Reconfigurable Manufacturing Systems: Key to World-Class Manufacturer Status for Indian Organisations, An overview

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ABSTRACT

In this dynamic world only one thing is constant – Change. Change has also become a constant in today's manufacturing environment. While change is inevitable, it is important to take advantage of it and make it happen efficiently through good designs and by developing effective change enablers. Present world is changing giving a unstable business environment. The performance of the manufacturing system is largely dependent on the ability to be agile as well as being changeable. A Reconfigurable Manufacturing System (RMS) is designed for rapid adjustment of production capacity and functionality in response to new market conditions and new process technology. Reconfigurable manufacturing system promises customized flexibility in a short time. With growing global competition and the demanding nature of the customer it is very vital for Indian Companies/organizations to respond quickly and cost effectively to be there and to take the lead among the competitors. This requires a changeable structure of the organization to cater to a wide product variety. This can be attained through adoption of the concept of RMS, which comprises of reconfigurable machines, controllers and the software support systems. RMS technologies will provide Indian manufacturers exactly the production capabilities needed, exactly on time when needed to compete with global players.

This research paper is a descriptive attempt to define and discuss concept of RMS. Also strategic importance of RMS in obtaining the global competitiveness and World-Class Manufacturer status for Indian organizations is discussed.

***Keywords**:* Reconfigurable Manufacturing System, customized flexibility, Indian Manufacturers, global competition.

INTRODUCTION

In this dynamic world only one thing is constant – Change. Change has also become a constant in today's manufacturing environment. While change is inevitable, it is important to take advantage of it and make it happen efficiently through good designs and by developing

effective change enablers. Present world is changing giving a unstable business environment. The performance of the manufacturing system is largely dependent on the ability to be agile as well as being changeable. A Reconfigurable Manufacturing System (RMS) is designed for rapid adjustment of production capacity and functionality in response to new market conditions and new process technology.

RMS – The Concept

A reconfigurable manufacturing system (RMS) is one designed at the outset for rapid change in its structure, as well as its hardware and software components, in order to quickly adjust its production capacity and functionality within a part family in response to sudden market changes or intrinsic system change.

RMS may be defined as the machine system which can be created by incorporating basic process modules both hardware and software that can be arranged or replaced quickly and reliably.

The RMS as well as one of its components – the Reconfigurable Machine Tool (RMT) were invented in 1999 in the Engineering Research Center for Reconfigurable Manufacturing Systems (ERC/RMS) at the University of Michigan College of Engineering. The RMS goal is summarized by the statement – Exactly the capacity and functionality needed, exactly when needed.

RMS is an open-ended system, which allows –

1. Continuous improvement by integrating new technology,
2. Ability to be rapidly reconfigured to accommodate future products and changes in product demand rather than scrapped and replaced.

Components of reconfigurable manufacturing system

The reconfigurable manufacturing systems have following important components

1. **Reconfigurable machine tool**: - A major component of RMS is the reconfigurable machine tools (RMT). RMT are designed for specific customized range of operation requirement and may be cost effectively converted when the requirements change. Reconfigurable machine tools that are designed to produce specific set of features for specific range of cycle time. Some operation requirement will be constant over the life time of the machining system.

The primary aim of the reconfigurable machine tool is to cope with various changes in the products or parts to be manufactured. The following possible changes must be taken in to consideration.

- Work piece size
- Part geometry and complexity
- Production volume and production rates
- Required processes
- Accuracy requirement in terms of geometrical

- accuracy, surface quality
- Material property such as kind of material,
- Hardness etc.

2. Reconfigurable Controller: - To control a particular machine, any machine specific functions or classes currently must be designed and built into a Reconfigurable Controller. The Reconfigurable controller becomes unchangeable at run-time for controlling different machines.

3. Reconfigurable Inspection Machines

4. Material transport systems (such as gantries and conveyors) that connect the machines to form the system.

Different arrangements and configurations of these machines will have an impact on the system productivity. A collection of mathematical tools, which are defined as the RMS Science Base, may be utilized to maximize system productivity with the smallest possible number of machines.

Characteristics of ideal RMS:-

Ideal Reconfigurable Manufacturing Systems possess six core RMS characteristics:

1) **Modularity**:- The compartmentalization of production functions and requirements into operational units that can be manipulated between alternate production schemes to achieve the optimal arrangement to fit a given set of needs. In a reconfigurable manufacturing system, many components are typically modular (e.g., machines, axes of motion, controls, and tooling
2) **Integrability**:- the ability to integrate modules rapidly and precisely by a set of mechanical, informational, and control interfaces that enable integration and communication. At the machine level, axes of motions and spindles can be integrated to form machines.
3) **Customized flexibility**:- to design system/machine flexibility just around a product family, obtaining thereby customized-flexibility, as opposed to the general flexibility of FMS/CNC. This characteristic drastically distinguishes RMS from flexible manufacturing systems (FMS), and allows a reduction in investment cost.
4) **Scalability**:- the ability to easily change production capacity by rearranging an existing manufacturing system and/or changing the production capacity of reconfigurable stations. Scalability is the counterpart characteristic of convertibility.

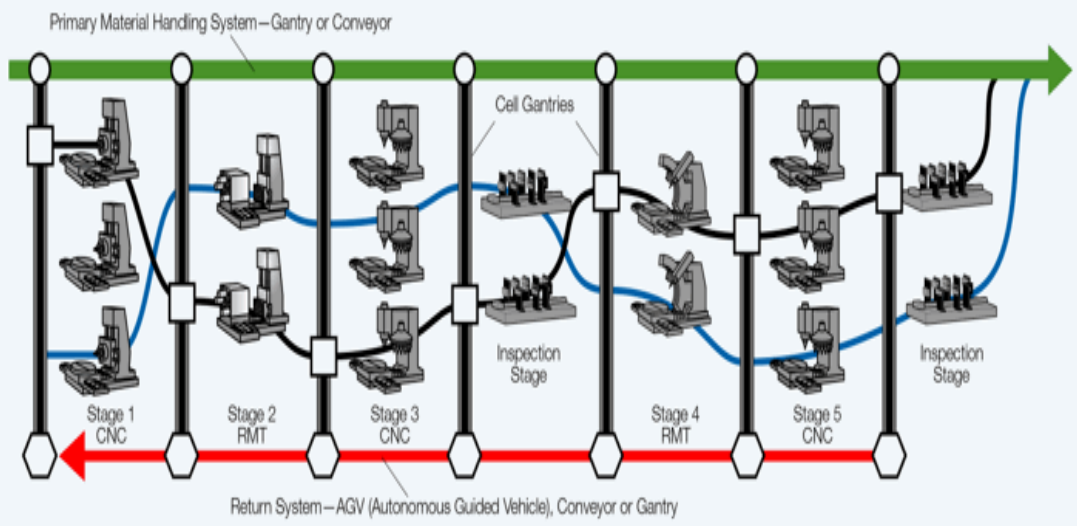


Figure 1 Reconfigurable Manufacturing System

5) **Convertibility**: - the ability to easily transform the functionality of existing systems, machines, and controls to suit new production requirements. System convertibility may have several levels.

6) **Diagnosability**: - the ability to automatically read the current state of a system for detecting and diagnosing the root-cause of output product defects and subsequently correct operational defects quickly.

A typical RMS will have several of these characteristics, though not necessarily all. When possessing these characteristics, RMS increases the speed of responsiveness of manufacturing systems to unpredicted events, such as sudden market demand changes or unexpected machine failures.

The RMS facilitates a quick production launch of new products, and allows for adjustment of production quantities that might unexpectedly vary. The ideal reconfigurable system provides exactly the functionality and production capacity needed, and can be economically adjusted exactly when needed. These systems are designed and operated according to Koren's RMS Principles.

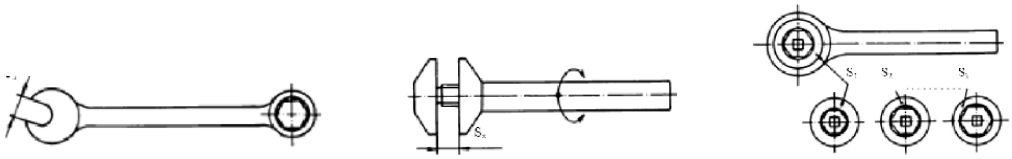
Comparison of RMS with older manufacturing systems

The table given below describes in depth how RMS is superior to previous manufacturing techniques. The Economic objectives of various systems are also mentioned in the table.

Table 1. Summary of Manufacturing Methods

SYSTEMS	DEFINITIONS	OBJECTIVES
Machining System	One or more metal removal machine tools and tooling, and auxiliary equipment (e.g., material handling, control, communications), that operate in a coordinated manner to produce parts at the required volumes and quality.	To produce jobs as per requirement.
Dedicated Machining Systems	A machining system designed for production of a specific part, and which uses transfer line technology with fixed tooling and automation.	To cost-effectively produce one specific part type at the high volumes and the required quality.
Flexible Manufacturing System	A machining system configuration with fixed hardware and fixed, but programmable, software to handle changes in work orders, production schedules, part-programs, and tooling for several types of parts.	The economic objective of a FMS is to make possible the cost-effective manufacture of several types of parts that can change overtime, with shortened changeover time on the same system at the required volume and quality.
Reconfigurable Manufacturing Systems	A machining system which can be created by incorporating basic process modules — both hardware and software — that can be rearranged or replaced quickly and reliably. Reconfiguration will allow adding, removing, or modifying specific process capabilities, controls, software, or machine structure to adjust production capacity in response to changing market demands or technologies. This type of system will provide customized flexibility for a particular part family, and will be open-ended, so that it can be improved, upgraded, and reconfigured, rather than replaced.	The objective of an RMS is to provide the functionality and capacity that is needed, when it is needed. Thus, a given RMS configuration can be dedicated or flexible, or in between, and can change as needed. An RMS goes beyond the economic objectives of FMS by permitting: (1) reduction of lead time for launching new systems and reconfiguring existing systems, and (2) the rapid manufacturing modification and quick integration of new technology and/or new functions into existing systems.

The following figure is a simple example explaining the evolution of one tool used in assembling operation from Dedicated Manufacturing system to Reconfigurable Manufacturing System.



a) b) c)

Figure 2. Evolution steps in case of a tool used in assembling operations.
a – Dedicated; b – Flexible; c – Reconfigurable.

RMS Principles

Reconfigurable manufacturing systems operate according to a set of basic principles formulated by professor Yoram Koren and are called Koren's RMS principles. The more of these principles applicable to a given manufacturing system, the more reconfigurable is that system. The RMS principles are:

1. The RMS is designed for adjustable production resources to respond to imminent needs.
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
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).

CONCLUSION

According to a futurist report of Manufacturing Challenges 2020 conducted in the USA, one of the six grand challenges is the ability to reconfigure manufacturing enterprises rapidly in response to changing needs and opportunities. The concept of reconfiguration has sparked interest in the academic and industrial communities.

In this paper, I have tried to introduce the concept of reconfigurable manufacturing systems (RMS), the Components of reconfigurable manufacturing system, capabilities of reconfigurable manufacturing system, , Characteristics of Reconfigurable Manufacturing Systems. The reconfigurable manufacturing systems approach proposed in this paper indicates an effort towards comprehensively addressing manufacturing under a global umbrella of reconfigurability.

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