RESEARCH PAPER

NEED OF RECONFIGURABLE MANUFACTURING SYSTEMS FOR THE MODERN MANUFACTURING INDUSTRIES

[1]Devendra Kumar Singh* and [2]S.C. Jayswal
[1]Research Scholar, [2]Head of Department, [1,2]Department of Mechanical Engineering, MMMUT, Gorakhpur, Uttar Pradesh, INDIA.
*Corresponding Author's Email ID: devmjpru010@gmail.com

ABSTRACT

RMS permit alterable functionality and scalable capability (Koren, 2006) by physically innovate the components of the system through adding, removal or alter machine modules, machining cells, material handling devices and/or whole lines. Hence, RMS corresponds to innovate by proffering centered flexibility on demand by physically reconfiguring the manufacturing system. Hardware reconfiguration also direct greater shift in the software utility to direct individual machines, entire cells, & systems as well as to project and to control distinctive processes and overall production. Thus to combat with every day market requisition RMS works as an essential tool to compensate consumer demand within minimum period and economy.

Keywords: RMS, FMS, Convertibility, Customization, Agility, Modularity.

1. INTRODUCTION

These days, CNC machine tool systems with high flexibility and versatility to deal with dynamic changes in production volume and part variation are demanded. Traditional dedicated production lines, like flexible transfer lines, cannot efficiently adapt to the nature of changing parts and fluctuating lot sizes. Manufacturing systems with variable machine tool centers & turning centers are gradually replacing dedicated systems for medium lot size type of production. This requires the production system's basic element, the machine tool, to exhibit high speed, precision, and to be reconfigurable, compatible, and convertible to create economic benefits for the customers.

Technological breakthroughs and the need for expanded functionality in reduced package sizes are trending towards greater complexity of designed parts. In a multi-machine production line, this complexity is best addressed by dividing production into a series of interchangeable machining units of differing configurations, such as a CNC horizontal machining spindle-based or a vertical machining spindle-based machine, and a turning machine. Rather than achieve finished product status by multiple or manual setup on one or a few machines, each is assigned to a unique module. Addition of modules increases the available complexity of the part without sacrificing cycle time bringing about a productively improved line framework [1][2].

Moreover, frequent work piece plan modifications and generation part estimate changes require retooling or re-modularizing the creation line. Machining focus units must be equipped for insertion and substitution anyplace in the generation line. This permits more noteworthy usage of processing plant assets. Basically, this suggests distinctive machine sorts must have the capacity to supplant others of various arrangements without aggravating the line. In this way, machines must be planned around a typical stage while keeping up inconceivably distinctive machining capacities. Making the interchange uncomplicated and straightforward it allows maximum productivity amid work piece design and lot size.

Change has turned into a steady in today's assembling surroundings. While change is unavoidable, it is imperative to exploit it and get it developing so as to go proficiently through great outlines and compelling change empowering agents. Globalization, flighty markets, expanded items customization and the mission for upper hands are yet a couple of the numerous difficulties confronting producing endeavors now and later on.

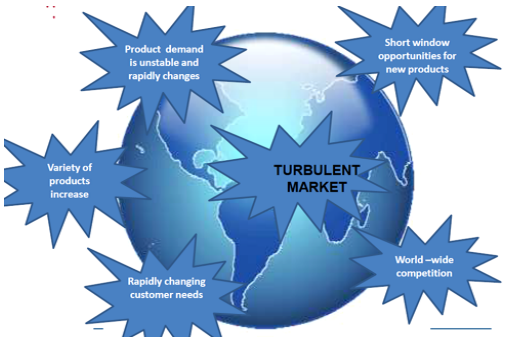


Fig. 1: Shows Market Turbulence

Variability is characterized as the qualities to economically achieve early and foresighted modification of the plant's structures and procedures on all levels, in light of progress motivations. A few assembling frameworks ideal models have risen as a consequence of these progressions including agile, versatile, adaptable

and reconfigurable assembling. The capacity to adapt to change is the shared factor among every one of these standards, each of which exhibits an arrangement of innovative answers for empower changes to happen effectively and gainfully. Flexible manufacturing for instance changes the framework conduct without changing its setup, while reconfigurable manufacturing would change the system behavior by changing its configuration.

"The only thing we know about the future is that it will be different." - Peter drucker (1909–2005)

Different types of manufacturing systems Models have appeared as a result over the years in view of these drivers and against a back drop of volatility in market demands, changing client's preferences and requirement for more items separation and customization. Furthermore, worldwide and distributed supply chains and pressures from the labor issues, also competition due to developing countries and currency fluctuations increase the pressure. Recently introduced manufacturing models, such as Flexible & Reconfigurable manufacturing system, are responding to these needs in various ways. They can be viewed as enablers of change and transformation at different levels. They can be seen as empowering agents of progress and change at various levels.

Flexible manufacturing: FMS permits changing individual operations, forms, parts steering and generation plans. This compares to varieties in items inside of a pre-characterized extent of a part family. Also apart from these it also allows changing generation limit inside of the points of confinement of the current framework. Thus, FMS offers generalized flexibility that is inherent a convent and permits changes and adjustment of procedures and creation volumes, inside of the pre-characterized limits, without physically changing the assembling framework itself.

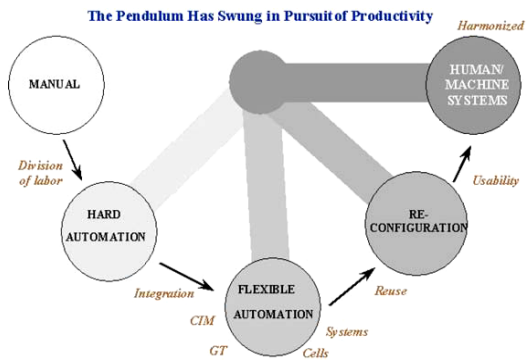


Fig. 2: Role of Humans and Automation in the Evolution of Manufacturing Systems

Reconfigurable manufacturing: RMS allows alterable functionality and scalable capability (Koren, 2006) by physically innovate the components of the system through adding, removal or alter machine modules, machining cells, material handling devices and/or whole lines. Hence, RMS corresponds to innovate by proffering centered flexibility on demand by physically reconfiguring the manufacturing system. Hardware reconfiguration also direct greater shift in the software utility to direct individual machines, entire cells, & systems as well as to project and to control distinctive processes and overall production. Thus to combat with every day market requisition RMS works as an essential tool to compensate consumer demand within minimum period and economy.

2. RMS AND FMS

Flexible Manufacturing Units and Reconfigurable Manufacturing Units have distinctive objectives. FMS goes for expanding the assortment of parts produced. RMS goes for expanding the pace of responsiveness to business sectors and clients. RMS is likewise adaptable, yet just to a constrained degree — its adaptability is limited to just that important to create a part family, which shows RMS have "customized flexibility", which is not the general adaptability that FMS offers. The benefits of customized flexibility are speedier throughput and higher generation rates. Other imperative preferences of RMS are fast adaptability to the wanted volume and convertibility, which are gotten inside sensible expense to makers. The best utilization of a FMS is found underway of little arrangements of items; With RMS, notwithstanding, creation volume might fluctuate from little to huge.

3. DIFFERENT TYPES OF MANUFACTURING SYSTEMS ALONG WITH DEFINITIONS AND OBJECTIVES

The manufacturing frameworks utilized for this new approach must be quickly outlined, ready to change over rapidly to the creation of new models, ready to conform limit rapidly, and ready to coordinate innovation and to deliver an expanded assortment of items in erratic amounts.

Table 1 compresses the significant manufacturing ideal models and their definitions and Fig. 3 demonstrates their monetary goals. Large scale manufacturing frameworks were centered around the decrease of item cost. Incline fabricating places accentuation on consistent change in item quality while diminishing item costs. Adaptable assembling frameworks make conceivable the production of an assortment of items (adaptability) on the same framework. While this is an essential target, these frameworks have met with constrained achievement.

For example, Flexible manufacturing systems (FMSs) created in the most recent two decades: (i) are costly, since by and large they incorporate a bigger number of capacities than required, (ii) use insufficient framework programming, since creating client determined programming is to a great degree costly, (iii) are not exceptionally dependable, and (iv) are liable to outdated nature because of advances in innovation and their settled framework programming/equipment.

The high danger of a costly adaptable creation framework getting to be out of date is one of producers' most disturbing issues. Since advances in PCs, data, preparing, controls, optics, fast engines, direct drives, and materials infrequently happen in cycles as short as six months, today's most proficient generation framework can get to be wasteful a little while later. Moreover, the present client driven market and expanded consciousness of natural issues lead to the ever-faster presentation of new items. Yet, adjustment of existing production frameworks to new items is moderate and the starting of new frameworks can take long time. (up to 2 years.)

To Address These Limitations, Future Manufacturing Systems Technology Must Meet The Following Objectives, Which Go Beyond The Objectives Of Mass, Lean, And Flexible Manufacturing:

- Reduction of lead time (including ramp-up time) for launching new manufacturing systems and reconfiguring existing systems.
- The rapid upgrading and quick integration of new process technology and new functionality into existing systems.

Table 1: Summary of Definitions and Objectives

Systems (Machining/manufacturing)	Definitions and 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.
Dedicated machining systems	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.
Flexible manufacturing systems	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 strut. 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.

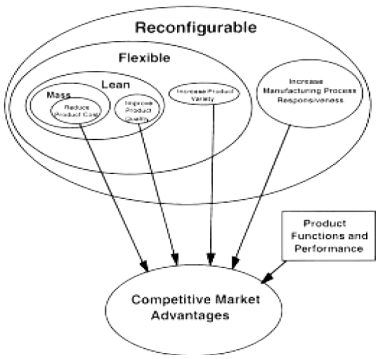


Fig. 3: Economic Goals for various Manufacturing Paradigms

4. RMS PRINCIPLES

Reconfigurable manufacturing frameworks work as indicated by an arrangement of essential standards figured by researcher Yoram Koren and are called Koren's RMS standards. The more of these standards are relevant to a given manufacturing framework, the more reconfigurable is that framework. The RMS standards are:

- The RMS is intended for adjustable production resources to react to approaching needs. The RMS limit is quickly versatile in little, optimal additions.
- The RMS usefulness is quickly versatile to the creation of new items.
- To improve the pace of responsiveness of a production framework, center RMS attributes are inserted in the entire framework and also in its parts (mechanical, communication as well as controls).
- The RMS is planned about a part family, having simply enough with customized flexibility expected to create all parts in that crew.
- The RMS contains a financial gear blend of adaptable (ex. CNC) and reconfigurable machines units with customized flexibility, for example, Reconfigurable Machine centers, Reconfigurable Inspection tools , and Reconfigurable Assembly units
- RMS has equipment and programming abilities to cost-adequately react to erratic occasions — both outside (market sector changes) and inborn occasions (machine failure).

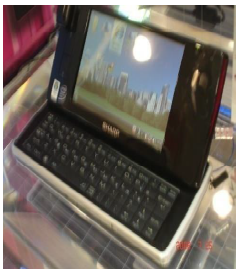
5. FUNCTIONS OF RMS

RMS in contrast with traditional manufacturing frameworks has some unique kind capacities as follows:

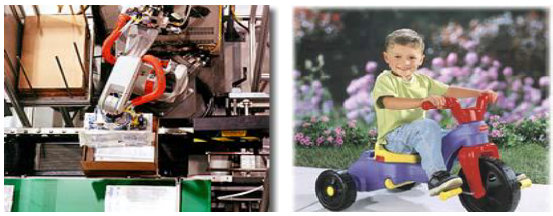
- The product of procedure arranging and control with more agile reconfiguration, appropriating open-architecture based independence.
- The format of assembling framework are reconfigured quickly as per procedure making arrangements for changed item and aggregated new modules which offers advanced technology.
- Scale size of creation is broadened agile and consistent.
- The qualities of RMS can be represented by terms convertibility, customization, modularity, agility, integrability, diagnosability, rapid generation versatility and economic affordability. So RMS is a smart type of manufacturing units and can be defined as “RMS is a convertible manufacturing system can respond rapidly to the market demand and according to design plan by the aid of rearrangement, reuse and reengineering of cells and subsystems to realize the system functionality and capacity with low reconfiguring cost.

6. EXAMPLES OF RECONFIGURABLE PRODUCTS

Toy House



Cell phone-TV-Camera- laptop



Gripper for Packing Rock Roll & Ride

Fig. 4: Examples of Reconfigurable Products

7. RMS CORE CHARACTERISTICS

Ideal Reconfigurable Manufacturing Systems possess six core characteristics: Modularity, Integrability, Customized flexibility, Scalability, Convertibility, and Diagnosability. These characteristics, which were introduced by Professor Yoram Koren in 1995, apply to the design of whole manufacturing systems, as well as to some of its components – reconfigurable machines, their controllers, and also to the system control software[4].

Modularity: The compartmentalization of generation capacities and necessities into operational units that can be controlled between exchange creation plans to accomplish the ideal course of action to fit a given arrangement of requirements. In a reconfigurable assembling framework, numerous segments are regularly measured (e.g., machines, tomahawks of movement, controls, and tooling). Whenever fundamental, the needed segments can be implemented or moved up to suit better new advanced applications. Modules are less demanding to keep up and upgrade, in this manner bringing down life-cycle expenses of frameworks. New alignment calculations can be promptly coordinated into the machine controller, bringing about a framework with more noteworthy exactness. For instance, incorporating cross-coupling control [9] within CNC controllers significantly improves its precision.

The essential inquiries when outlining with the secluded methodology are: (a) what are the proper building pieces or modules, and (b) how should they be connected to synthesize a functioning whole? Determination of essential modules and the way they are associated take into account the production of frameworks that can be effortlessly incorporated, analyzed, modified, and changed over.

Reconfigurable Machine device with a modular structure, containing axle modules that can be reconfigured to permit diverse machining operations.

Integrability: The capacity to incorporate modules quickly and correctly by an arrangement of mechanical, instructive, and control interfaces that empower coordination and correspondence. At the machine level, axis of motion and shafts can be coordinated to frame machines. Combination rules permit machine planners to relate bunches of part elements and their comparing machining operations to machine modules, in this manner empowering product process reconciliation. At the

framework level the machines are the modules that are coordinated by means of material transport frameworks, (for example, transports and gantries) to shape a reconfigurable framework. To help in outlining reconfigurable frameworks, framework setup principles are used. Also, machine controllers can be intended for coordination into a production line control framework.

Customization: To outline framework/machine adaptability just around a part family, getting in this way customized-flexibility, instead of the general adaptability of FMS/CNC. This characteristic definitely recognizes RMS from flexible manufacturing systems (FMS), and permits a reduction in investment cost. It empowers the outline of a framework for the generation of a part family, rather than single part (as produced by DML) or any part (common FMS). "Part family" implies, for instance, a few sorts of motor pieces or a few sorts of microchips, or a wide range of Boeing 747. In the connection of RMS, a part family is characterized as all parts (or items) that have comparative geometric components and shapes, the same level of tolerances, require the same procedures, and are inside of the same scope of expense. The definition of the part family should guarantee that most manufacturing framework assets are used for the generation of each part. The RMS design must be altered to fit the predominant components of the entire part family by using the normal for Customized flexibility. Customized flexibility for the part family permits the usage of different instruments (e.g., axles in machining or nozzles in injection moldings) on the same machine, in this manner expanding profitability at decreased expense without compromising adaptability & flexibility.

Convertibility: The capacity to effectively change the usefulness of existing frameworks, machines and controls to made suitable to new generation necessities. Framework convertibility might have a few levels. Transformation might require exchanging axles on a processing machine (e.g. from low-torque fast shaft madeup of aluminum to high-torque low-speed axle for titanium), or manual alteration of inactive degrees-of-flexibility changes when exchanging generation between two individuals from the part family inside of a given day. Framework transformation this daily level must be carried out quickly to be effective. To accomplish this, the RMS must use not just ordinary techniques, for example, such as off-line setting, however in addition it contain advanced components that take into account simple transformation between parts, and detecting and control strategies that empower quick alignment of the machines after conversion.

Scalability: The capacity to effectively change production limit by improving a current assembling framework and changing the production limit of a reconfigurable unit. Scalability is counterpart for convertibility. Scalability might be required at the machine level such as adding spindles to a machine to increase its productivity & efficiency and at system framework level by changing parts routing and adding machines to expand overall system capabilities and capacity (i.e., maximum volume) as the demand for the product grows in the market.

Diagnosability: The capacity to consequently read the present condition of a framework for distinguishing and diagnosing the underlying driver of output products flaws and defects, and in this way rectify operational defects rapidly.

Diagnosability has two viewpoints: identifying machine disappointment and recognizing unstable part quality. The second aspects are critical in RMS. As generation frameworks are made more and more reconfigurable and their formats are changed all the more every now and again, it gets to be vital to quickly tune (or increase) the recently reconfigured framework with the goal that it produces quality parts. Hence, reconfigurable frameworks should likewise be outlined with item quality estimation frameworks as an essential part. For instance, a Reconfigurable Inspection Machine (RIM) inserted in the RMS empowers speedy identification. These estimation frameworks are expected to distinguish the wellsprings of item quality issues in the generation framework quickly, so they can be amended using control strategies, measurements, and signal preparing procedures.

8. INCREASED FLEXIBILITY AND PRODUCTIVITY OF MANUFACTURING SYSTEMS

"I do not know whether it becomes better if it changes. But it must change if it should become better."

German Philosopher,
Georg Christoph Lichtenberg (1742–1799)

To expand the adaptability of machining stations diverse methodologies are taken under thought. A secluded idea for masterminding the mechanical segments, consolidated with particular control innovation, makes extremely adaptable machining stations. These stations are versatile to various client prerequisites and backing additionally resulting changes in the item range. For the arrangement and re-setup process and to discover the perfect modules for the client particular requests a ""Computer Aided Configuration (CAC)" apparatus is a work in progress. In this product a tenet based master framework investigations all accessible data about the item range and the current assembling environment to discover the best creation arrangement and the required assembling forms. In view of this data the master framework begins to arrange the selecting so as to machine stations and the entire assembling framework every required module. All properties of the last arrangement are computed after a programmed virtual get together of the assembling framework in a computerized mock-up framework. The material stream, the creation forms, and the control framework can be reenacted to test the static and element practices of the new assembling framework. The instrument is likewise ready to bolster the reconfiguration procedure of officially existing particular assembling frameworks when an adjustment in the item range makes an adjustment of the framework important. To build the efficiency of an entire assembling framework rapid

machining components are being worked on. This incorporates new cutting materials and additionally the improvement of new rapid shafts, guide ways, and pivot.

An expanded adaptability and efficiency of the assembling framework is additionally bolstered through the improvement of a smart shop floor control. This decentralized PC-based shop floor control will have the capacity to cleverly deal with the stream of work pieces and devices for ideal utilization of the generation assets.

9. COMPARISON OF SYSTEM FEATURES (DEDICATED VS. RMS VS. FMS)

Table 2: To Show Advantage of RMS on Different Manufacturing System

	Dedicated	RMS/RMT	FMS/CNC
System Structure	Fixed	Adjustable	Adjustable
Machine Structure	Fixed	Adjustable	Fixed
System focus	Part	Part Family	Machine
Scalability	No	Yes	Yes
Flexibility	No	Customized	General
Simultaneously Operating Tool	Yes	Yes	No
Productivity	High	High	Low
Lifetime Cost	Low for a single part, when fully utilized	Medium or production at me lium-to-high volume new parts and vari-able demand during system lifetime	Reasonable for simultaneous pro-duction of many parts (at low volume); otherwise – High

10. LIMITATIONS OF RMS

- Can take control over the product mix just in admiration to level of opportunity of machine.
- Good assessment is required to safeguard smooth stream of work.
- Complications increments because of more secluded nature of machines.
- Proper study and research work must be done before use of RMS for any sort of mechanical setup.
- Result in more exceptional condition by making more unemployment.

11. CONCLUSION

Worldwide economic competition and quick social and innovative changes have constrained producers to confront towards another financial goal: producing responsiveness (i.e., adjustment of the assembling framework to economic situations). To react to these difficulties another sort of assembling framework, a Reconfigurable Manufacturing System, is required. RMSs are very not quite the same as the present assembling innovations (i.e., committed assembling lines and adaptable assembling frameworks) in that they are planned at the start with movable assets keeping in mind the end goal to give precisely the limit and usefulness that are required, precisely when required.

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