CULEGERE DE LUCRĂRI ȘTIINȚIFICE

TEHNOLOGII MODERNE, CALITATE,

RESTRUCTURARE

Chișinău, mai 2007

# A MODULAR MANUFACTURING CONTROL SYSTEM

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**Keywords**: reconfigurable, modularity, open communication

**Abstract:** This paper proposes a modular manufacturing system structure. The key concept is to modularize the machines, the auxiliary equipment and finally the plant. In architecture, each module has a set of configuration parameters used by the main module of each sub-structure. The multiprocessor structure allows the production facility to adapt itself to the production task.

## 1. Introduction

The increased competition between manufacturing enterprises requires the frequent change of production batch. The use of dedicated machine tools is no longer the optimal solution of the production business strategy. Flexible manufacturing systems were a solution to increase diversity of the part families. A flexible manufacturing system consists in several machine tools and material handling stations with fixed structure that were used for resolving a specific production task. The system structure was fixed but the flow of the production was flexible. The result was the capacity to produce a part family. The reconfigurable manufacturing system (RMS) is the ultimate concept emerged in order to adapt the production to the increasing changes of volumes and product types.

The basic element of a RMS is the reconfigurable machine tools. An overview of those systems is made in [1-3]. A modular structure adapted to the diversity of the parts is used. The scalability of the machine tool is ensured by adding production modules to a basic structure. The result of this

concept is the development of the "plug and produce" modules. These modules must be connected to an open bus, each module having its own processor. In [4-6] a machine control structure based on field buses is proposed. The field bus solution is preferred due to the reduced wiring and the facilities of client server and publisher / subscriber. The solution proposed in these papers is intended only to be applied only for the sensors and for the actuators.

In this paper an open machine tool structure is proposed. The idea of producing production modules by different machine tool vendors is a challenge to the industry. Its results may be similar to the development of computer industry. The major challenge is to design a system structure and the required software.

## 2. Plug and Produce

The rapid change of the production capacity and functionality requires the frequent change of the structure of the machine tools and of the manufacturing system.

The modularity of the machine tools is a key element for the future of manufacturing. The scalability of the RMS will be made by simply adding or removing machine modules. This modular approach requires the development of standard mechanical, software and hardware interfaces for the modules. The machine tools vendors will produce custom modules, each module having in common only the standard interfaces. The configuration of a machine during a structure modification will be made automatically by its modules which will supply the machine processor with a software structure describing its configuration and usage mode. The proposed structure has an open architecture with the possibility of scalability.

The modular structure of a machine tool will have a basic module, a machine processor which will store configuration data referring to the list of machine modules, their capabilities, the required machine global performances. The machine's structure will be organized around an open bus capable of connecting its module. This configuration data is acquired from the machine modules during a detection procedure. Each module will have a modular structure itself. This approach allows the use of different modules for allowing the machine module to execute its basic task. Due the modular structure of the modules, the machine bus can be any bus used currently in industry.

The machine modules can be:

- HMI modules – which have software structure involving a CAD-CAM software module, a reconfigurable interpreter which can be configured by the user of the machine and by the machine processor.
- Axis and spindle modules- which are used for the movement of the machine. Each module commands a speed drive and receive data from an encoder. The speed drive should be an intelligent device that should provide data about the provided torque and about the electrical parameters. The data should be used for the axis processor for detecting the work

conditions. The speed drive has a set of parameter regarding its speed and torque regulators and about the motor used. These parameters would be transferred to the axis processor that has using a communication link. The axis or spindle processor would include these parameters in its configuration data profile. The axis or spindle processor has also the possibility to control a set of auxiliary IO such as reference limit switch, brake, speed gears, temperature sensors. The processor would have a configuration data set that describes its structure and the possibilities of control.

- Tool processors- with the task of management of a tool holder turret or magazine. The tool processor task is to control each tool regarding its dimensions, position, profile, were and to select the tool used for operation. Giving the diversity of tools and their custom mode of use the configuration of the tool processor requires a set of complete data profile referring not only to the tools but also to the tool holder position, tool-axis or spindle correlation.
- Specific processor- used for a set of auxiliary operations.

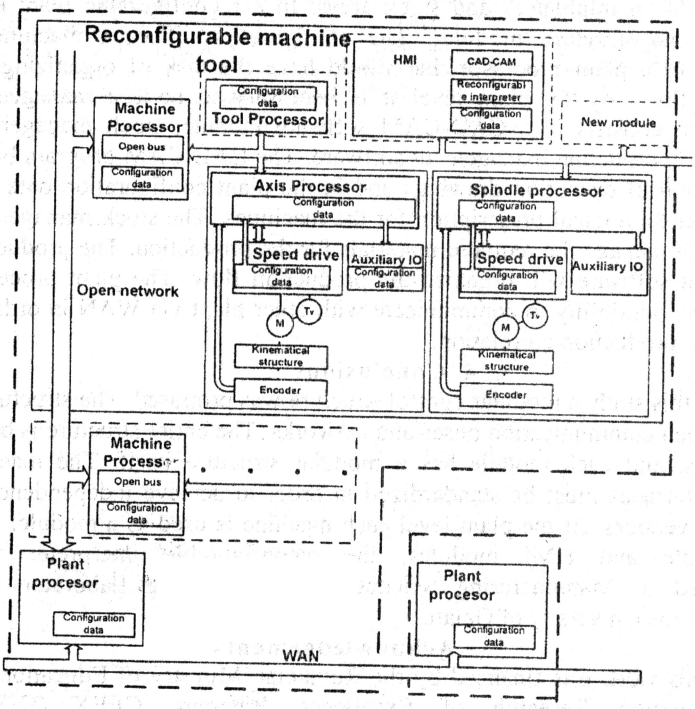


*Fig. 1.* Modular approach of the manufacturing systems

The modular structure is a challenging tasks but also a necessity. The personal computer industry had a similar task giving the diversity of computer hardware elements. The solution to this problem was to standardize a set of physical interfaces and communication mediums and to let the vendors to produce device drivers that would contain a set of configuration data. The plug and play was the answer to this problem.

The "plug and produce" is the answer to the challenging task of producing a modular machine with a scalable configuration. The standard use of resources for the "plug and produce" does not restrict the possibilities of each module. The proposed structure can be change at any time. The change of configuration would be automatically detected by machine processor that will store the altered data.

A standard software interface is a required in order to let the each module to communicate its data profile and the data referring to the operation of the module.

## 3. Production plant management

A similar approach can be used at the plant level. Each plant consists in a set of RMT, manipulators and stock areas. In a reconfigurable plant each element of its structure modular. The configuration of each machine is transmitted to a plant processor that would have the task of organizing the production flow. At the plant level it is necessary to have a management program that consists in a CAD-CAM software module, stock management software and production management software. The CAD CAM program based in a collection of execution drawings and in the plant configuration data will generate a technological prescription for the machines. The stock management software will manage the required materials for the production. The production management software will organize the production flow. The plant processor will have the possibility to communicate with other plant via WAN in order to allow a total production correlation.

## 4. Conclusions

In this study a modular control structure was proposed. The structure is based on open communication buses and networks. The entire structure is based on modules, and each module has a modular structure itself. The machine modules interfaces must be standardized in order to achieve independence of production vendors. At the plant level each machine is used as a module. The axis, spindle and HMI modules, the reconfigurable interpreter were implemented in Manufacturing Science and Engineering Laborator from Dunarea de Jos University of Galați.

## Acknowledgements

This work was financed by the Romanian Ministry of Education and Research within Research of Excellence Program: CEEX 22/2005,

*Received February 25th, 2007*

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**References**

1. Hoda ElMaraghy. *Flexible and reconfigurable manufacturing system paradigms.* International Journal of Flexible Manufacturing Systems 2006. 17:261-276
2. M. Mehrabi ,A . Ulsoy and Y. Koren. *Reconfigurable manufacturing systems: Key to future manufacturing.* Journal of Intelligent Manufacturing. Kluwer Academic Publishers 2000 0956-5515
3. Reuven Katz. *Design principles of reconfigurable machines.* International Journal of Advanced Manufacturing Technologies. 2006.
4. Feng Li Lang, James R Moyne, Dawn Tilbury. *Implementation of Networked Machine Tools in Reconfigurable Manufacturing Systems.* 2000 Japan USA. Symposium on Flexible Automation
5. Z.D. Zhou. J.M. Xie. Y.P.Chen .Development of a field-based open CNC system. International Journal of Advanced Manufacturing Technologies. 2004. 23:507-513
6. J. Zuo. Y. P. Chen1, Z. D. Zhou, A. Y. C. Nee, Y. S. Wong and Y. F. Zhang. *Building Open CNC Systems with Software IC Chips Based and Software Reuse.* International Journal of Advanced Manufacturing Technologies. 2000. 16:643–648