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# ENHANCING FLEXIBLE MANUFACTURING COMPETENCE

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**Abstract:** One of most important aspect that modern technology has managed in area of manufacturing systems and technologies are Flexible Manufacturing Systems. In a corporation, the aim is to hold inventory levels at a minimum level, to plan production by considering a lot of parameters, manufacturing high quality products and manufacturing the desired goods on time, place and at an appropriate cost. Flexible Manufacturing Systems has added some advantages to corporations, due to its manufacturing and marketing advantages. An important component in design and development of flexibility in a production system is the establishment of appropriate flexibility measures. A flexibility measure or a set of flexibility measures is used to determine the level of flexibility in a typical production system at a given situation. Although there is economical un-stability, insufficient industry structure or to high inventory levels, high technologies must be used to respond to changing demands, to produce high quality goods, to manufacture products at appropriate price in Macedonia. Macedonia needs to use and manufacture these modern technologies to compete and survive in international markets.

***Keywords***: Flexible manufacturing system, production system, operations management, advanced manufacturing technologies, competences.

## Introduction

One of the traditional functions of business globalization phenomenon to be addressed on a global scale in production and marketing, and has revealed the need to be treated. Globalization is not a national phenomenon businesses are forced to think and act globally. The reason for this is competition. All with the trend of globalization in the world, especially in efforts to preserve the competitiveness of businesses in the advanced industrial countries have come to the fore. When the 1980 recovery in industrial countries, the bride survived the shock of the oil crisis in the 1970s, removing many important lessons have turned a new search. Especially in Japan, the world market quality, price, competition appearing with prominent product features such as speed has become very severe. In addition, regional economic and trade integration, which give rise to the effect of increasing trade among themselves, another aspect of the competition against other countries entering the solidification trends have caused the effect of generating even more severe. Production to begin widespread use of new information technologies, the organization of markets and the company has facilitated profound changes: Lean manufacturing, so-skills and teamwork, the removal of organizational levels (or reduction) and the managing authority of wages by transferring the business units or profit centers, the center of decisions on working hours taking has led to developments such as taking over instead.



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Flexible production, the main source of flexible working and flexible organizational approach is a natural consequence of these last twenty years, it becomes very violent and brutal " competition " with the developments in the case and information technology. Competitive conditions faced by Enterprises them quickly, producing various and variable products, directs it to create appropriate employment and organizational structures. Information and new production technologies offered by information technology also makes it more feasible mode of production and forms of organization as well as more effective.

This study attempted to examine flexible manufacturing flexible organization and flexible working cases, respectively.

## Flexible Manufacturing Concept

Flexible production, classical / traditional mode of production, which process is divided into relatively simple parts on a moving belt of this transaction is carried out by specialized work co-opted in this regard, the process of simple, repetitive and stack that give rise to the production of different production systems in production form. Flexible production in the name of such an amount can be understood; not repeated mass production of multi-purpose due to changing customer and market demand, production of different function with the same period of the means of production can be made. In other words, instead of the large quantities of inflexible is carried out on special-purpose machinery and production systems, content and type of increased machine and high quality and diversified products generating systems and workflow systems constitute the flexible manufacturing system. General-purpose production tools, special-purpose computer programs / software and directing, the production of small batches of parts to constitute a specific product family, is carried out in a smooth flow similar to the continuous system has become possible. Of course, as this provides a significant competitive advantage to businesses engaged in flexible manufacturing. This explanation is possible due to the flexible manufacturing concept described as follows. Flexible production; to changes in the production system is a concept to market quickly and effectively adapt. Flexible manufacturing systems in another definition of " micro- electronic technology, which involves the exploitation of the most comprehensive is needed for the production of small batches of different qualities of various goods and equipment brought to the realization of an effective information flow.

In other words, flexible manufacturing systems by providing macro operations planning and control with integrated control systems are computer-based systems and produces a wide range of goods or services quickly.

Flexible work on the first production system is said to have started in 1960 in England by an R & D engineer David Willionson. Later improved further by the effect of competition has reached today.

## Flexible Manufacturing Systems and Characteristics

Flexible manufacturing systems, intermediate or final consumers (to customers) to meet the different demands and needs, protecting businesses that in the conditions of competition in them enough to ever made, are designed as a system can produce different goods and services with small changes to be made. Production lines are supported by computer. The requested to produce the desired product or CAD (Computer Aided Design) designed the method, CAM (Computer Aided Manufacturing) is produced by the method and system can be connected to a central computer. Besides all these features, quality rising, falling costs and prices therefore provide a larger market share as opportunities enables businesses to benefit could be called cheap. Flexible manufacturing systems to be based largely corresponds to the computer, the operating system administrator for the purposes of establishing a complete and accurate description of the utmost importance. Managers demand, constraints and success criteria by determining the processing order of priority in scheduling their own order processing system and then easily identify with the conditions of the study. Thus, the system would have held the bench of movement between parts of the machines without defining their study time. Flexible manufacturing systems are automated factory system that is closest to the conceptual definition. by the methods used in this system, known control and workflow systems are combined in a fully automated production.

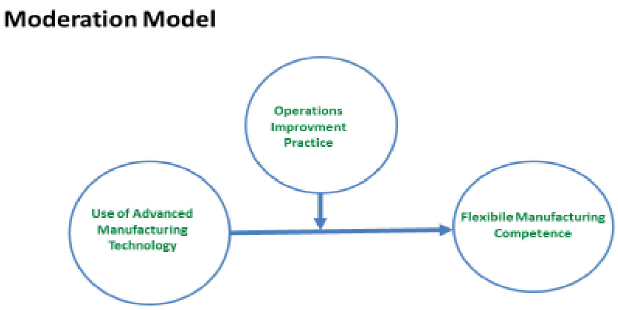
Today integration has become the auto industry and see a wide acceptance in the computer Integrated Manufacturing (CIM: Computer Integrated Manufacturing) is expressed. Mani integration of material and operating capacity alongside the main purpose of a better way to organize the flow of information, eliminating bottlenecks to increase the capacity utilization rate resulting from the lack of material and information.

Flexible Manufacturing Systems (FMS: Flexible Manufacturing Systems) is also emerging as part of the CIM. Instead of producing flexible manufacturing systems into parties, a variety of products within a particular component or group of products are suitable for production of system components are. This kind of flexibility the system, part of the market was wanted at that time to produce and market the moments when he wants to stop the product in a very fast manner gives the opportunity to opt-out of production. Also the design of new products is lower cost and more quickly. However, it should be known that flexible production systems are preferred by small and medium-sized enterprises at give more or successful enterprises in this scale. Flexible manufacturing systems, automation of even becoming a lot more robots are used in the production process is claimed to be the future of the production system in effect. Besides being the factory of the future of these flexible manufacturing system called "unmanned factory"

## Operations Improvement Practices

OIP is the extent to which a firm implements plans and programs that focus on continuous improvement in manufacturing. Continuous improvement was a centerpiece as Japanese firms began to penetrate global automobile markets in the 1970s. From a customer's perspective, the attractiveness of Japanese products was based upon cost and quality. From a company perspective, success was based on flexibility and speed that eliminated waste and mistakes in the production system. Japanese companies' emphasis on repetitive manufacturing, timely production, and smooth workflows enabled them to increase productivity and enhance quality (Monden, 1983).

For this study, OIP includes key just-in-time (JIT) principles: set-up reduction, preventive maintenance, cellular layout, pull production, total quality management, and continuous improvement. JIT identifies all sources of variability, uncertainty, or disturbances, and it eliminates them or reduces their magnitude (Fullerton and McWatters, 2001; Ohno, 1988; Schonberger, 1982, 1986; Shingo, 1989). It provides cost-effective production and delivery of the necessary quality parts, in the right quantity, at the right time and place, while using a minimum of facilities, equipment, materials, and human resources (Voss and Robinson, 1987). JIT practices help firms achieve flexibility by reducing impediments to change (Hyun and Ahn, 1992; Upton, 1994, 1995; Zhang et al., 2002).




| Use of advanced manufacturing technology | Definition | References |
|---|---|---|
| Product and process design | The extent to which that advanced manufacturing technology such as CAD, CAE, CAPP, GT, and the internet are used to support product drafting, design, and engineering | Adler (1988), Boyer et al. (1996), Dahan and Hauser (2002), Huang and Mak (1999), Lei and Goldhar (1991) and Meredith (1987) |
| Manufacturing | The extent to which that advanced manufacturing technology such as CNC, CAM, FMS, AMHS, and robotics are used to control processes and produce physical products | Gunasekaran and Love (1999), Kotha and Swamidass (2000), Lei and Goldhar (1991), Meredith (1987), Saraph and Sebastian (1992) and Sun (2000) |
| Planning and control | The extent to which that advanced manufacturing technology such as MRP, MRPII, Bar Code, and EDI are used to plan and track manufacturing and logistics activities | Adler (1988), Boyer et al. (1996), Cunningham (1996), Lei and Goldhar (1991), Meredith (1987) and Saraph and Sebastian (1992) |
| Integration | The extent to which that advanced manufacturing technology such as CIM, ERP, LAN, and WAN are | Ettlie and Reifeis (1987), Huang and Mak (2003), Jonsson (2000), Melnyk and Narasimhan (1992), |

| | | |
|---|---|---|
| | used to integrate work between functions and between processes | Nemetz and Fry (1988), Parthasarthy and Sethi (1992) and Small and Chen (1997a) |

**Use of Advanced Manufacturing Technology**

Advanced manufacturing technology is a set of tools that automate and integrate steps in product design, manufacturing, and planning and control (Ettlie and Reifeis, 1987). UAMT is the application of manufacturing and information technology to increase responsiveness and create performance improvements in the production process.

UAMT is recognized as an important element in building a competitive manufacturing system that can deliver the product variety that customers demand (Boyer et al., 1996; Gerwin and Kolodny, 1992; Lei et al., 1996; Meredith, 1987; Saraph and Sebastian, 1992; Small and Chen, 1997b). As mass production and single-product assembly are reduced in scope, research is focusing on UAMT to achieve flexibility while keeping operating costs low (Doll and Vonderembse, 1987; Gerwin and Kolodny, 1992). Advanced manufacturing technology has been categorized in a variety of ways. Small and Chen (1997b) use stand-alone systems (computer-aided design (CAD), computer-aided process planning (CAPP), CNC machines, etc.), intermediate systems (automated guided vehicles (AGVS), automated storage and retrieval systems (AS/RS), automated material handling systems (AMHS), etc), and integrated systems (flexible manufacturing systems (FMS), computer integrated manufacturing (CIM), MRP, etc).

Boyer et al. (1996) identify three types of advanced manufacturing technology based on an empirical analysis of the patterns by which companies invest in advanced manufacturing technologies: design (CAD, computer-aided engineering (CAE), CAPP), manufacturing (CNC machines, computer-aided manufacturing (CAM), FMS, group technology, AMHS), and administration (MRP, MRPII). Similar classifications can be found in the work of Adler (1988), Lei and Goldhar (1991), Meredith (1987) and Saraph and Sebastian (1992). The classification shown in Table I is used in this study.

Design technologies, such as CAD, CAE, and the internet, support product designand engineering (Dahan and Hauser, 2002; Huang and Mak, 1999). They enable firms to work selectively with external designers, suppliers, and customers to compress product development and commercialization. The application of group technology and CAPP has improved process design, which enables firms to make a variety of related parts. Manufacturing technologies, such as CNC, CAM, and AMHS, make production easier and faster. FMS and robotics, which began to attract interest in the early 1970s, allow job shops to reduce batch sizes through short change-over and set-up times (Gunasekaran and Love, 1999; Jonsson, 2000).

Planning and control activities are facilitated by the development of MRP, MRP II, electronic data interchange, and bar coding, which allow firms to manage material flow within the firm and between the firm and its suppliers (Boyer et al., 1996; Cunningham, 1996; Meredith, 1987). Integration technologies such as CIM, local area networking, and enterprise-wide resource planning allow a flow of information and coordinated decision-making between functions within a firm and between firms (Doll and Vonderembse, 1991; Jonsson, 2000).

**Flexible Manufacturing Competence**

Several studies suggest that FMC is a source of competitive advantage. Cleveland et al. (1989) propose production competence as a link between business strategy and manufacturing strategy and as a measure of the pooled effects of a manufacturer's resources and assets. Vickery et al. (1993) define production competence as the degree to which manufacturing performance supports a firm's business strategy. Choe et al. (1997) view production competence as a function of fit between business strategy and manufacturing structure. These studies empirically confirm that production competence has a significant positive relationship with business performance. FMC is a measure of a firm's ability to flexibly deploy resources to support its business strategy.

FMC is a set of internal abilities (machine, labor, material handling, and routing flexibilities), which customers cannot see and do not fully appreciate, but firms develop them to create responsive production systems (D'Souza and Williams, 2000; Zhang et al., 2003). According to Zhang et al. (2003), FMC is the foundation for creating volume and mix flexibilities, which customers do value. This classification is echoed by Hyun and Ahn's (1992) cone model where manufacturing flexibility has several components consisting of machine, routing, material handling, and labor flexibilities and an environmental perspective that includes mix and volume flexibilities. Prahalad and Hamel (1990) contend that firms should focus on building core competencies that create competitive advantage. FMC is the process and infrastructure that support manufacturing flexibility and enables firms to perform at high levels.

### Flexibility Measures

Firms usually follow four different combinations for parts (components) to be produced. The measures for various flexibility dimension focuses mainly on the number of machines in use, number of batch, configuration of part type, process plan, operations in each process plan and material handling equipments in use. Objective of this research work is to explore and form an overall assessment of the flexibility in production system and its implications in process industry. Process, expansion, operation and material handling flexibility related to process industry are selected for this research. Each dimension of flexibility is defined and measures as developed are discussed below:

### Process Flexibility Measure

Process flexibility (PRF) of a production system over time, t, is defined as the ratio of the volume of the set of part types that the system (machine) can produce without major setups to the total number of part types produced in a production system. Volume may be expressed by the number of different part types in the set. Process flexibility of a system derives from the machine flexibility of machines, operation flexibility of parts, and the flexibility of the material handling system composing the system. It is useful in reducing batch sizes and, in turn, inventory costs. The flexibility measures for different machine-part combinations are as follows:
(i) One machine producing one part type

$$\mathrm{PRF}_{\mathrm{it}} = \frac{\mathrm{L}_{\mathrm{it}}}{\sum_{\mathrm{k}=1}^{\mathrm{s}_{\mathrm{i}}} \mathrm{L}_{\mathrm{ikt}}}$$

(ii) Many machines producing one part type

$$\mathrm{PRF}_{\mathrm{t}} = \frac{\sum_{\mathrm{i}-1}^{\mathrm{n}} \mathrm{L}_{\mathrm{it}}}{\sum_{\mathrm{i}-1}^{\mathrm{s}_{\mathrm{i}}} \sum_{\mathrm{k}-1}^{\mathrm{s}_{\mathrm{i}}} \mathrm{L}_{\mathrm{ikt}}}$$

(iii) One machine producing many part types

$$\mathrm{PRF}_{\mathrm{it}} = \frac{\sum_{\mathrm{j}-1}^{\mathrm{m}_{\mathrm{i}}} \mathrm{L}_{\mathrm{ijt}}}{\sum_{\mathrm{j}=1}^{\mathrm{m}_{\mathrm{i}}} \sum_{\mathrm{k}=1}^{\mathrm{s}_{\mathrm{i}}} \mathrm{L}_{\mathrm{ijkt}}}$$

where, i is the number of machines, i = 1, … n; j is number of part features, j = 1, … m; k is number of setups, k = 1, … s; and t is the time period.
PRFt : Process flexibility measure during time, t (measured at the end of the t th period)
$\mathrm{L}_{\mathrm{it}}$: Number of part types produced in the i th machine, without setup change, in time, t
$\mathrm{L}_{\mathrm{ikt}}$: Number of part types produced in the i th machine, during the kth setups in time, t
$\mathrm{L}_{\mathrm{ijt}}$: Number of part types produced in the i th machine, with the j th feature of a part, without setup change in time,t
$\mathrm{L}_{\mathrm{ijkt}}$: Number of part types produced in the i th machine, with the j th feature of a part, during kth setups, in time period, t
$\mathrm{s}_{\mathrm{i}}$: Number of setup changes in the i th machine during the period, t
$\mathrm{m}_{\mathrm{i}}$: Number of part features produced in the i th machine during time period, t.

## Discussion And Conclusions

### Contribution

The proposed methodology is comprehensive in the sense that, it considers (i) several dimensions simultaneously with (ii) any number of possible factors describing each dimension and (iii) may be applicable for measuring various dimension on flexibility in manufacturing firms producing multiple part(s) and/or product(s). A firm implementing the proposed methodology needs to consider a number of points: (i) depending on the type of part or product, the relevant input variables are to be identified, (ii) the values of the variables as computed need to be updated at a regular interval and (iii) as the methodology proposed is generic in nature, the numbers and types of factors to be considered depend on the type of flexibility.

**Managerial Applications**

This research has identified three types of manufacturing firms, namely independent company, operating/subsidiary unit of large firm and public sector undertakings. Independent companies are adopting cost-driven strategies. Their dominant competitive priority is low cost. These companies focus on short-term gains. For large firm, conformance to quality is the top preferred competitive priority. Firms have moderate investment in quality tools. These firms place high emphasis on innovation and flexibility issues. Public sector undertaking firms invest more in activities such as CAD, CNC, etc.

**Limitations and Future Research**

Development of the above models is a first step towards developing a metric to quantify the flexibility of production systems. Such models are missing in the literature. There are certain important directions of future flexibility research. Though the measures developed in this research concentrates only to determine the level of flexibility in a production system, yet it can be extended to obtain other flexibility dimensions, such as, worker flexibility, delivery flexibility, design flexibility etc.

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