Chapter 25
Industrial Machining Robot with Incorporated Robotic CAM System

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ABSTRACT

This chapter first describes the robotic CAM system proposed from the viewpoint of robotic servo controller for an industrial robot RV1A. Then, a reverse post-processor is proposed for the robotic CAM system to online generate the original CL data from the NC data post-processed for a five-axis NC machine tool with a tilting head. Next, an application of the industrial robot with incorporated the robotic CAM system is introduced. The application is developed to efficiently machine foamed polystyrene patterns which are typically used for master pattern of sand mold or for lost-foam pattern for full mold casting (i.e., lost-foam casting). If the target material is limited to such foamed polystyrenes, it is expected that the developed machining robot is superior to conventional NC machine tools in terms of introduction cost, running cost, compactness, and easiness of use. Finally, promising machining results of foamed polystyrene materials are shown.

1. INTRODUCTION

Mechatronics is an interdisciplinary filed and robotics represents a specific class of Mechatroni systems. Mechatronics deals with applications associated with modern systems and control methods aiming to solve practical problems and fulfilling needs. Habib (2007) showed mechatronics evolution time line from 1970s to present and introduced the mechatronics knowledge space paradigm, while exploring the importance and the prospect of the future development in the mechatronics field. In addition, the synergetic and interactive development environment for the mechatronics design and development process were illustrated in detail.

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One of representative mechatronics systems is an articulated industrial robot, which has been remarkably advanced and applied to several tasks such as welding, handling, painting, polishing and so on. At the present stage, however, the relationship between CAD/CAM systems and industrial robots are not well established compared to NC machine tools that are widely spread in manufacturing industries. Generally, the main-processor of CAD/CAM system generates CL data according to each model's shape and machining conditions, then the post-processor produces suitable NC data according to an NC machine tool actually used. The controller of the NC machine tool sequentially deals with NC data and accurately controls the positions of main head and the angles of other axes. Thus, the CAM systems for NC machine tools are already established. On the other hand, however, the CAM system for industrial robots has not been sufficiently considered and developed yet. A teaching pendant is generally used to obtain position and orientation data of the arm tip before an industrial robot works.

Nagata et al. (2001, 2006) developed a joystick teaching system for a polishing robot to safely obtain desirable orientation data of a sanding tool attached to the tip of robot arm. Maeda et al. (2002) proposed a simple teaching method for industrial robots by human demonstration. The proposed automated camera calibration enabled labor-saving teaching and compensated the absolute positional error of an industrial robot. Also, Kushida et al. (2001) proposed a method of force-free control for an industrial articulated robot arm. The control method was applied to the direct teaching of industrial articulated robot arms, in which the robot arm was directly moved by human force. Further, Sugita et al. (2003) developed two kinds of teaching support devices, i.e., a three-wire type and an arm type, for a deburring and finishing robot. The validity the proposed devices were verified through experiments by using an industrial robot. As for off-line teaching, Ahn and Lee (2000) proposed an off-line automatic teaching method using vision information for robotic assembly task. Also, CAD-based off-line teaching system was proposed by Neto et al. (2010), which allowed users with basic CAD skills to generate robot programs off-line, without stopping the production by using a robot. Besides, Ge et al. (1993) showed a basic transformation from CAD data to position and orientation vectors for a polishing robot. As one of the pioneers about teaching-less industrial robotic system, Sugitani et al. (1996) developed welding robots which were successfully controlled by the teaching-less CAD/CAM system, in which there were 26 sets of arc welding robot for steel bridge panel fabrication. Further, Chen and Dong (2013) reported recent developments and future issues, however, it seems that the necessity of teachingless was not discussed.

This chapter first describes the robotic CAM system proposed from the view point of robotic servo controller for an articulated industrial robot RV1A (Nagata et al., 2013). It is defined here that the CAM system includes an important function which allows an industrial robot to move the tip of robot arm along not only numerical control data (NC data) but also cutter location data (CL data) consisting of position and orientation components. Then, a reverse post-processor is proposed for the robotic CAM system to online generate the original CL data from the NC data post-processed for a five-axis NC machine tool with a tilting head. The developed CAM system has a high applicability to other industrial robots with an open architecture controller whose servo system is technically opened to end-users, and also works as a straightforward interface between a general CAD/CAM system and the industrial robots.

Figure 1 shows a six-DOFs articulated industrial robot RV1A with an open architecture controller that is used to evaluate the effectiveness of the proposed robotic CAM system. In Figure 2, the proposed robotic CAM system is shown in comparison with the conventional CAM process using an NC machine tool. Also, in Figure 3, the proposed robotic CAM system is compared with the conventional off-line

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