Chapter 32
Multi-Modal Assembly-Support System for Cellular Manufacturing

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ABSTRACT

Cellular manufacturing meets the diversified production and quantity requirements flexibly. However, its efficiency mainly depends on the operators' working performance. In order to improve its efficiency, an effective assembly-support system should be developed to assist operators during the assembly process. In this chapter, a multi-modal assembly-support system (MASS) was proposed, which aims to support operators from both information and physical aspects. To protect operators in MASS system, five main safety designs as both hardware and control levels were also discussed. With the information and physical support from the MASS system, the assembly complexity and burden to the assembly operators are reduced. To evaluate the effect of MASS, a group of operators were required to execute a cable harness task. From the experimental results, it can be concluded that by using this system, the operators' assembly performance is improved and their mental work load is reduced. Consequently the efficiency of the cellular manufacturing is improved.

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INTRODUCTION

Traditionally, when the mass production was major in industry production, various assembly systems had been designed as automated manufacturing lines, which are aimed to produce a single specific product without much flexibility. Nowadays, the tastes of consumers change from time to time; therefore, traditional automated manufacturing lines cannot meet the flexibility and efficiency at the same time. To solve this problem, cellular manufacturing system, also called cell production system, has been introduced. In this system, an operator manually assembles each product from start to finish (Isa & Tsuru, 2002; Wemmerlov & Johnson, 1997). The operator enables a cellular manufacturing system to meet the diversified production and quantity requirements flexibly. However, due to the negative growth of the population in Japan, it will become difficult to maintain the cellular manufacturing system with enough skilled operators in the near future. How to improve the assembly performance of the operators and how to reduce their assembly burden are two important factors, which limit the efficiency of the cellular manufacturing system.

Without an effective supporting system, it is difficult to maintain the cellular manufacturing system in Japan. Taking the advantages of the operators and robots, but avoiding their disadvantages at the same time, a new cellular manufacturing system was proposed, namely, the human-robot collaboration assembly system (Duan, 2008). In this human-robot collaboration assembly system, the operators are only required to execute the complicated and flexible assembly tasks that need human assembly skills; while the robots are employed to execute the monotonous and repeated tasks, such as the repetitions of parts feeding during assembly process (Arai, 2009). To make this system has the applicability to assemble a variety of products in different manufacturing circumstances, the following assembly sequence is assumed: each assembly part is collected from the tray shelf by manipulators; all the parts are automatically fed to the operator on a tray as a kit of parts; an operator grasps the individual part respectively and assembles it to form a final product; the assembled product is transferred out to the next station, and so on.

In the following part, a multi-modal assembly-support system (MASS) is introduced, which aims to support an assembly operator in a cellular manufacturing system from both information side and physical side while satisfying the actual manufacturing requirements. MASS system utilizes robots to support the operator and several information devices to monitor and guide the operator during the assembly process. Since it is a human-robot collaboration assembly system, safety strategy must be designed to protect the operator with a reasonable cost benefit balance in the real production line.

The remainder of the chapter is organized as follows: Firstly, the background information and the related studies are introduced. Then, the entire MASS system and its subsystems are briefly described. After that, a description of two manipulators and a mobile base are introduced in physical support part, which are used to feed assembly parts to the assembly operator. Assembly information support part contains a discussion of a multimedia-based assembly table and corresponding devices. Safety standard and safety design are presented in safety strategy part. Taking a cable harness task as an example, the effect of MASS system was evaluated. Finally, the conclusion and the future work are given.

PREVIOUS RELATED STUDIES

To improve the efficiency of the cellular manufacturing system, various cellular manufacturing systems have been designed to improve the assembly performance of the operators and reduce their assembly burden.