force at pressure foot axis. Therefore, the force applies on the robot tool flange is static, and its value equals clamp force. The clamp force serves to compensate for the gravity effect of angle of the drill end effector, close interlaminar gaps in order to prevent chips from wandering into any gap between the two materials, and serves to stabilize the system during drilling. In any case, the clamp force should be greater than thrust force in order to ensure good hole quality and system stability. But the clamp force should not too big so as not to cause deformation of the workpiece.

2.2. The payload of the robot

Considering the payload characteristic and the load situation (the gravity and the clamp force) of the robot, the payload capacity of the robot should be three times larger than the weight of the drill end effector.

2.3. The accuracy of the robot

In view of the application background of the robot drilling system in the aviation industry, the positioning