Reconfiguration of Manufacturing System

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Abstract:
The current paper presents reconfiguration of manufacturing system. The aim of RMS is developing manufacturing system capable of rapid change in structure, hardware and software components to quickly adjust production capacity and functionality in response to market situation. The RMS functionality is easily adapted to fabrication of new product of the same product family. The RMS posses certain key characteristic as modularity, integrability, customization, convertability and diagnosability that are needed for rapid and cost effective reconfiguration. The ultimate goal of RMS is to have machine and system that are designed to be reconfigurable simultaneously in hardware and software. They allow flexibility not only in producing a variety of products but also in changing the system itself.

Keywords: Reconfiguration of manufacturing system (RMS), Reconfiguration machine tool (RMT), Reconfiguration.

1. Introduction:
The present day manufacturing environment is faced by several challenges and changes. A typical manufacturing company faces constantly changing product volumes. It is commonly accepted that traditional manufacturing systems do not fit to current 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 combined global view of manufacturing and address only some perspectives of manufacturing. The requirements of product design in the 21st century current an ever-increasing challenge. Consumers now demand products that go with their specific, yet constantly changing needs. The additional enhanced features to a product do not guarantee the customer will receive exactly what they want. The changes of customer requirements create a need for new designs of manufacturing systems. In order to sustain competitiveness in dynamic markets, manufacturing organizations should provide the sufficient flexibility to produce a variety of products on the same system.

In this way advanced manufacturing systems need to accurately consider economical aspects as well as engineering aspects; otherwise they cannot obtain a reasonable share of competitive market to validate their investments. RMSs are planned to rapidly produce different product families in the shortest time and at the lowest cost without sacrificing quality. The Major feature of such systems is called reconfigurablity, which is the ability of rearranging and changing manufacturing elements aimed at adjusting to new environmental and technological changes. A modularity based structure must be an objective in the layout design stage enabling RMSs to produce product variants. This characteristic allows manufacturing systems to produce high product variety. As a result an RMS must be upgradeable in process technology with new operational requirements and able to adjust capacity rapidly while it's changing product types. The same set of machines under different configurations direct to different system throughputs, and for the same layout the determination of the types and number of machines will affect the efficiency of the manufacturing system. Reconfigurable systems are designed to maintain a high level of performance by altering their configuration to meet multiple functional requirements or a change in operating conditions. A distinguishing feature of RMS is that its configuration evolves over time in order to provide the functionality and capacity needed, when it is needed. These configuration changes can be in the form of adding machines to the system. It is desirable to change configuration when demand changes in order to minimize the unused capacity and functionality. In summary Reconfigurable Manufacturing System (RMS) is a manufacturing system with customized flexibility.

2. Background:

Dedicated machine tools and controllers were broadly used among manufacturing enterprises before the first Numerically Controlled (NC) machine was invented. During that time, most machine tools and controllers were only mechanical or electromechanical systems. The major disadvantage of these systems was that each machine tool and controller was adapted for a special product. As a result the function of a dedicated machine tool controller could not be changed without great difficulty. As customer demands for different products changed over time, manufacturing enterprises often had to replace the dedicated machine tools and controllers to contain this demand. The invention of Numerically Controlled (NC) machines and their successive evolution. (i.e., Computer Numerical Control (CNC), Distributed Numerical Control (DNC). CNC, together with Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM), have become core technologies in flexible manufacturing systems (FMS).

Dedicated Manufacturing System	Flexible Manufacturing System
Not flexible	Expensive
For a single part	Machine focus
Fixed capacity	Low throughput
Not scalable	Single tool machine
Fixed variety	Complex

Table 2.1 Summaries the weakness of DMS and FMS

SYSTEM	DEFINATION AND OBJECTIVES
Machining system	One or more metal removal machines tools and tooling that operate in coordinated manner to produce parts at required volume and quality.
Dedicated manufacturing systems	A machining system designed for production of a specific part type at high volume. The objective of DMS is to cost effectively produce one specific part type at high volume and required quality.
Flexible manufacturing system	Flexible Manufacturing System is an integrated system of manufacturing machine modules and material handling equipment under systems computer control for the automatic random processing of parts The objective is to cost-effectively manufacture several types of parts, within pre-defined part families that can change over time, with minimum changeover cost.
Reconfigurable manufacturing system	A machining system which can be created by basic modules that can be arranged quickly and reliability. Reconfiguration will allow adding, removing or modifying specific process capabilities, control to adjust production capacity in response to market demands. Reconfigurable Manufacturing System is designed for rapid manufacturing change in structure in order to quickly adjust production capacity systems.. The objective is to provide exactly the functionality and capacity that is needed, when it is needed.

Table 2.2- Summary of three types of manufacturing systems

Operator noted the deficiencies of existing CNC machine tools and controllers, which include lack of interchangeability, modularity, extensibility, and reconfigurablity. He predicted that a new generation of reconfigurable machine tools, based on an open-architecture controller with adjustable modular structure, will come into existence in the next decade .During the last few years, two enablers for reconfigurable machine tools have emerged in machine hardware, modular machine tools that offer end customers more machine options.

3.Requirement of manufacturing atmosphere:

A manufacturing system transforms raw materials into products. Its final goal is to gain value such as profit, status, and market share. An enterprise can survive only if this objective is achieved suitably. Manufacturing atmosphere has a great impact on the performance of a manufacturing system. Current atmosphere has some critical requirements for a manufacturing system. These requirements are briefly summarized as follows.

(i) Short lead-time: Product lead-time affects the performance of a manufacturing system in different ways 1) If a product is introduced early, it is a benefit over the competitors since their lag in matching or surpassing is larger. 2) Early product introduction increases peak sales. The earlier a product is made,

the better its prospect is for obtaining and retaining a large share of the market. 3) A new product brings a higher profit margin.

(ii) More variants: Products become versatile and customerized. Versatility implies a product needs more components for additional functions and features. Customerization means a product has options for individual tastes. A manufacturing system is forced to produce more product variants to meet fragmented, sophisticated and personalized needs.

(iii) Low and fluctuating volumes: The required volumes of many products are falling since: 1) The limited market niches are shared by global competitors. 2) The life cycle of a new product becomes shorter and the durability of the product becomes longer. Different-generation products exist on the market at the same time.3) Product customization has fragmented the entire market demands into small portions.

(iv) Low price: The product price is a primary feature to most of the customers. On the one hand the globalized market offers customers with more windows to purchase low-price products with the same quality and repair. On the other hand the price is greatly time-dependent, and the price margin can be reached its limit very soon after the product is introduced into the market.

Many other requirements, such as quality and durability are not discussed here since the customers tend to regard them as essential features of a product. The abovementioned requirements have a significant impact on the best choice of production paradigms.

4. Components of reconfigurable manufacturing system

The reconfigurable manufacturing systems have two important components

1. Reconfigurable machine tool.
2. Reconfigurable Controller.

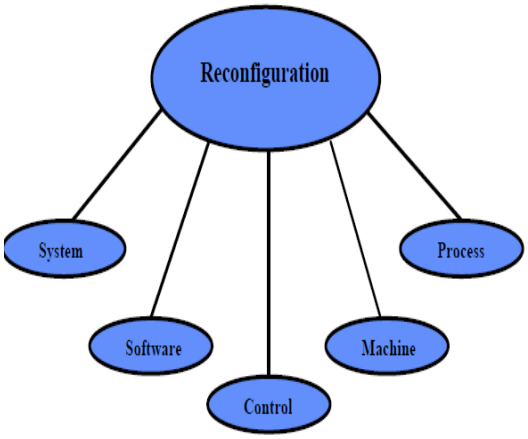

Fig.4.1 Reconfigurable components.

4.1 Reconfigurable machine tool:

The uniqueness of reconfigurable manufacturing system is that the structure of the system as well as of its machines and control can be quickly changed in response to market changes The primary aim of the reconfigurable machine tool is to cope with various changes in the products or parts to be manufactured. A major component of RMS is the reconfigurable machine tools (RMT). According to reconfigurable machines, tools have four important modules to develop reconfigurable machine tool control system as follows.

1. Automatic Part Transfer System control module.
2. Automatic Part Clamping Rotating System control module.
3. Automatic Part Lifting System control module.
4. Automatic Tool Changing System control module.

4.2 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. For instance, Reconfigurable Controller can control a three-axis tabletop mill and a five-axis mill. To allow reconfiguration of the motion planner and servo controller necessary for controlling different mechanisms, some additions and modifications must be made to Reconfigurable Controller. The configuration system is directly interfaced so that it can receive configuration commands from this interface. Based on these different configuration instructions, the configuration system will do one of two operations. It will either set up a correct machine operational parameter, such as machine joint limits. After the configuration system finishes all of these configuration processes, the Reconfigurable controller is dynamically reconfigured for a particular mechanism. CAD/CAM applications can then pass the manufacturing process instructions to the Reconfigurable controller for direct machining.

5. Example of reconfiguration

The following example shows the dynamics of an RMS. I will go through a 6 year production development, illustrated in figs 5.1 to 5.4 and describe the reconfiguration driver and modes.

1. Driver: New Product

Mode: Design of a new Reconfigurable system

Assume that the projected annual volume of product A is between 30,000 to 40,000 units. Traditionally a dedicated manufacturing line with capacity of 40,000 units is designed and built. Alternatively an flexible manufacturing system (FMS) with capacity of 30,000 units may be built. With the RMS methodology, a system with reconfigurable machine and capacity of 30,000 units is built and starts to operate at 0 year, as shown in fig 5.2. Unlike FMS the new RMS for a new product is installed just with the functionality needed for this product, and therefore is less expensive than FMS. The RMS design enables the

upgrading of the system functionality when an additional new product is introduced.

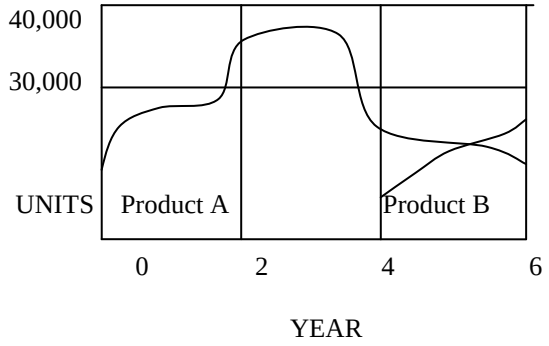

Fig.5.1 Production capacity

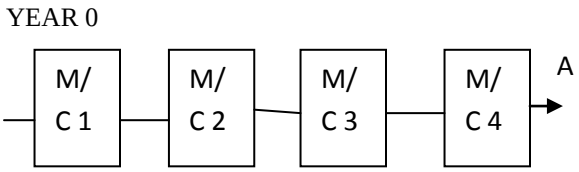

Fig.5.2 Single line production system

2.Driver: Changing Product Demand

Mode: Change Incremental Production Capacity on existing System

The actual demand does not exceed the planned capacity for one year. Toward the second year, demand starts to accelerate. The RMS capacity is quickly upgraded by 50% (from 4 to 6machine) to supply the additional demand. To enhance reliability, the system configuration is changed to two parallel lines both producing product A. However at the 3rd year, the unexpected happens-demand starts to decrease and the system capacity becomes underutilized.

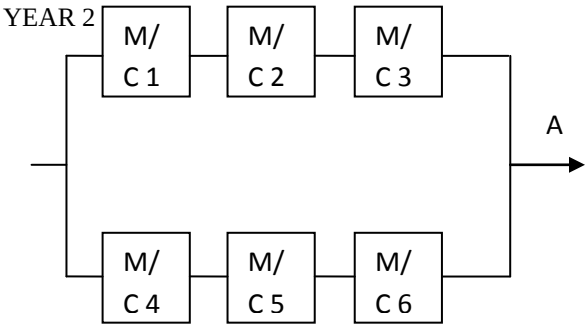

Fig.5.3parallel line production system for a single product A.

3.Driver: Add New Product

Mode: Add Functionality

The company realized that the original product A is phasing out and introduced a new product (i.e. product B) of the same part family. The RMS in 4 year is changed to accommodate the new situation: Product A is phasing out and product B is ramping – up; both should be produced on the existing system the functionality of the several individual machines in line 2 is upgraded to accommodate the production of product B the new system is shown in fig.5. Line 1 produces 20,000 units of product A. Line 2 produces both product: 10,000 of A and 10,000 of B. For 50% of time line 2 produce product B (10,000 units annually) and for 45% of the time it produces product A. It operate as follows. For 4 hours it produces only product B. then the line is tuned off (for 25 minutes) and the machine is converted to produce product A. the machine are designed for quick reconfiguration. the next shift starts with production of product A and then the line is stopped and converted; only one conversion per shift is needed.

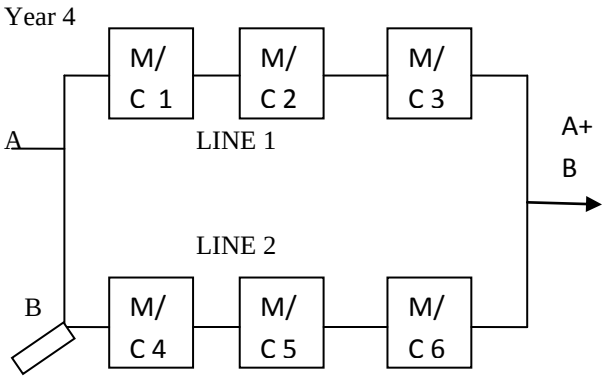

Fig.5.4 parallel line production system for two A and B product.

4.Driver: Changing Product Demand

Mode: Change Incremental Production Capacity on Existing System

The demand for product A remains steady at 25,000 and product B continues the new situation requires adding 12% additional capacity. The new configuration of the system at year 6 is shown in fig.5.5

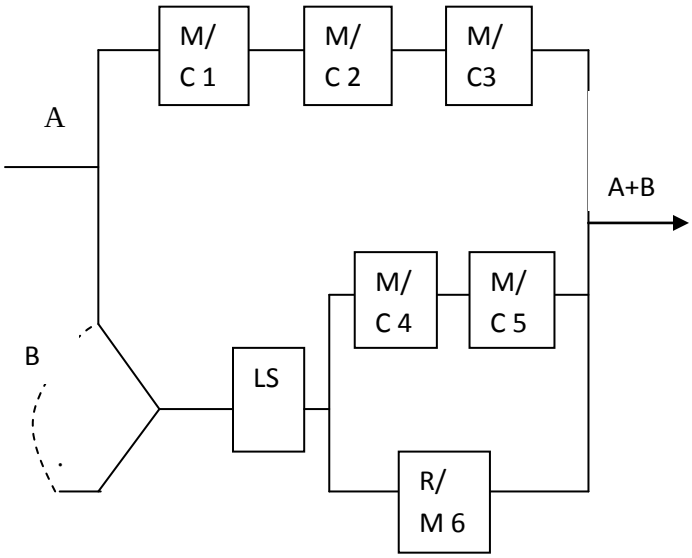

Fig.5.5 Parallel line production with reconfigurable machine (R/M)

5.Driver: Improved Quality or Productivity Requirements

Mode: Integrate New Process Technology in to Existing System

A troubling problem with FMS is the high risk of an expensive flexible production system becoming obsolete. Because advances in software, computers, information processing, controls, high speed motors, linear drives and materials sometimes occur in cycles as short as one year, today's most efficient production system can become inefficient, and even obsolete, almost as soon as it goes on-line. This problem is avoided with RMS technology, which enables the integration of advanced components and controls into existing RMS_s. in year 6 a laser station is also incorporated into the system to improve productivity and quality.

6.Driver: New Product Family

Mode: Integrate Reusable Existing Modules with New Modules

Although not shown in fig.5.1eventually the demand for product B also declines. Sometimes after year 6, the decision is made to no longer produce either Product A or B, or any other products in that same product family. However some of the machines, because they are reconfigurable still have considerable value for use in a new production system. This is especially true for some of new machines. Furthermore as demand declines these on other production systems; this changeover does not necessarily need to occur after production is completely stopped.

6. Conclusion :

In this paper, we have introduced the concept of reconfigurable manufacturing systems (RMS), the Components of reconfigurable manufacturing system, requirement of manufacturing atmosphere. The recent researches in reconfigurable design such as cost of reconfigurablity and variable selection for design has studied in this research paper. The challenges of reconfigurable manufacturing system have encouraged active role in supportive areas that are proving very beneficial to existing manufacturing systems. The reconfigurable manufacturing systems provide a viable solution for manufacturing situations where operations requirements change within prescribed bounds over the life times of the machine tool. However reconfigurable manufacturing systems are also designed such that they may be cost effectively converted when operations requirements change. Reconfigurable manufacturing systems are also capable of cost effectively to incorporating the new technologies. The reconfigurable manufacturing systems approach proposed in this paper indicates an effort towards comprehensively addressing manufacturing under a global umbrella of reconfigurablity. It is believed that reconfigurablity is of great importance for manufacturing systems to survive in the environments of high unpredictability.

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