CHAPTER 13

COMPUTER / PROGRAMMABLE CONTROL
OF A FLEXIBLE MANUFACTURING CELL

J.RICHARD, F.LEPAGE, G.MOREL
Centre de Recherche en Automatique de Nancy
CNRS URA 821
BP.239
54506 VANDOEUVRE LES NANCY CEDEX

ABSTRACT: This chapter presents the study and realization of a control loop flexible cell. The first part is a description of the functional requirements, which define the functions that have to be made by the physical manufacturing system, the industrial information system, and the manufacturing controller. The structural requirements are described in the second part. They specify both the distributed control architecture at cell and machine level, and the communication architecture. The control loop of the cell is achieved by the quality control of the products and the monitoring of the equipment. The third part comprises the study and the realization of an experimental cell in the laboratory. Many functions form the running at the cell level. We only present the coordination between cell and station, and the planning of part handling. The realization of the communication functions is presented; MAP, Ethernet, 3+ Open, and Bitbus networks are used. The machine level is formed by three main components: the machine computer, supporting the supervision, the numerical controller, and the fieldbus which for example achieves control and monitoring of the fixturing device. The control loop of the machining process by dimensional measurement, is achieved directly on the machine by gauging or by a vision system. It permits to correct in real time the machining process, which achieves to keep optimal quality.

1. Introduction

The control of manufacturing units relies upon the implementation of many functions, including the design of the products, the design of the associated manufacturing posts and the maintenance of the means of production. Only the integration of these functions allows to search for a global optimization of the process.

The integration of the control functions needs a suitable computer structure, which is necessarily distributed, because the intelligence of the various functions is geographically distributed. This requires methods and efficient tools in order to use and maintain:

- communication networks which carry different types of information,
- databases which store this information, and have to achieve their coherence and consistence,
- real time and distributed computer systems which have permanently to co-operate.
Obviously reliable operating and quality assurance are essential to ensure economical interest.

This article presents the implementation of these principles limited at the level of a manufacturing cell. With the experience of the study and realization of an automated manufacturing island, [1], we have developed a flexible manufacturing cell, which uses the same concepts:

- utilization of quality control as feedback,
- maximal flexibility of the cell related to new production,
- distribution of the control.

New concepts have been inserted:

- control loop for the equipment at each level,
- development of the distribution of decisions taken related to work chain defaults,
- global management of the information.

This cell can be integrated into the global shop management. The integration of this concept is only possible by the use of evolved computer systems, special local area networks which assume the distribution of functions, and multi-task real time operating systems.

The project is presented in three parts:
- the functional requirements which define the functions to integrate,
- the structural requirements which define the functional structure,
- the study and the realization as they have been made at laboratory.

2. Cell Functional Requirements

2.1. INTRODUCTION

The cell is materially integrated in the workshop structure as a product transformation unit and as a manufacturing information unit. It is also integrated as a structural entity of the manufacturing function which is able to plan its own manufacturing activity. The cell's real performance depends on the functional specifications described in this paragraph.

2.2. THE PHYSICAL MANUFACTURING SYSTEM

In the workshop, machine regrouping and consequently cell machines is a result of group structuration technologies. The cell is a transformation entity of material flow composed of parts flow and tools flow. The cell can be in the situation of bottleneck or non bottleneck.

- Non bottleneck. It does not slow down the product flow. Its local productivity is not an optimization criterion. However, it is advantageous to use idle time to optimize quality assurance and so, to increase speed of material flow in downstream cells, which can be in a bottleneck situation.

- Bottleneck. It slows down the product flow. All possibilities which can increase material flow speed must be studied, especially by using possibilities of freedom degrees which belong to manufacturing process. Productivity research is not an optimization criterion for the cell, but only for all the manufacturing process. The manufacturing cell plan is determined by workshop