

Reconfigurable Manufacturing Systems

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Abstract— In 21st century, many manufacturing companies can face high frequency market change due to the global competition. The systems which are cost-effective and very responsive to all the market changes should be accepted by the manufacturing companies to stay in the competition. An engineering technology called Configurability, which is cost effective and has a quick response to the market change should be used by the companies. Reconfigurable manufacturing systems (RMS), whose components are reconfigurable machines and reconfigurable controllers, as well as methodologies for their systematic design and rapid ramp-up, are the cornerstones of this new manufacturing paradigm.

Keywords— *Reconfiguration, Manufacturing system, Machine tools, Machine design, Ramp-up time reduction.*

I. INTRODUCTION

The unpredictable market change increases the need of Reconfigurable Manufacturing Systems (RMS). These changes include:-

- Introduction of new products.
- Modifications required in the existing product.
- Variations in the product, and requirement of consumers.
- Rules and regulations imposed by the government.
- Changes in production technology.

These changes are caused by the increase in the global competition, educated customers and the change in the production technology. These drivers reflect a new balance among economy, technology and society. The companies should have a quick response to these changes, to survive in the market.

The new technology of Computer Aided Design (CAD) has reduced the time required for the product design to large extent. This helps the manufacturing companies to develop their product as quickly as possible with minimum investment.

If the lead-time of the manufacturing systems is reduced, it can achieve a major economic savings. A rapid design of systems which are created from modular components, or by the reconfiguration of an existing design of the system can reduce the lead-time. Through reconfiguration, new functions should be added to the manufacturing systems in order to produce new products and accommodate required changes in existing products. To accommodate government regulations and integrating new process technology (such as new sensors, more reliable machine elements, etc.), such types of reconfiguration is needed. During the lifetime of the system, many reconfiguration periods will occur. Short ramp-up (RU) becomes critical to successful reconfiguration. When there is large fluctuation in the product demand caused by the market conditions, a different type of the reconfiguration is needed. A rapid change in the system production capacity is required by such type of reconfiguration. In summary, a responsive system whose production capacity is adjustable to fluctuations in product demand, and whose functionality is adaptable to new products, is needed. Current manufacturing systems are not able to meet these requirements dictated by the new, competitive environment and integrating new process technology (such as new sensors, more reliable machine elements, etc.

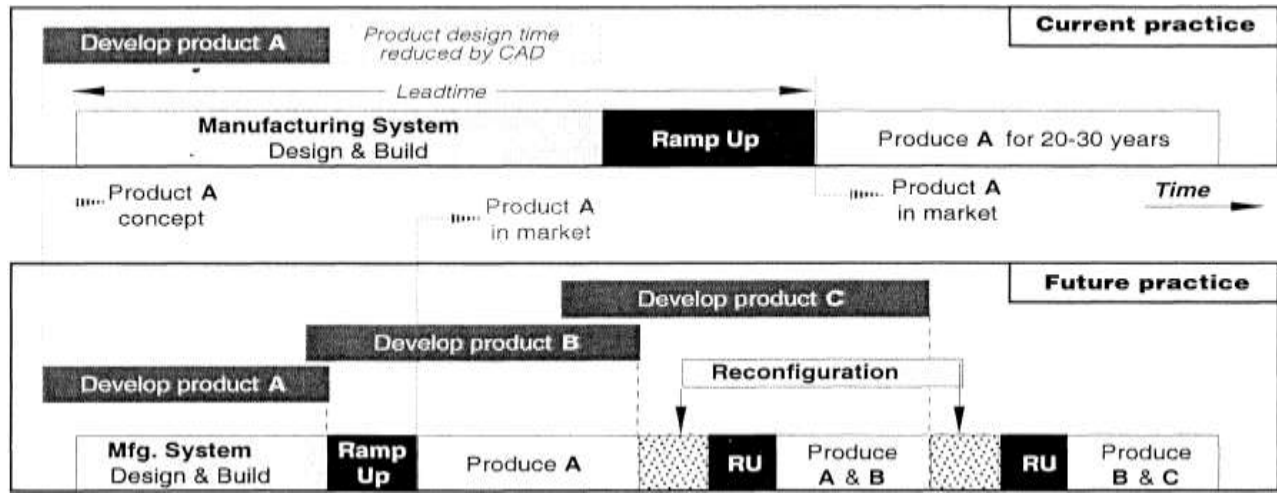


Figure 1: While product development time was reduced dramatically by CAD, nothing equivalent was done with the manufacturing system (top). Increase in frequency of new products introduction requires shortening the manufacturing system design time, and enabling its adaptation to production of new products through rapid reconfiguration.

II. TYPES OF MANUFACTURING SYSTEMS

Portfolio of dedicated and flexible manufacturing systems are used by the companies.

Core products of company are produced by an inexpensive fixed automation system called **dedicated manufacturing lines (DML)**, or transfer lines. A single part is manufactured at high production rate on each dedicated line. This is achieved by simultaneously performing various operation. Due to the mass production, the cost of the product is very less. This manufacturing system can be operated at full capacity and are also cost effective. But sometimes a situation can arise when dedicated lines do not operate at full capacity due to the increasing global competition.

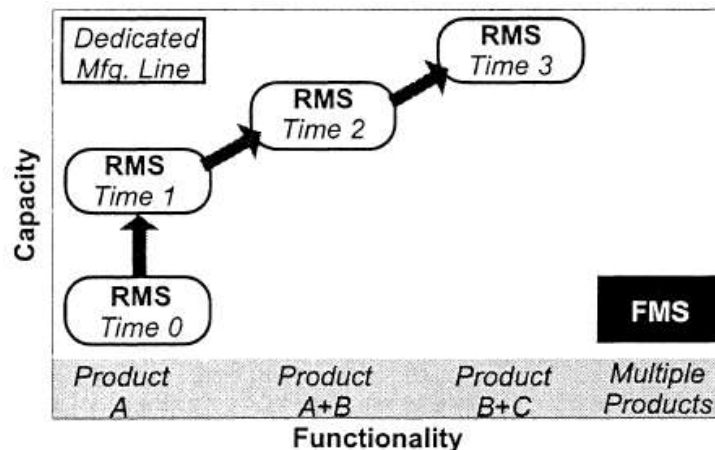


Figure 2: Both DML and FMS are static systems, while an RMS is a dynamic, evolving system.

A variety of products can be produced by using Flexible manufacturing systems (FMS). This system consists of expensive CNC machines. The output of FMS is lower than that of the DML. This happens because the single tool operation of CNC machines. The cost of the products manufactured by the FMS is higher. Low production rate and high equipment cost increases the cost of product. The initial cost of FMS production lines is higher than that DML.

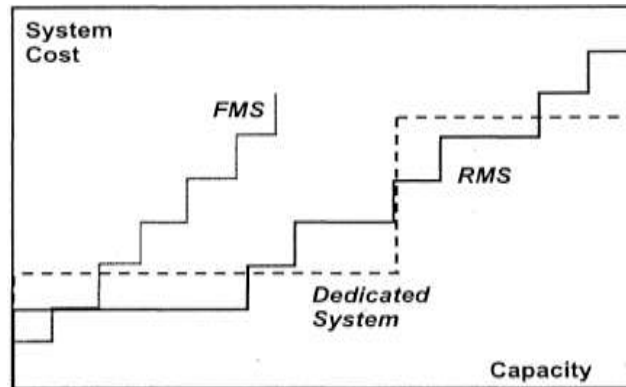


Figure 3: Manufacturing system cost versus capacity (or production rate).

The test of adapting to huge variances in item request can't be fathomed with devoted lines that are not versatile. DMLs are not versatile on the grounds that they are not intended for variable process durations. Along these lines, frequently, the accessible generation limit remains to a great extent underutilized.

On the other hand, this test is hypothetically met by adaptable assembling frameworks that are versatile when planned with multi-hub CNC machines that work in parallel. Regardless of this favorable position, in any case, an ongoing review demonstrates that adaptable frameworks have not been broadly embraced, and a large number of the makers that purchased FMSs are not satisfied their execution

Responsive frameworks are made by giving a flexible structure, versatility, and adaptability (that despite the fact that "altered," gives all the adaptability expected to the part family). Financially savvy frameworks are made by part-family center and redone adaptability (as opposed to general adaptability) that empowers the task of synchronous devices. In the System-Cost versus Limit plane the DML is a steady at its most extreme arranged limit, and after that, for more noteworthy limit, an extra, costly line must be constructed. The FMS is adaptable at a steady rate (calculators in parallel), as portrayed in Figure 3. The RMS is adaptable, yet at a non-consistent rate that relies upon the underlying structure of the RMS and market conditions.

**Table 1
 Comparison between DML and FMS.**

<i>Dedicated Manufacturing Lines</i>	<i>Flexible Manufacturing Systems</i>
Advantages:	Advantages:
1. Fast lead times 2. Low cost 3. Easy to manage 4. High production rates 5. Low product cost	1. Can produce large product variety & mix 2. Reduced part inventories 3. Improved quality 4. Improved efficiency 5. Adaptability to CAD/CAM operations
Disadvantages:	Disadvantages:
1. Not flexible – for a single part 2. Fixed capacity – Not scalable	1. Very high initial investment 2. Slow single-tool operation

The primary segments of RMS are CNC machines and Reconfigurable Machine Tools (RMTs) - another kind of secluded machine with a variable structure that permits change of its assets (e.g., including a second axle unit). Notwithstanding RMTs, likewise reconfigurable controls that can be quickly changed and coordinated in open-design condition are basic to the

accomplishment of RMS. The meaning of a reconfigurable assembling framework is, in this way, as pursues A Reconfigurable Manufacturing System (RMS) is planned at the start for quick change in structure, just as in equipment and programming segments, so as to rapidly modify creation limit and usefulness inside a section family because of sudden changes in market or in administrative necessities.

Table 2
RMS combines features of dedicated and flexible systems.

	<i>Dedicated</i>	<i>RMS</i>	<i>FMS</i>
System Structure	Fixed	Changeable	Changeable
Machine Structure	Fixed	Changeable	Fixed
System Focus	Part	Part Family	Machine
Scalability	No	Yes	Yes
Flexibility	No	Customized	General
Simultaneously Operating Tool	Yes	Possible	No
Productivity	Very High	High	Low
Cost per Part	Low	Medium	Reasonable

In the event that the framework and its machines are not structured at the beginning for configurability, the reconfiguration procedure will demonstrate extensive and unrealistic. Frameworks intended for reconfigurability don't exist today, nor do their plan and reconfiguration approaches. In any case, a considerable lot of the empowering innovations that are the foundations for reconfiguration do exist across the world.

III. TECHNOLOGIES ENABLING RECONFIGURATION

The shared factor for existing committed and adaptable frameworks is their utilization of settled equipment and settled programming. For instance, just part projects can be changed on CNC machines, however not the product design or the control calculations. Consequently, these frameworks, including CNC furthermore, FMS, are static frameworks and are not reconfigurable. Assembling frameworks structured at the start for reconfigurability don't exist today. Amid the most recent couple of years, nonetheless, two innovations that are vital empowering influences for reconfiguration have developed: in programming, secluded, open architecture controls that go for permitting reconfiguration of the controller; and in machine equipment, measured machine apparatuses that go for offering the client more machine choices. These rising advances demonstrate a pattern toward the structure of frameworks with reconfigurable equipment what's more, reconfigurable programming. Reconfigurable equipment and programming are fundamental yet not adequate conditions for a genuine RMS. A definitive objective of RMS is to use a frameworks approach in the plan of the assembling procedure that permits concurrent reconfiguration of the whole framework, the machine equipment, and the control programming. The RMS worldview will likewise make a new age of reconfigurable machines that permit reconfigurations to accomplish savvy adaptability.

Not at all like existing assembling frameworks that use settled equipment and settled programming (e.g., CNC and FMS), the RMS will be structured using reconfigurable equipment and programming. With such structure, the framework limit and usefulness are not settled but rather change after some time because of advertise request, as appeared in Figure 2. This new sort of reconfigurable assembling framework will permit adaptability not just in delivering an assortment of parts, yet in addition in changing the framework itself. Both the reconfigurable frameworks and the reconfigurable machines must be structured at the beginning to be reconfigurable, and must be made by utilizing essential equipment and programming modules that can be incorporated rapidly using assigned interfaces. To satisfy the necessities of an open, particular machine structure, the modules and their interfaces must be indicated in a very much characterized way. While looking at an independent machine module, three fundamental interfaces can be recognized: mechanical, power, and data or control interface (Figure 4). Just with the utilization of very much characterized interfaces will reconfigurable manufacturing systems become open-ended so they may be improved and upgraded rather than simply replaced.

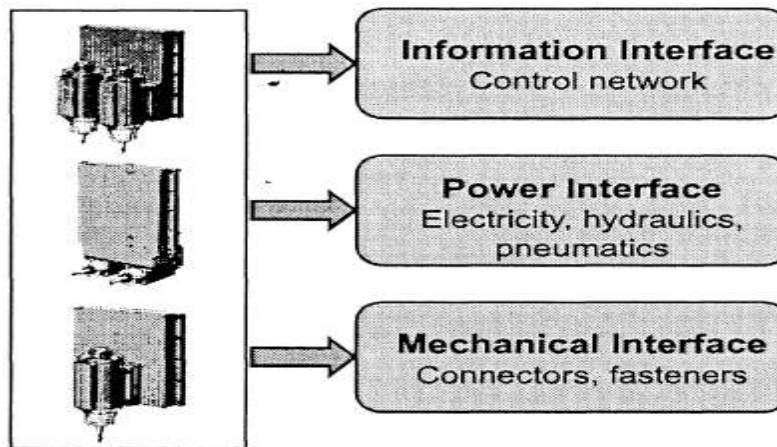


Figure 4: Interfaces for machine modules.

Key Characteristics. Reconfigurable frameworks must be planned at the beginning to be reconfigurable, and must be made by utilizing equipment and programming modules that can be incorporated rapidly and dependably; something else, the reconfiguration process will be both extensive and unrealistic. Accomplishing this structure objective requires a RMS that has the few key qualities recorded beneath.

Modularity. In a reconfigurable assembling framework, all real segments are particular (e.g., auxiliary components, tomahawks, controls, programming, and tooling).

Integrability. Machine and control modules are designed with interfaces for component integration. The integrated system performance is predicted based on a given performance of its components and the interfaces of both software and machine hardware modules.

Customization. This trademark has two viewpoints: modified adaptability and altered control. Tweaked adaptability implies that machines are worked around parts of the family that are being produced and give just the adaptability required for those particular parts, along these lines diminishing expense. Tweaked control is accomplished by coordinating control modules with the guide of open-design innovation, giving the correct control capacities required.

Convertibility. In a reconfigurable framework the ideal working mode is designed in clumps that ought to be finished amid one day, with short change times between bunches. Transformation requires evolving devices, part-programs, what's more, installations, and furthermore may require manual alteration of uninvolved degrees-of-opportunity.

Diagnosability. Identifying unsatisfactory part quality is basic in diminishing incline up time in RMS. As creation frameworks are made progressively reconfigurable and are adjusted more every now and again, it winds up fundamental to quickly tune the recently reconfigured framework with the goal that it produces quality parts. Measured quality, integrability, and diagnosability diminish the reconfiguration time and exertion; customization and convertibility lessen cost. In this manner, these key RMS qualities decide the simplicity and cost of reconfigurability of assembling frameworks. A framework that has these key attributes has an abnormal state of reconfigurability.

IV. STATE OF THE ART

Reconfigurable assembling is the most recent advancement in the general field of PC incorporated assembling frameworks. One of the primary firms to build up an incorporated assembling framework was Molins Company Ltd. In 1967 this organization

exhibited the "Molins System 24", an adaptable and incorporated framework, created by Mr. Williamson, appearing novel approach to expand profitability. In this framework the machining stations were connected by a computerized taking care of framework for work pieces settled on beds. After four years, in 1971, Sundstrand built up the "Bus Car System", a rail-type bed exchange framework on which work piece stream to and from the machining stations, situated along the rail track. This framework, notwithstanding, was appropriate just for long and variable machining times. At the Leipzig Spring Fair in 1972, Auerbach, a machine device processing plant, displayed the assembling framework "M250/02 CNC". Furnished with two three axis machining focuses, three two-arm changers and one four-arm robot, this framework empowered a five-confront machining of kaleidoscopic parts. In 1977 the advancement of Flexible Manufacturing Framework Complexes (FMC), a test-industrial facility comprising of measured machining units and get together robots for the creation of an entirety scope of parts inside a given envelope began in Tsukuba, Japan (see underneath).

Advances in reconfigurable assembling won't happen without machine devices that have measured structures to give the essential trademark to snappy reconfiguration. In any case, the absence of machine device plan procedure and the absence of interfaces are the real boundaries that obstruct measured quality. Reconfiguration appears to be progressively troublesome the closer one gets to the ironware side since equipment interfaces are significantly harder to acknowledge than programming or control interfaces. While the last is more an institutionalization issue, the equipment interface issue is troublesome as a result of its inalienable specialized multifaceted nature. With regards to the equipment seclusion issue, there are not many recorded research ventures portrayed in the writing that handle the issue conventionally. Maybe the principal sizeable endeavor to take care of the issue, and still a milestone accomplishment, was the FMC (Flexible Manufacturing Framework Complex gave laser) venture propelled in 1977 by MITI in Japan, and coming full circle in 1983 of every a test manufacturing plant worked in Tsukuba, Japan. Despite the fact that the undertaking was conveyed out quite a while prior, the major idea is as yet legitimate.

Another huge scale activity was propelled by the European Association (EU) in the mid-nineties. In light of a European Commission-supported report on the state and eventual fate of the European machine apparatus industry, it planned a survival procedure for the European machine instrument part. The report declares that, in the event that machine apparatuses were structured and constructed separately, machine instrument manufacturers could have some expertise specifically modules rather than in total frameworks. Framework integrators would then form total frameworks from the modules as indicated by the particular needs of the clients. This methodology requires part a machine device into a lot of self-sufficient utilitarian units that can be fitting and-play interfaced to frame total frameworks for specific needs. A few European undertakings have been finished or are being worked on to accomplish this objective. A couple of them are talked about beneath.

The European MOSYN (Modular Synthesis of Advanced Machine Tools) venture, led by the Hannover University, takes a gander at client explicit designs of particular machine apparatuses. Another realized task is KERNEL, which looks for to create two distinctive measured machine instruments utilizing equal axis modules. The "Exceptional Research Program 467" at Stuttgart University, upheld by the German research establishment, centres around transformable business structures for multi-variation sequential creation. A sub-venture inside SRP 467 was entitled Reconfigurable Machining Systems, and appointed the objective of building up the reason for the acknowledgment of limit and useful reconfigurability of machining frameworks. This undertaking endeavored to empower momentary flexibility of machine instruments' ability and usefulness to the rapidly changing generation circumstance caused by tempestuous conditions. The utilization of equivalent modules for various machines, and the plan of interfaces, are imperative research issues in this undertaking, as well as in another undertaking entitled MOTION (Modular Technologies for Intelligent Motion Unit with Linear Motor and Hub Control).

In 1996 the Engineering Research Centre of Reconfigurable Machining Systems (ERC/RMS) was established at the University of Michigan by the National Science Foundation and 25 organizations with the mission to build up the total range of RMS. The ERC/RMS has more than 100 scientists that are creating RMS innovation in three primary territories. (1) Decrease of configuration lead-time of reconfigurable frameworks, (2) Design of reconfigurable machines and their reconfigurable

controllers, and (3) Reduction of increase time. The Centre was granted a patent for a reconfigurable machine instrument. The ERC/RMS takes a framework point of view, in consolidating particular machines and controllers, as well as in including the fundamental systems for RMS plan and activity. These incorporate, for instance, strategies for framework setup investigation and structure, monetary demonstrating, amalgamation of reconfigurable machine apparatuses, also, alignment and increase of RMS. A test RMS test bed fills in as the confirmation device for the created innovation. The point of the inside is to build up a logical base for reconfiguration of machining frameworks. The science base will be relevant to other assembling areas.

With respect to of control, inquire about endeavours have been cantered on open control models. On a worldwide scale, the three most vital activities in open design control frameworks are the EU venture, OSACA, and its German successor, HOMNOS; the Japanese activity OSEC; and the North American OMAC-TEAM venture. With the objective of indicating reference engineering for control frameworks, the OSACA venture (cooperation among Stuttgart University, Aachen University, and industry) began in 1992. The principle result from the OSACA venture is the article situated structure and particular of a seller impartial open design for machine control frameworks. OMAC is an activity driven by the craving to build up a lot of utilization programming interfaces (APIs) to be utilized by merchants to move controller items and administrations to the aviation and car businesses. Notwithstanding displaying receptiveness, controllers of future reconfigurable machines will be conveyed and heterogeneous. The previously mentioned activities have not unequivocally mulled over these issues, despite the fact that they permit control of heterogeneous, disseminated procedures to a few degree. Worth referencing in this regard is the EU-supported venture HEDRA (Heterogeneous and Distributed Real-time Design), which utilizes the continuous portion VIRTUOSO.

V. SYSTEM-LEVEL DESIGN ISSUES IN RMS

Eccentric, visit showcase changes as of now describe the earth of many assembling organizations. Changing requests because modifying prerequisites concerning the yield limit and the preparing elements of the producing frameworks. Reconfigurable assembling frameworks meet these necessities by offering a quick flexibility of both their ability and usefulness to the new circumstance. This flexibility highlight of reconfigurable assembling frameworks likewise offers a present moment resetting of the assembling frameworks to deliver distinctive variations of the present items. Besides it gives framework versatility to new items and in this manner ensures a high long haul advantage to-cost-proportion. Like adaptable frameworks reconfigurable fabricating frameworks are furnished with computerized work piece and apparatus supply. The structure of the supply frameworks impacts fundamentally the profitability, part quality, and dependability of the reconfigurable assembling frameworks.

VI. RECONFIGURABLE MACHINE TOOLS

The two centre building techniques required for machine-level configuration are (I) a technique for orderly plan of particular, reconfigurable machines, and (ii) plan standards for open architecture controller. The machine structure strategy ought to use a library of machine modules each can give a fundamental movement. This scientific methodology may generate new kinds of machines - reconfigurable machine tool (RMT). On account of machining frameworks, the reconfigurable machines ought to perform such procedures as turning, processing, boring and tapping, or mix of these procedures. In the more extensive assembling case, joined procedures, such as machining, warm treatment, get together and metrology are to be considered. The discourses here, nonetheless, are basically restricted to machining forms. The test in this case is to plan an ideal reconfigurable machining system regarding cost, efficiency, part quality, and reconfiguration time. The measured plan of machine instruments is a key empowering technology to reconfigurability, as the machining framework can effectively be reconfigured by essentially evacuating, including or changing the constituent units or modules of the framework or the machine. The idea of particular plan of machine apparatuses is as of now surely understood. Be that as it may, late improvement of new machine equipment is opening new probability to measured plan of machine devices. Figure 5 demonstrates schematic illustration of run of the mill 3-hub measured machining focuses. The discussion here is fundamentally cantered around how to increment reconfigurability of

this sort of machine instruments. Variety of items. The essential point of a reconfigurable machine instrument (RMT) is to adapt to different changes in the items or parts to be fabricated. The accompanying possible changes must be thought about:

- (a) Work piece measure
- (b) Part geometry and intricacy
- (c) Production volume and creation rate
- (d) Required procedures
- (e) Accuracy prerequisites as far as geometrical accuracy, surface quality, and so on.
- (f) Material property, for example, sort of material, hardness, and so forth.

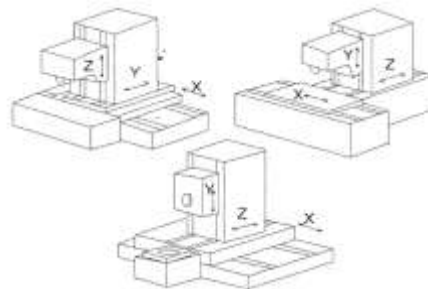


Figure 5: Modular machining centers.

Reconfigurability for work piece size So as to adapt to basic changes in the span of the work piece, it will be sufficient to plan machine units (modules, for example, a section, table, axle unit, and so forth with various sizes. Reconfigurability is accomplished by evolving modules.

Reconfigurability for part geometry. So as to increment the machine usefulness for geometrical unpredictability of the parts, the quantity of tomahawks of-movement is expanded by including new movement units or by supplanting one of the units with one having a few degrees of opportunity. Figure 11 demonstrates a schematic delineation of a conceivable reconfiguration of a 5-hub machining focus. A portion of the financially accessible 5- hub machines are reconfigured by supplanting a rotating work-table with a three-pivot table, and the others by supplanting the shaft head with a flexible axle head unit.

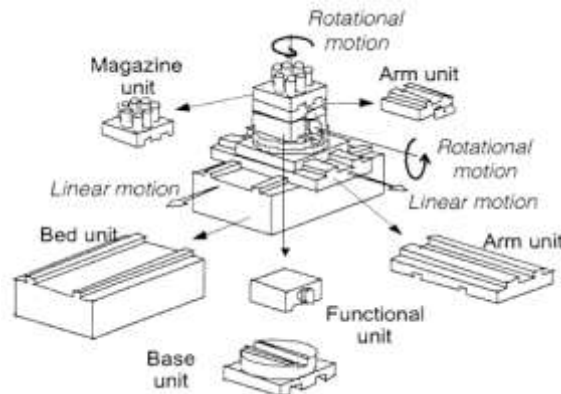


Figure 6: Assembly of modules for a rotary axis.

Reconfigurability for generation volume and rate In order to expand creation rate, the limit of the machine axle unit can be changed from single-shaft unit to double or on the other hand even multi-shaft unit. The multi-axle unit is a very useful asset to expand the profitability. Modularized axle units with various speed range and strength are genuine instances of using reconfigurable machine instruments.

Reconfigurability for changes in machining process In request to adapt to changes in the machining procedure, not just the cutting device must be changed, yet once in a while even the setup of the machine apparatus must be changed as well. In a few applications turning, as well as processing what's more, penetrating activities can be performed on a turning centre using a processing axle, which replaces the settled device post. The test is, be that as it may, including for instance a grinding unit to the turning focus when required.

Reconfigurability for machining accuracy RMTs comprise of modules, every ha its own interface. In such cases, the mechanical interfaces that are determined by geometrical features, have related resilience's. The unfortunate addition or potentially superposition of resilience fields can negatively affect the machine precision after reconfiguration.

Parallel-Kinematics in Reconfigurable Manufacturing System. Parallel-kinematic machines may frame an uncommon class of reconfigurable machine apparatuses. They can be categorized into various classes relying upon the kind of their swagger for example those with steady length and those with variable length - and on their drive structure, for example, direct drives, ball screw drives and rack-pinion drives.

Most parallel-kinematics machines are acknowledged as tripod or hexapod frameworks, which contrast, by the number, the specification and setup of its swaggers. The attributes of these kinematics result from their low moved masses and the high swagger firmness. As these machines comprise of basic and indistinguishable modules. It is conceivable to design diverse machines from these modules. The utilization of many equivalent modules suggests the institutionalization of drive components, joints and module interfaces. Subsequently swaggers, joints and drives wind up interchangeable between frameworks of various setup, which empowers the design of solitary reconfigurable assembling modules. These parallel-kinematic machines can be utilized as particular modules in exchange lines for the machining of barrel hinders with computerized work piece stream and as remain solitary C-styled or entrance styled laser places for the machining of sheet metal. It is likewise conceivable to acknowledge adaptable producing frameworks for added substance machining with this sort of kinematics. Difficulties the idea of secluded plan of a machine apparatus isn't new, however it has not been generally embraced in practical utilize up until now. The primary issues with secluded and reconfigurable plan are as per the following:

(1) Design Methodology for RMT: The advancement of a numerical system for blend of reconfigurable machine apparatuses (RMTs) and their approval is a noteworthy challenge. The Engineering Research Centre at the University of Michigan is building up a numerical hypothesis for synthesis of RMTs, which includes:

- Development of a formal and a brought together portrayal plot for mechanical (kinematic, and auxiliary) functions of modules.
- Compilation of a library of machine modules
- A system for systematic blend of reconfigurable machine apparatuses utilizing screw hypothesis for kinematics and chart hypothesis auxiliary combination.

(2) Interfaces: It isn't so natural to gather the machine secluded precisely enough to meet the exactness requirements of the machine apparatus. The interfaces between the modules to be collected must be institutionalized and precisely produced. Strategies should likewise be produced to quickly measure and alter the arrangement of the modules. Decrease of the static and dynamic rigidities at the interface is likewise an issue to be tackled.

(3) Module Autonomy: Most of the mobile and drive units are provided with power and are associated with the controller by wires. Some of them likewise require power through pressure and packed air. The wiring and funnelling with the outside vitality sources are a disturbance. The location of water powered siphons, blowers and gatherers can be a hindrance for reconfiguration of the machine units. It is alluring that every module ought to be self-governing and independently serviceable.

VII. CONTROL FOR RECONFIGURABLE MACHINES IN OPEN ARCHITECTURE

Additionally, to building a library of machine modules, controller programming parts (e.g., servo control calculations, temperature control calculations, interpolators, and so forth.) are likewise catalogued and put away for re-use. The modules required for the application are chosen, and after that designed by a technique named a "Control Configurator" that guides in coordinating the controller for the chose machine (both persistent and discrete control), and consequently checks its continuous constraints. At last the reconfigurable controller must be implemented as an open-design control. The measured plan of the machine segments specifically impacts the necessities for the relating control gear. So as to help the measured development of reconfigurable machines, the control framework itself must be planned by the standards of an open architecture. IEEE characterizes this as "an open framework gives capabilities that empower appropriately executed applications to keep running on a wide assortment of stages from numerous merchants, interoperate with other framework applications, and present a consistent style of connection with the client". The controller transparency is the empowering innovation expected to incorporate, expand, supplant and reuse equipment and programming components in a control framework even after its establishment at the shop floor (Figure 7).

Table 3
Capabilities of a control system for reconfigurable machines.

Capability	Meaning	Hardware options	Software options
Modular	decentralized structures are supported	Standardized arid distributed comm. systems	distributed appl. modules
Interoperable	components can cooperate		standardized data exchange
Portable	integr. of components in diff. environment		standardized AP\
Scalable	increased performance, topology can be modified	processor upgrade	parallel software tasks
Extendable	functionality can be enhanced	additional plug-in cards	addtl. application modules

To get the greatest combination adaptability, reuse and distribution of programming modules must be accomplished. A nonpartisan framework stage which is free from explicit applications and which can be effectively adjusted to a particular hardware is crucial to satisfy these prerequisites. The framework stage exemplifies every particular piece of a control framework so as to give a nonpartisan interface to the application programming. The framework stage depends on electronic hardware, for example, PC sheets, module cards or intelligent I/O hubs associated through control systems. Over the stage is found the framework programming which gives the usefulness expected to help receptiveness for the application programming.

From the required abilities for application modules the essential usefulness of the framework programming can be determined (Figure 8). The ideal movability of AM's prompts the need for the meaning of a uniform application program interface (AP\) to get to the framework stage. This empowers modules to be set on any framework stage that offers the API. This makes it additionally conceivable to change a specific configuration by repositioning a module in the framework and by this altering a given topology. It verifiably requests that the framework programming needs to shield the application programming completely from the framework equipment.

The framework programming for an open control framework characterized as above needs to contain no less than three segments:

(I) a working framework, or run-time framework, to execute modules,

- (ii) an arrangement framework to join modules into a running framework at boot-up of the control, and
- (iii) a correspondence framework to empower data interchange between modules based on a standardized convention.

Issues identified with continuous confinements caused by the communications arrange transfer speed are talked about in. Albeit joined control segments on the physical dimension relies upon the control framework stages (Figure 8 right), the stage looks straightforward to the client, since a lot of uniform AP Is is accommodated the application programming. The AP\ shrouds all the equipment angles and offers one homogeneous framework stage even in appropriated control frameworks. Instances of such framework stages are CORSA of the Object Management Group (OMG) and DCOM of Microsoft. As these business stages have no devoted ongoing abilities they can't specifically be utilized as stages for machine-and process-related control programming. For this reason, a particular framework stage was structured and implemented by the European OSACA activity. This software can be effectively ported to various working systems and furthermore bolsters constant highlights. The product was as of now ported to different working frameworks including the MS-Windows family, a few constant working frameworks (for example, OS-9 and VxWorks) and distinctive UNIX derivatives. For the physical coupling of circulated stages a wide scope of correspondence models, (for example, Serco's, Profibus, Ethernet) are accessible.

Utilizing the above portrayed standards of a control framework stage with a framework autonomous API, application software can be planned and actualized in an exceptionally secluded also, adaptable way. So as to help a simultaneous plan of the machine and the related control programming it is useful that the product modules compare to the parts of the machine. Regarding object-arranged standards it implies that a machine object compares to a controller object offering the control usefulness of the machine object (see Figure 9).

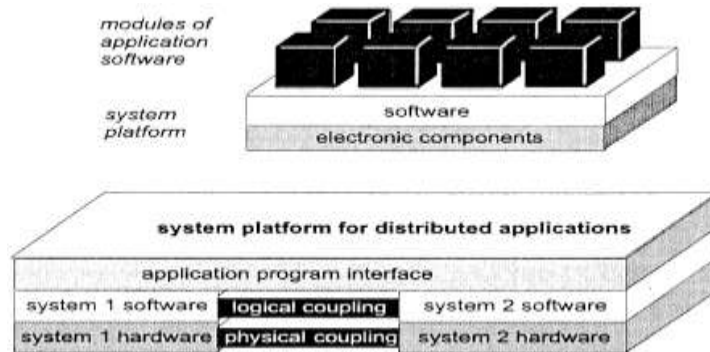


Figure 8: Structure of the system platform (top) of an open controller architecture (bottom).

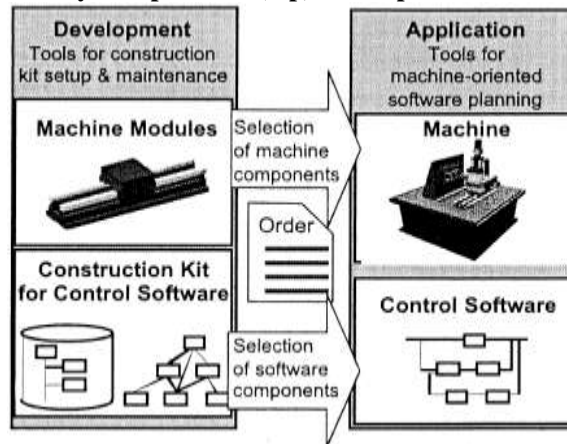


Figure 9: Concurrent Engineering of Structure of Machine and Control Software

Control programming components are stored in a module library. They are capsulated into autonomous units that contain both auxiliary and practical data. This causes a high reusability of the modules. In light of this library, new designs are produced by choosing the modules into an undertaking and by partner the furnished correspondence interfaces with one another. Automatic testing components keep the age of defective designs.

Utilizing a graphical design instrument diminishes the ideal opportunity for making a control design by utilizing libraries and building plans. Programming would thus be able to be created at lower cost. At a similar time, the nature of the product increments on the grounds that of its incorporated testing components and for being based on models. First models of such design devices have been structured and created inside the German ventures MOWIMA and HUMNOS.

VIII. SYSTEM RAMP-UP

Increase time decrease is a basic target for responding to short lucky chances for new items also concerning scaling frameworks to adapt to evolving request. Ramp up period is characterized as The timeframe it takes a recently presented or reconfigured fabricating framework to achieve sustainable, long haul dimensions of creation in wording of throughput and part quality, considering the effect of gear and work on efficiency.

Accomplishing the goal of increase time decrease requires diagnostics and increase procedures, at both the system and machine levels. As creation frameworks are made increasingly reconfigurable, and their usefulness and formats are adjusted all the more habitually, it moves toward becoming essential to quickly tune the recently reconfigured framework with the goal that it produces quality parts. In the event that increase isn't done rapidly, the reconfiguration advantage is lost.

The explanation behind the likelihood of getting crumbled quality parts after reconfiguration is that reconfigurable machines are for the most part planned based on modularized frameworks whereby every one of the individual modules has its own interfaces. In this way, it is basic to perform diagnostics of the reconfigured framework after get together, and play out the consequent blunder alignment and pay of the system. Thusly, reconfigurable frameworks must be designed with item quality estimation frameworks as an fundamental part.

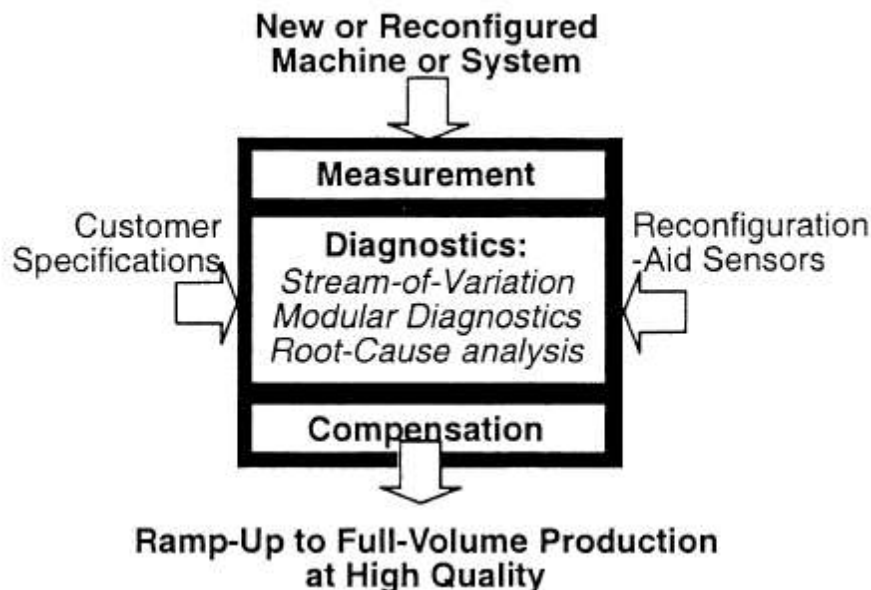


Figure 10: Ramp-up process of RMS.

The fundamental designing advances required are abridged in Figure 18. The estimation step requires the choice of type and arrangement of sensor modules (e.g., part dimensions, pivot position, cutting power). The diagnostics step utilizes that sensor data to distinguish blunders and blames (e.g., machine or apparatus geometric mistakes, device breakage). Diagnostics ought to be installed at the segment level, and proliferate the data through the machine level, to the cell and plant PCs. The estimation framework and the demonstrative approach ought to take into consideration machine/system diagnosability - distinguishing the hotspots for a blame or a part quality issue. In a perfect world, the sole reason or hotspot for blunders ought to be recognized. The remuneration step, either naturally or through administrator mediation, empowers corrective move to be made (e.g., alignment, change of working parameters, support).

So as to ensure short framework increase after each reconfiguration, it is important to gauge item includes or on the other hand process factors that must be chosen well-ordered on the premise of the particular issue and circumstance close by. To achieve this objective, it is important to have both reconfigurable sensors and investigation gadgets and proper quality control and dependability apparatuses that assistance in characterizing where inspection focuses must be presented and which examining system ought to be connected.

The estimation frameworks of RMS are planned to help quickly recognize the wellsprings of item quality issues in the generation framework and to address them by using modern data innovations, measurements, and flag processing strategies. In view of the mind boggling structures of reconfigurable frameworks, numerous ordinary procedures, such as laser interferometry for the assurance of resilience's, are never again reasonable. Subsequently, inquire about is at present being embraced in connection to the appropriateness of 3-D estimation frameworks that can quantify part and product measurements in-process. These frameworks can be subdivided into mechanical (e.g., triangulation or explained arm with a test), optical (e.g., interferometry), and ultrasonic frameworks.

The similar tests utilizing the diverse 3-D estimation frameworks in respect to the outcomes from the organize measuring machine yielded results having noteworthy deviation. In this way the down to earth use of business frameworks needs to date been in fact inadmissible and by virtue of the high venture costs renders the frameworks non-prudent. Inside the structure of new innovative work enhanced strategies for the adjustment and mistake compensation are being looked for. In Germany, close participation among industry and the colleges is occurring inside the contact of the ACCOMAT Project. The rule of activity of the estimation system depends on a method understood in navigational engineering and uses a canny tooling framework in which the sensor and pictuation components are incorporated for its alignment.



Figure 11: Optical measurement of automotive body dimensions using laser triangulation sensors to achieve detection and isolation of faults.

Case of System Ramp-Up. Figure 11 demonstrates optical sensors on a car body mechanical production system. These sensors, when appropriately planned and found, can help diagnose issues on the mechanical production system (e.g., broken locator, erroneously modified robot) that can prompt buyer issues, for example, wind clamour, water spillage, and so forth. Figure 21 appears, with results from genuine creation, the advantages that can be accomplished as far as fast decrease of the variety (6σ) in basic body measurements by applying the methodology delineated with the Stream-of-Variations hypothesis. Note that both the decrease in variety is quick, also, the last dimension of variety is low.

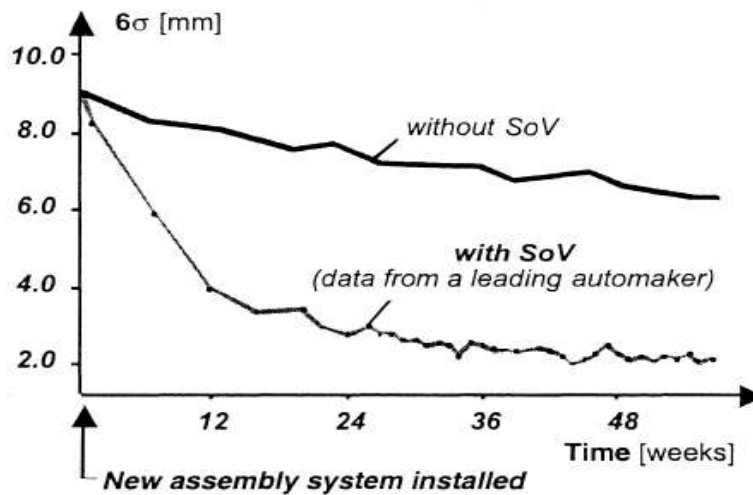


Figure 12: Results showing ramp-up time reduction in automotive assembly.

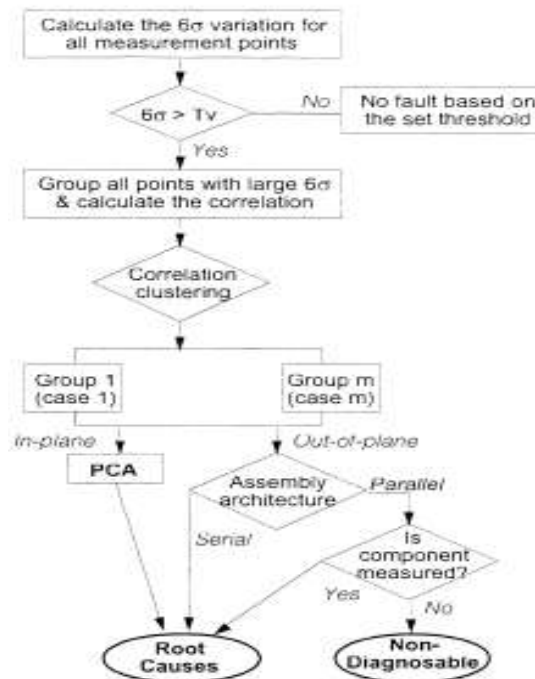


Figure 13: A flow-chart of the stream-of-variations methodology.

The Stream-of-Variation (So) strategy joins engineering process models with measurable investigation to account for how item dimensional varieties gather as the item travels through an assembling framework. It very well may be utilized, with suitably chose and put sensors, to analyse the underlying drivers of the dimensional blunders in the generation framework.

- Obtain estimation information for a lot of bodies and calculate the standard deviations of all estimation focuses.
- Group all the estimation guides agreeing toward the six sigma limit, TV (e.g., 2.0 mm).
- Calculate the relationship framework for the gathering of measurement focuses with six sigma bigger than TV.
- Use bunching examination to partition the estimation focuses into subgroups. Each gathering structures a contextual investigation (i.e., potential issue). The area of the procedure blame is in the gathering station that is one dimension higher in the pecking order and has the above gathered component as information.
- Perform foremost part investigation for assembled estimations that have variety in the in-plane direction. Show eigenvectors to vivify variety patterns for motivations behind perception. On the off chance that the assembled measurements have variety in the out-of-plane heading, recognize gathering engineering (i.e., sequential versus parallel). Sequential get together is completely diagnosable, while parallel assembly requires extra estimation to be diagnosable.

Utilizing this technique, blame stations and underlying drivers of variety can be methodically recognized. This methodology has been connected to diminish variety, and to abbreviate dispatch time, in numerous car gathering plants. A regular outcome, from genuine car body generation.

IX. CONCLUSIONS

Worldwide monetary challenge and quick social and technological changes have constrained producers to confront another monetary goal: fabricating responsiveness (i.e., adjustment of the assembling framework to showcase conditions). To react to these difficulties another sort of manufacturing framework, a Reconfigurable Manufacturing System, is required. RMSs are very not the same as the current manufacturing advances (i.e., committed assembling lines what's more, adaptable assembling frameworks) in that they are planned at the beginning with customizable assets so as to give precisely the limit and usefulness that are required, exactly when required.

Structure for Reconfigurability is as of late rising as an imperative new pattern in structuring fabricating frameworks. In this way, reconfigurable assembling is a wide region that keeps on drawing in multi-disciplinary abilities for its development. A portion of its exploration themes include:

- Life-cycle monetary demonstrating of assembling systems, to decide the item request go in which RMS is the ideal decision.
- Automatic age of framework setups and their effect on throughput, part quality and cost that leads to the foundation of design hypothesis.
- Optimal adaptability of arrangements for interest scenarios
- Ramp-up technique for changing arrangements at both the machine level and the framework level.
- Reconfiguration of observing and data frameworks in RMS condition.
- Reconfigurable controls for expansive frameworks in open architecture condition
- Methodology to produce reconfigurable machines for given assembling undertakings..

- Relationships between machine developers and clients of reconfigurable frameworks.
- Benefits of reconfigurable frameworks to society and their effect on occupation creation.

The industrialized world is looked with the test of maintaining its high calibre of life and welfare notwithstanding worldwide economic rivalry. A focused assembling industry is required to keep employments and create new ones straightforwardly, and, through initiated benefits by implication. To add to manageability, the assembling business must move towards a shut and improved life cycle of items and related forms. This, thus, ought to advance after the change in affordable, social and innovative setting, along these lines accomplishing maintainability. RMS, thus, might be viewed as a system for accomplishing process manageability at two distinctive dimensions:

- (1) Strategic dimension, to react to disturbance of the interest, inner and outer change.
- (2) Key level, to represent showcase development.

Rivalry was without a doubt basically dependent on the capacity to optimize the mechanical answer for a given setting. In recent years, be that as it may, the setting has turned out to be to an ever increasing extent tempestuous: society has new needs in quick development, economy is profoundly influenced by the development toward globalization, and innovation shows an exponential development. Given such turbulence, rivalry is increasingly more dependent on the capacity to rapidly adjust to change.

Subsequently the accentuation is never again put on the optimization of the mechanical arrangement statically, yet on the dynamical issue of ceaselessly adjusting the technological arrangement requiring little to no effort. Reconfigurable manufacturing frameworks can speak to one of the foundations of this procedure.

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