Advancement of manufacturing system in changing environment: An Overview

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Abstract - **In the manufacturing industry, some of the challenges faced by manufacturers include reducing the lead time, increasing the quality, providing variety of products. Although dedicated manufacturing lines (DMLs) the traditional manufacturing system are capable of producing the similar products in bulk but are incapable of accommodating the product variety. On the other side, Flexible manufacturing system (FMSs) are capable of accommodating the product variety but in comparison to DML the productivity is low . In addition to this the operating and installation cost of FMSs are high and therefore, FMSs have very limited acceptability among the manufacturers. This paper focuses on the advancement of manufacturing system in a changing environment. This paper describes how to improve the responsiveness.**

Keywords – Manufacturing System, Advancement, Scalability.

1. INTRODUCTION TO MANUFACTURING SYSTEMS

A manufacturing system (fig.1) is defined as a collection of integrated equipments and human resources, the basic function of which is to perform one or more processing and/or assembly operations on a starting raw material, part or set of parts [El Maraghy, 2006a; Goyal et al., 2013a, 2013b].

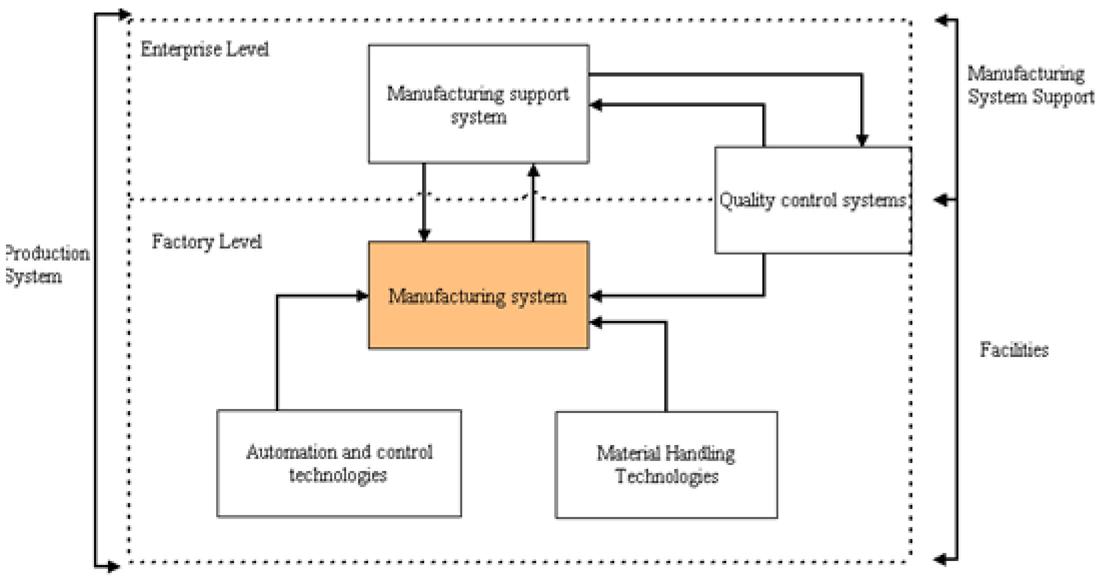


Fig.1 Manufacturing system

The components of a Manufacturing system include:

- Production machines and tools, fixtures and other related hardware
- Material Handling System like AGVs, Conveyors, Pallet trucks etc.
- Computer system to coordinate and control the above components
- Human workers

1.1Types of Manufacturing Systems

(i) Dedicated Manufacturing Lines (DML): A machining system designed for production of a specific part, and which uses (fig.2) transfer line technology with fixed tooling. These are based on fixed automation and produce company’s core products or parts at high volume with less variety. Each dedicated line typically produces a single part (e.g., pump housing).

	Fixed Hardware
No Software	Dedicated Manufacturing Lines
Fixed Software	FMS

Fig.2 Features of DML and FMS

(ii). Flexible Manufacturing system (FMS): 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, which can change overtime, with shortened changeover time, on the same system at the required volume and quality. It consists of computer numerically controlled (CNC) machines and other programmable automation which can produce a variety of products on the same system. The production capacity of FMSs is usually lower than that of dedicated lines and their initial cost is higher [Scott et al.,2007].

2. THE CHANGING MANUFACTURING ENVIRONMENT

Medium and high-volume manufacturers in the U.S. are now facing new market conditions characterized by: (i) short windows of opportunity for new products, and (ii) large fluctuations in product demand [Goyal et al., 2013c, 2012a, 2012 b, 2012c, 2012d]. To cope with the need for quick introduction of products, computer-aided design (CAD) and concurrent engineering methods have dramatically reduced product development times during the last decade. Notable examples include the design of the Boeing 777 and the Chrysler Neon. The production system lead time (i.e., the time to design and build the production system, and to ramp-up to full-volume, high-quality production) has now become the bottle neck. Reducing lead time for manufacturing systems that produce the new products provides major economic savings and is the critical objective for responding to short windows of opportunity.

The other challenge-coping with large fluctuations in product demand — can be theoretically solved by utilizing flexible manufacturing systems (FMSs) that have the ability to produce a variety of products [Phanden et al., 2013, 2012a, 2012b, 2011a, 2011b; Sharma et al., 2012]. However, these systems have not been widely adopted, and two thirds of the manufacturers that bought FMSs are not pleased with their performance. The main reasons for the low level of acceptance or satisfaction are: (i) FMS is expensive, (ii) it utilizes inadequate system software since developing user-specific software is extremely expensive,(iii) takes a long time to ramp-up a new system (there are cases of two years), and (iv) the systems are subject to rapid obsolescence[Mehrabi and Ulsoy, 2000; Koren and Ulsoy,1997; Goyal et al., 2011].

The most troubling problem 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. Furthermore, if the FMS is already producing at full capacity, adaptation to market growth is not an option. Addressing these limitations as well as the new market conditions require a new manufacturing approach that enables:

1. The launch of new product models to be undertaken very quickly
2. Addition of incremental manufacturing capacity as the market grows
3. New developments in manufacturing technology to be utilized in production

3. ADVANCEMENT IN MANUFACTURING SYSTEM

Development in Manufacturing System is designed at the outset for rapid change in structure, as well as in hardware and software components, in order to quickly adjust production capacity and functionality within a part family [Mehrabi and Ulsoy,2000; Hasan et al., 2013, 2014a, 2014b].

A manufacturing systems, whose components are changeable machines and changeable controllers, as well as methodologies for their systematic design and diagnostics, are the cornerstones of this new manufacturing paradigm. Components may be machines and conveyors for entire production systems, mechanisms for individual machines, new sensors, and new controller algorithms [Attila et al.,2010; Chao et al.,2010; Bo and Janet 2006]. New circumstances may be changing product demand, producing a new product on an existing system, or integrating new process technology into existing manufacturing systems. Table 1 summarizes several scenarios that require change and their corresponding modes of alteration.

Table 1 Scenarios requiring alteration

Driver for Change	**Alteration Mode**
New Product	Design of a New Changeable System
Add New Product	Add or change functionality
Changing Product Demand	Change Incremental Production Capacity
Improved quality or productivity	Integrate New Process Technology into existing System

4. SCALABILITY PLANNING FOR MANUFACTURING SYSTEM

4.1Introduction:

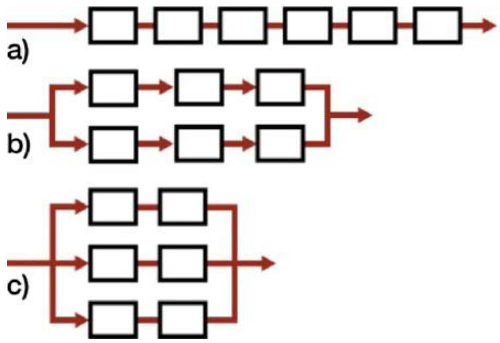
Scalability is a key characteristic of chageable manufacturing systems, which allows system throughput capacity to be rapidly and cost-effectively adjusted to abrupt changes in market demand. Scalability is an important system design characteristic in markets subjected to volatile demand, and its cost-effective solution requires knowledge from engineering and business.

Scalability planning is a methodology of adding or removing machines to match the new throughput requirements and concurrently rebalancing the system for each configuration, accomplishes the system reconfiguration. Capacity scalability may be also achieved by scaling the capacity of individual pieces of equipment, but the most practical approach to system scalability is adding or removing machines to or from existing manufacturing systems, and in this case the original system layout design is critical for achieving cost-effective scalability.

4.2 System scalability:

To adapt the throughput of manufacturing systems to the fluctuations in product demand, the system capacities must be adjusted quickly and cost-effectively. Capacity scalability of a manufacturing system is a necessary characteristic for rapidly adjusting the production capacity in discrete steps, thereby allowing the system throughput to be adjusted from one yield to another to meet changing market demands [Alejandro et al.,2013; Shigang et al.,2011; Goyal et. al.,2013]. Dedicated lines do not have scalable capacity and cannot cope with large fluctuations in product demand. This challenge can only be met by flexible or reconfigurable manufacturing systems, which are composed of CNC machines or reconfigurable machines, as these systems are scalable in small increments accomplished by adding or removing individual machines as a need arises.

The different types of scalability configurations are depicted in fig5 showing the arrangement of machines and stages. If the minimal capacity increment by which the system output can be adjusted to meet new market demand is small, then the system is highly scalable[Wencai and Koren,2012; ElMaraghy,2006b;Goyal et al.,2012]. For example, if a serial line (Fig.5 (a) needs to increase its production capacity to satisfy a larger market demand, an entire new line must be added. The step-size of this addition doubles the production capacity of the system. Doubling the line capacity (when double capacity is not really needed) will be expensive because there is no guarantee that the extra capacity will ever be fully utilized, risking thereby a substantial financial loss. In this example, the configuration depicted in Fig. c of a two stage system with three machines per stage, might be a compromise between reasonable scalability and investment cost[El Maraghy,2006c]. In this case, if a product requires machining on both the upper and side surfaces, the three machines in the first stage might be 3-axis vertical milling machines and the three machines in the second stage might be 3-axis horizontal milling machines. Conversely, in a parallel system, all six machines in must be 5-axis milling machines making the system much more expensive. in practice means adding one 5-axis machine with a large tool magazine that contains every tool needed for the whole part processing – an expensive addition.



(Fig.5)Scalability Configurations

To conclude, in general, the smallest scalability adjustment steps can be accomplished when the original system is purely parallel. However, the initial cost of a parallel system is the highest of all system configurations. In parallel configurations, each machine must perform all the manufacturing tasks needed to complete the part. Therefore, each machine must have the entire set of tools needed to produce the whole part and should also be able to perform more functions, for which more axes of motion are needed. As a result, the capital cost per additional volume increment added to a parallel configuration is the highest of all configurations.

5. CURRENT AND FUTURE RESEARCH SCENARIO ON MANUFACTURING SYSTEM

The various areas that are being focused for future research are given below:

- Several key research projects has already established by the Engineering Research Center for advancement of manufacturing Systems in different University.
- Changeable environment is being given highest priority for future research in manufacturing, and it I being identified as one of the key manufacturing challenges for the next decade.
- In Manufacturing System maximization of throughput is yet to be carried out.
- Scalability planning needs to be explore in detail.
- Various cost factors like labor, tooling, floor space, operating cost is yet to be discussed in detail.

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