Vision, Principles and Impact of Reconfigurable Manufacturing System

Abhinav Singh, Pranay Kumar, Sunil Singh

Abstract: The current day manufacturing environment is characterized by numerous challenges and changes. A typical manufacturing company faces constantly changing product volumes and mix. It is commonly recognized that traditional manufacturing systems do not fit to present market competition and a shift is needed. A great amount of research efforts has been put on looking for new manufacturing systems. However, many of these newly emerging approaches lack a Unified global view of manufacturing and address only some perspectives of manufacturing. The Requirements of product design in the 21st century present an ever-increasing challenge. And this Advanced Manufacturing System popularly named and known as Reconfigurable Manufacturing System can help us face and sustain this challenge.This paper shows the definition and background of Reconfigurable Manufacturing Systems. In this paper an overview of components of reconfigurable manufacturing system and comparisons of different manufacturing system with their merits and demerits are presented. The capabilities of reconfigurable manufacturing system, challenges of reconfigurable manufacturing system and key role in reconfigurable manufacturing system are explained. The characteristic of reconfigurable manufacturing system are also presented in this paper.

Keywords- Unified Global View

I.INTRODUCTION

Manufacturing industry has an important role in economy. Research studies estimate that the total added value of these industries is about € 1.300 Billion in Europe (In 2007). Thus because of this important role of manufacturing in the economy there has been continuous developments going on in the manufacturing systems. And RMS is the latest development in the field of manufacturing systems. Modern manufacturing environment is extremely turbulent and uncertain, due to Phenomena related to market globalisation and the rapid improvements achieved in Technology. Such turbulent environment as well as the strong competition force manufacturing industries to dynamically innovate adapt and improve manufacturing systems, by reassessing their production paradigms to operate efficiently in the ever-changing environment.

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II.TYPES OF MANUFACTURING SYSTEMS

A. Dedicated Manufacturing System

A machining system designed for production of a specific part, and which uses transfer line technology with fixed tooling and automation. The economic objective of a DMS is to cost-effectively produce one specific part type at the high volumes and the required quality.

B. Flexible Manufacturing System

As the competition in the global market increased, there came the need of a better and more efficient manufacturing system. Thus, in the time of 1960's the idea of 'Flexible Manufacturing System' came up on the surface.

Flexible manufacturing systems were developed to address mid-volume, mid-variety production needs, by taking advantage of the similarities between parts in design and/or manufacture in order to achieve economy of scope. In this way, changes in work orders, production schedules, part-programs, and tooling for production of a family of parts can be addressed.

Limitations of Flexible Manufacturing System

In terms of design, FMSs possess an integral architecture (hardware/software), where the boundaries between the components and their functionalities are often difficult to identify and they are tightly linked together. Furthermore, it has fixed hardware and fixed, but programmable, software. This type of architecture does not allow changes to be made on the system structure. Therefore, FMSs have limited capabilities in terms of upgrading, add-ons and customization.

III. NEED OF A BETTER MANUFACTURING SYSTEM

Flexible Manufacturing Systems (FMSs) developed in the last two decades: (i) are *expensive*, since in many cases they include more functions than needed, (ii) utilize *inadequate system software*, since developing user-specified software is extremely expensive, (iii) are *not highly reliable*, and (iv) are subject to *obsolescence* due to advances in technology and their fixed system software/hardware. The high risk of an expensive flexible production system becoming obsolete is one of manufacturers' most troubling problems. Because advances in computers, information, processing, controls, optics, high-speed motors, linear drives, and materials sometimes occur in cycles as short as six months, today's most efficient production system can become inefficient after a short time.

The need for an increased responsiveness of manufacturing systems directed the research efforts towards the concept of re-configurability that can be defined as the ability to repeatedly change and rearrange the components or a system in a cost-effective way. A manufacturing system must be able to dynamically change its configurations (for this reason the term "reconfiguration" is employed), in terms of its own structure as well as functional principles.

IV. RECONFIGURABLE MANUFACTURING SYSTEM

The concept of RMS was developed by Prof. Yoram Koren in the year 1999. This new type of manufacturing system, which we call *the reconfigurable manufacturing system*, allows flexibility not only in producing a variety of parts, but also in changing the system itself. Such a system will be created using basic process modules —hardware and software — that will be rearranged quickly and reliably. These systems will not run the risk of becoming obsolete, because they will enable the rapid changing of system components and the rapid addition of application-specific software modules. This system will be open-ended, so that it can: (i) be continuously improved by integrating new technology, and (ii) be rapidly reconfigured to accommodate future products and changes in product demand rather than scrapped and replaced.
System re-configurability can be classified in terms of the levels where the reconfigurable actions are taken. Re-configurability at lower levels is mainly achieved by changing hardware resources, and re-configurability at the higher levels is mainly achieved by changing software resources and/or by choosing alternatives methods or organization structures by flexible people.

	Fixed Hardware	Reconfigurable Hardware
No Software	Manual Machines, Dedicated Manufacturing Lines	Convertible Transfer Line
Fixed Software	CNC, Robot, FMS	Modular CNC Machines
Reconfigurable Software	Modular Open-Architecture Controller	R M S

Comparison of the three types of system

A. Characteristics of RMS

[1] Modularity: Design all system components, both software and hardware, to be Modular. (I.e. independent)
[2] Integrability: Design systems and components for both ready integration and Future introduction of new technology.
[3] Customization: Design the system capability and flexibility (hardware and controls) to match the application (product family).
[4] Diagnosability: Identify quickly the sources of quality and reliability problems that occur in large systems
[5] Scalability: Changing the production capacity of reconfigurable components (e.g. machines) within that system.
[6] Convertibility: Allow quick changeover between existing products and quick system adaptability for future products.

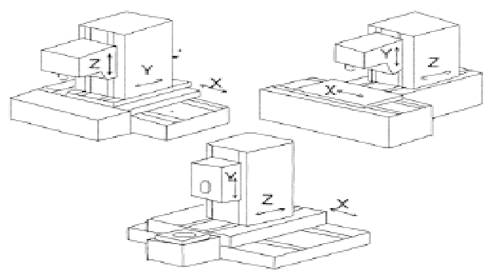
B. Principles of Reconfigurable Manufacturing System

[1] The RMS is designed for adjustable production resources to respond to imminent needs. * The RMS capacity is rapidly scalable in small, optimal increments. * The RMS functionality is rapidly adaptable to the production of new products.
[2] To enhance the speed of responsiveness of a manufacturing system, core RMS characteristics should be embedded in the whole system as well as in its components (mechanical, communications and controls).
[3] The RMS is designed around a part family, with just enough customized flexibility needed to produce all parts in that family.
[4] The RMS contains an economic equipment mix of flexible (e.g., CNC) and reconfigurable machines with customized flexibility, such as Reconfigurable Machine Tools, Reconfigurable Inspection Machines, and Reconfigurable Assembly Machines.
[5] The RMS possesses hardware and software capabilities to cost-effectively respond to unpredictable events — both external (market changes) and intrinsic events (machine failure).

C. Application of Reconfigurable Manufacturing System

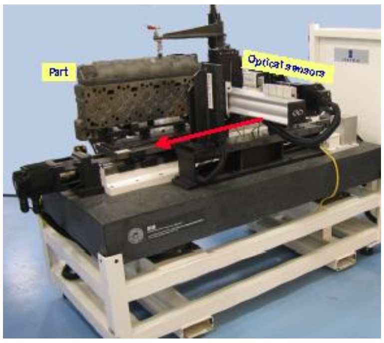
[1] Reconfigurable Machine Tools:

The object of this invention are accomplished by providing a reconfigurable machine tool that has multiple support units that are support the desired tools, each of which is easily reconfigurable so that the machine tool is capable of performing a variety of machining process on a family of parts.
It provides for a machine tool assembly that includes a base, a table, at least one support unit and at least one spindle unit. The base has several slots or holes positioned in a generally circular orientation around the table, which is positioned approximately at the center of the base and may be movable in the horizontally or vertically, or may be tilted or angled so that it is non-parallel with a base. A part is secured to the table to hold it stationary as it is processed.
The machining spindles are mounted to the support unit and may be positioned at any location along each support unit. Each support unit is mounted to the base of the tool assembly through one or more of the slots or holes located about the base, and are easily and accurately movable by mounting the support unit to the base through a different set of slots and holes. This allows for customized flexibility and easy reconfiguration of the machine tool, thereby accomplishing a greater number of orientations for the axis of motion for each spindle unit. Each spindle unit can also be quickly and easily removed and replaced convert the machine to perform various type of machining operations, such as drilling, milling, turning, and grinding.



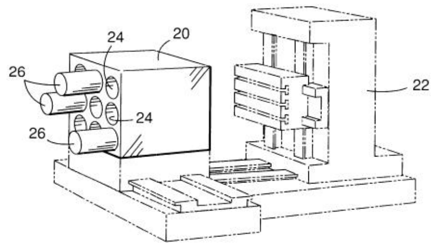
The re-configurable machine tools

[2] *Reconfigurable Inspection Machine*:



Used mainly for in-line surface porosity inspection of engine blocks that was integrated into production line. The system utilizes this specially designed vision system to acquire high-resolution images of the block surface, which are then analyzed to detect, locate, and measure pores (small pits < 1mm that are on the surface; resulted in by the casting). This technology is very important to engine manufacturers because of the difficulty in objectively measuring the sizes and location of irregularly shaped surface pores, and doing it at production line rates (20 seconds). In 2006 General Motors installed the in-line surface porosity inspection system at its engine plant in Flint, Michigan. The inspection system was integrated into the production line, and a conveyor moves all engine blocks through this inspection station. Namely, every engine block is measured within 15-20 seconds. By using this technology GM prevents defective parts from reaching the customers.

[3]Reconfigurable Power Spindle:



The re-configurable power spindle

A reconfigurable multi-spindle apparatus for use with a machining device in a plurality of configurations across part families. In one embodiment, the reconfigurable multi-spindle apparatus may include at least two spindle head modules, a mechanism for transmitting power between the spindle head modules, and a mechanism for reconfigurable connecting the spindle head modules such that the multi-spindle apparatus is reconfigured from a first configuration to a second configuration across part families. An embodiment of a spindle head module may include two tool holders and a mechanism for adjusting the distance between the tool holders such that the multi-spindle apparatus is reconfigured within a part family

V.CONCLUSION

There are many research efforts underway, however we are still at the beginning of a new era of modern manufacturing systems and there are many barriers to their advancement. Advances in manufacturing will not occur without the proper machine tools and equipment. Machine tools are undergoing some fundamental changes in terms of their structure (modular structure) and components (controllers, hardware/software, spindles, tooling, sensors, etc.); therefore new theories, design concepts and methodologies should be developed for these purposes. These changes are fundamental to the success of future reconfigurable manufacturing systems (RMSs)

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