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Application of Modularmanufacturing System in Garment Industries

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Abstract:

The manufacturing industry needs flexibility and changeability to accommodate the increasing market dynamics and related need for product change and variety and customisation. Such manufacturing responsiveness can be achieved through modular manufacturing system (MMS).

Key words: Modular Manufacturing, Productivity and Flexibility

1 INTRODUCTION

Different module based manufacturing concepts have emerged in response to the manufacturing challenges related to increasing dynamic of market requirements. These market requirements include: need for rapid adjustment of the product assortment, high product variance and customisation. Earlier flexible manufacturing system have been adopted as a solution to these challenges but have not yet been widely due to low system output, high complexity and high cost of general flexibility[1].

1.1. What is module?

The Manufacturing Module provides exact step-by-step assembly and/or test instructions that dynamically adapt to production workers' abilities. These instructions are in the form of annotated, photographic quality images and text directives. They are automatically generated for both custom orders and build-to-stock product model [2].The parts, products and manufacturing equipments as well as the design and operating activities themselves are all described in units called modules [3].

Modules are defined as physical structures that have a one-to-one correspondence with functional structures. They can be thought of quite simply as building blocks with defined interfaces [4]. Modular products may be defined as machines, assemblies or components that accomplish an overall function through combination of distinct building blocks or modules [4].

Modular manufacturing systems greatly reduce the time to design and deploy an automated assembly or machining system. The manufacturing floor space can be greatly reduced because one work cell can be reconfigured to cater to diversified task requirements without the use of several different machine tools. Mini workshops and desktop manufacturing become possible. Most important of all, converting a manufacturing line from one product to another can be very fast and easy to keep up with the rapid changing market [5].

1.2. Modular manufacturing systems:

According Tsukune et al. [6] discussed the characteristics of future manufacturing systems and proposed a concept of modular manufacturing which could be used to integrate intelligent machines. In large-scale manufacturing systems, modularization is indispensable for clarifying the logical structure and assuring a high degree of ease of construction. The parts, products and manufacturing equipment as well as the design and operating activities themselves are all described in units called modules. A manufacturing system is constructed and operated by combining these building blocks. Hardware and software modules are combined to meet specific requirements.

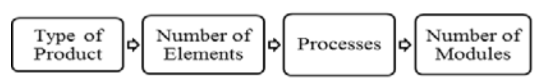

Figure1: **Modular manufacturing systems.**

The modular manufacturing systems (MMS) in Japan are aimed specifically at low to medium level technology consumer products, as typified by goods such as children's toys and kitchen appliances [7]. The rationale for MMS as a means of enabling concurrent product and manufacturing system design has been put forward and the long term implications and work required to establish the concept have been discussed [8]. The MMS concept has been proposed as a way of overcoming limitations resulting from a lack of modular machine standards [9]. Moreover, MMS seek to provide a radical new manufacturing business framework suitable for the 'agile' manufacturing era [10].

The module standards are based on a unified 'reduced' setoff 'primitive' production elements. The module categories are comprised of four classes, namely process machine primitives, motion units, modular fixturing and configurable control systems. Appropriate selection of modules from these categories should make it possible fora diverse range of efficient, automated and integrated production systems to be built. The modules in a product architecture are analogous to flexible cells or holons in manufacturing systems. A cell in the Group Technology (GT) is dedicated to a certain group of work pieces. The cellular system is likely to give the best match of machining capacity to process time for various work pieces [11].

The different type of products can be divided/formed by in this manufacturing, for example all home appliances like grinder, mixer andiron box washing machine and coffeemaker.

2. Modular Design in Industry:

Modular design is being in use by many industries and some of the following examples are air craft design, furniture design and home appliance (grinder, iron box) designs.

A. Aircraft Design:

In developing the Boeing 777 aircraft, the modular product architecture specifies at the beginning of the development process created a positive environment for efficient "localized learning" in developing specific components [12]. A localized learning environment is possible when development of components can be carried out through autonomous processes. Modular product architectures also provide a framework that supports expanded involvement of lead users in product development [13].

B. Furniture Design:

Romero-Sub iron and Rosado [14] described the design of a low cost hierarchical shop floor control system for the modular furniture industry. The system allows for the addition of line resource management modules, such as tools, fixtures, personnel, etc. Those modules that have not been actually developed can be critical to other industries, e.g., the mechanical product industry.

2.1. Difference between Conventional and Modular Designs:

Conventional product design definition: Attributes of 'optimal' product are determined by marketing research.

Design: Desired functionality is decomposed into component interfaces are not specified in design

Modular product design definition: Product conceived as a platform for leveraging product variations and improved models.

Design: modular product architecture fully specifies component inter faces and constraints subsequent component development According to Clark and Wheelwright [15] the conventional model of the product development process is based on the sequential staging of design tasks.
In the conventional model, after defining the product concept, design activities are typically sequenced so that technology and component development activities with the greatest uncertainty are resolved first. As new technical knowledge is developed and technological uncertainties about components are resolved, design decisions are made, thus allowing the next stage of design activities to be implemented. This process is repeated at each stage of the product development process until all the components and their interfaces are fully specified. Although the product development process may begin with a general idea for the arrangement of components in the design, the actual product architecture, i.e., the full specification of all component interfaces, is determined at the end of the design process. In essence, the product architecture is the output of the sequential design process.

A modular product design is one in which input and output relationships between components (i.e., component interfaces) in a product have been fully specified and standardized. Modular product design implies that there is a new model for managing information flow and knowledge during the product development process. In contrast to the evolving information structures characteristic of the sequential product development process, a modular product design creates a complete information structure fully specified component interfaces of a modular product architecture that defines the desired outputs of development tasks before beginning processes for development and detailed design of components.

According to Olesen [16] modular concepts are evaluated against the so-called universal virtues - cost, time, quality, efficiency, flexibility, risk and environment. The evaluation occurs using the modularity evaluation chart (MEC), including lead times in development and assembly, development, system and product cost, quality, development capacity, variant flexibility, service, and recyclability. The measures are used as a benchmark for a good modular design and centre on the number of parts Np, number of modules Nm, average part assembly time Tnorm, and interface time Tint in the new product. For a new product objectives are [16]:

$N_{P\,(NEW)} = 0.7 * \text{Old } Np$…………… (1)

$Nm = \sqrt{N_{P\,(old)}}$……………………… (2)

Where

0.7=A Relevant objective for a new concept 70%

$N_{P\,(NEW)}$ = Number of parts in average product, after design

Nm = Number of modules in one product

Lead time in assembly of one complete product is provided by the following equation:

$L = (Np\ T_{norm}) / N_m + (N_m - 1)\ T_{int}$ ……. (3)

According to Gershenson [17]. Manufacturing modularity takes into account manufacturing's effect on each product attribute. When looking for dependencies and interactions between modules and components, each attribute of the product, modules, and components must be considered. As an example, consider the housing of an electric coffeemaker which is one modular assembly composed of many components. All of the components of the housing are made of the same plastic, are manufactured to similar tolerance specifications, possess the same surface condition, and undergo the same manufacturing process. Product attributes include: geometry, features, tolerances, surface condition, materials, and facilities.

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3. Readymade Garment Industry in India:

The textile industry including readymade garments occupies a unique position in the Indian economy. Its predominant presence in the Indian economy is manifested in terms of its significant contribution to the industrial production, employment generation and foreign exchange earnings. The RMG or also called as the apparel sector is the final stage of the textile value chain and the maximum value addition takes place at this stage. In India RMG industry is fragmented and pre-dominantly in the small/scale sector. Therefore, the sector is low investment and highly labor-intensive industry. This industry is environment friendly as it is least polluting and it could provide employment to the rural population, as this sector does not need sophisticated skill sets [18].

The RMG industry contributes around 8 per cent of India's exports, 7 per cent of industrial output and is the largest employment generator after agriculture. It contributes about 14% to the industrial production and about 4% to the GDP [12]. It has immense potential for employment generation particularly in the rural and remote areas of the country on account of its close linkage with agriculture. The contribution of this industry to the gross export earnings of the country is about 37% while it adds only 1 – 1.5% to the gross import bill of the country. It is the only industry which is self-reliant and complete in value chain i.e. from raw material to the highest value added products i.e. garments/made ups. As a corollary to this the growth and promotion of this industry has a significant influence on the overall economic development of our country [19].

3.1. Production systems:

There are three types of production systems commonly used in mass production apparel are: Progressive Bundle System, Unit Production System and Modular Production System. Each system requires an appropriate management philosophy, materials handling methods, floor layout, and employee training. Firms may combine or adapt these systems to meet their specific production needs. Industries may use only one system, a combination of systems for one product line, or different systems for different product lines in the same plant.

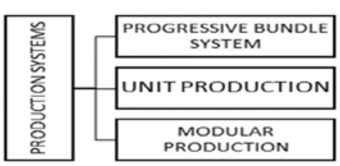

Figure2: Production systems.

3.1.2. Progressive Bundle System (PBS):

As the name implies the bundles of garment parts are moved sequentially from operation to operation. This system, often referred to as the traditional production system, has been widely used by apparel manufacturers for several decades and even today.

Figure3: Progressive Bundle System (PBS) [20].

Bundles consist of garment parts needed to complete a specific operation or garment component. For example, an operation bundle for pocket setting might include shirt fronts and pockets that are to be attached. Some firms operate with a standard bundle size, while other firms vary bundle sizes according to cutting orders, fabric shading, size of the pieces in the bundle, and the operation that is to be completed. Bundles are assembled in the cutting room where cut parts are matched up with corresponding parts and bundle tickets. Bundles of cut parts are transported to the sewing room and given to the operator scheduled to complete the operation. One operator is expected to perform the same operation on all the pieces in the bundle, retie the bundle, process coupon, and set it aside until it is picked up and moved to the next operation.

3.1.3. Advantages:

- This system may allow better utilization of specialized machines, as output from one special purpose automated machine may be able to supply several operators for the next operation.
- Small bundles allow faster throughput unless there are bottlenecks and extensive waiting between operations.

3.1.4. Disadvantages:

- Slow processing, absenteeism, and equipment failure may also cause major bottlenecks within the system
- Large quantities of work in process. This may lead to longer throughput time, poor quality concealed by bundles,
- Large inventory, extra handling and difficulty in controlling inventory.

3.2. Unit Production System:

A unit production system (UPS) is a type of line layout that uses an overhead transporter system to move garment components from work station to work station for assembly. All the parts for a single garment are advanced through the production line together by means of a hanging carrier that travels along an overhead conveyor. The overhead rail system consists of the main conveyor and accumulating rails for each work station. Carriers are moved along the main conveyor and switched to an accumulating rail at the work station where an operation is to be performed. At the completion of an operation the operator presses a button, and the carrier moves on to the next operation. Most unit production systems are linked to a computer control center that routes and tracks production and provides up-to-the-minute data for management decisions. The unit production system transports all the pieces of one complete product through the manufacturing process. An addressable product carrier takes all the pieces of one entire unit (i.e., for trousers - backs, fronts, pockets, etc.) through the different steps of production. Operations are performed at individual workstations. The end result is a cost-efficient product, processed from pieces to completion.

Figure4: Unit Production System [20].

3.2.1. Workflow in Unit Production System:

- Load all the pieces in a product carrier
- The product carrier with the pieces will be routed through the different operation steps
- At every machine/operation the patented chain will position the product ideally
- Completed product arrives to an unloading station. The empty product carrier returns to the loading station.

3.2.2. Advantages:

- Improved lead times - less Work in Process.
- Improved space utilization,
- Increased productivity

3.2.3. Disadvantages:

- Highly expensive - equipment and Cost of installation
- Specialized training for the system.

3.3. Comparison between Progressive Bundle System and Unit Production System (UPS):

In industrial garment manufacturing plants various types of sewing systems are installed. A plant owner chooses these systems depending on the production volume, product categories, and cost effectiveness of high tech machines. Among those “Progressive Bundle System” (PBS) is mostly installed sewing system till date. In this production system bundles of cut pieces (bundle of 5, 10, 20 or 30 pieces) are moved manually to feed the line. Then inside the line an operator himself drag the bundle from side table and transfer the bundle to the next Operator after completion of the work. With the advancement of the technology mechanical material transportation systems are brought in the sewing plant. An overhead material transport system, known as Unit Production System (UPS) transports cut pieces hanged in hangers (one hanger for one piece) by automated mechanical transport system. It reduces manual transportation and it has many other benefits against the progressive bundle system.

4. Production strategies in garment industry:

The identified production strategies in garment industry are:

1. Flexible Manufacturing Strategy
2. Value-Added Manufacturing Strategy
3. Mass Customization

4.1. Flexible Manufacturing Strategy:

This strives to be responsive to consumer demand for small orders and short lead times. Flexible Manufacturing Strategy means the capability to quickly and efficiently produce a variety of styles in small production runs with no defects. Industry adopting this strategy should effectively use the new technology and resources. In simple words the manufacturing firm adopting this strategy will operate with the flexibility needed to meet the demands of its consumers and the inherent ability to adapt immediate changes in the apparel market.

4.2. Value-Added Manufacturing Strategy:

This is a quick response strategy that focuses on unnecessary operations handling that do not increase the value of a product which will lead to delay in production. The rationale of this strategy is that each operation performed on a style should add value. Operations such as inspection, bundling and sorting warehousing requires extra time, handling and personnel but the activities do not add any value to the product.

4.3. Mass Customization:

The goal of mass customization is to produce products that can be made-to-order rather than made to plan. Product life cycle is short and the strategy requires processing single orders with immediate turn around. Considering the complexity of many apparel products and the number of processes that a style may require, the equipment, skills, information and the processes must be highly integrated. This may involve single ply cutting, single piece continuous floor manufacturing and integral information technology. The opportunity to have garments fully customized including style, fit, fabric and trim with delivery direct to their home in a few days at a price similar to the mass produced garments. Body scanning technology will be the basis of custom fit. Mass customization will reduce the risk associated with trying to anticipate consumer demand months ahead of point of sale to the ultimate consumer.

4.4. Modular Garments Production System:

A modular garments production system is a contained, manageable work unit that includes an empowered work team, equipment, and work to be executed. Modules frequently operate as mini factories with teams responsible for group goals and self-management. The number of teams in a plant varies with the size and needs of the firm and product line in garments. Teams can have a niche function as long as there are orders for that type of garments product, but the success of this type of garments operation is in the flexibility of being able to produce a wide variety of products in small quantities in garments [22].

Figure 5: Modular Garments Production System.

4.4.1. Advantages:

- High flexibility
- Fast throughput times
- Low wastages
- Improved Quality

4.4.2. Disadvantages:

- A high capital investment in equipment.
- High investment in initial training.
- High cost incurred in continued training

5. A Case Study:

The exploratory study was conducted to understand the characteristics of the Labour market in the selected RMG centres based on the sample survey in the Sewing Machine Operator (SMO) Training Centres. There are two sets of samples, from Rayagada and Paralakhemundi.

[i] The preliminary step is to get the views on the industry from all stakeholders, and to get their ideas on the kind of skills they require in their respective Labour markets. In the field visits, it was observed that there were different types of associations that functioned at Tirpur and Bangalore. The data from the local industrial associations formed the sampling frame for selecting the units for the research, also supported by inputs from committed local trade unions who are in the process of organizing the ready-made garment workers.

[ii] For the study on the characteristics of Labour, a random sample of 96 workers in Paralakhemundi and 120 workers in Rayagada were interviewed using an interview schedule, to elicit the following information- their demographic profile, socio-economic background, their knowledge regarding industry and current employment status, inclination for skill training and their possible affinity to any particular organization.

5.1. Work flow in modular garments production

Modular garments Production System operates as a Pull System, with demand for work coming from the next operator in line to process the garment. Wastage is normal, and workflow is continuous and does not wait ahead of each operation. This increases the potentials for flexibility of styles and quantities of products that can be produced. Teams usually operate as 'Stand-up'or'Sit-down'units. A module may be divided into several work zones based on the sequence of garments operations and the time required for each operation. A work zone consists of a group of sequential garment operations. Operators are trained to perform the operations in their work zone and adjacent operations in adjoining work zones so they can move freely from one operation to another as the garment progreses [21].

Work flow within a module may be with a Single-piece hand-off, Kanban, or Bump-back system. If a single-piece hand-off is used, machines are arranged in a very tight configuration. As soon as an operation is completed the part is handed to the next operator for processing. Operations need to be well balanced as there is usually only one garment component between each operation. Some modules may operate with a buffer or small bundle of up to ten pieces of work between operators. If a small bundle is used, an operator will complete the operation on the entire bundle and carry the bundle to the next operation. An operator may follow a component or bundle for as many operations as they have been trained or until the adjacent operator is ready to assume work on the bundle.

A Kanban uses a designated work space between operations to balance supply with demand. The designated space will hold a limited number of completed components (two or three) in queue for the next operation. If the designated space is full, there is no need to produce more until it is needed or the space empties. This limits build-up of product ahead of the next operation. When the space is full the operator can assist with other operations that may be slow [22].

Garment manufacturing includes number of processes from order receiving to dispatching shipment of the finished garments. A process flow chart helps to understand how raw materials are moved from one process to another process until raw materials are transformed into the desired product (garments).To be noted that a process flow chart made for the garment manufacturing processes will vary based on manufacturing facility and product types. As some companies do whole process in single plant when others do production jobs and other auxiliary processes are outsourced. Based on present apparel industry, garment manufacturing processes are categorized as, Pre-Production Processes, Production processes and Post production processes.

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[i] Pre-production processes - Pre-production process includes sampling, sourcing of raw materials, Approvals, PP meeting etc.

[ii] Production processes - Production processes are cutting, sewing etc.

[ii] Post production processes - thread trimming, pressing, checking, folding and packing, shipment inspection etc.

Example: Pant Making Operation in Garment Industries

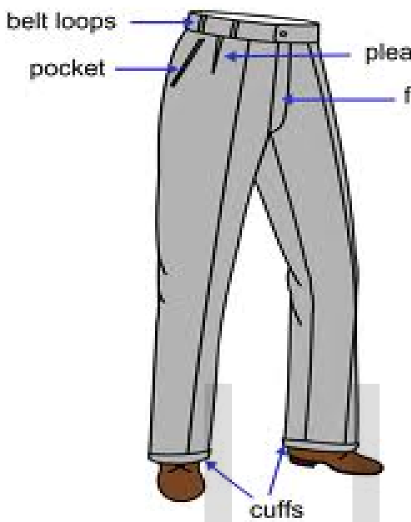

Figure 6: The Anatomy of a Trouser (Pant) [20].

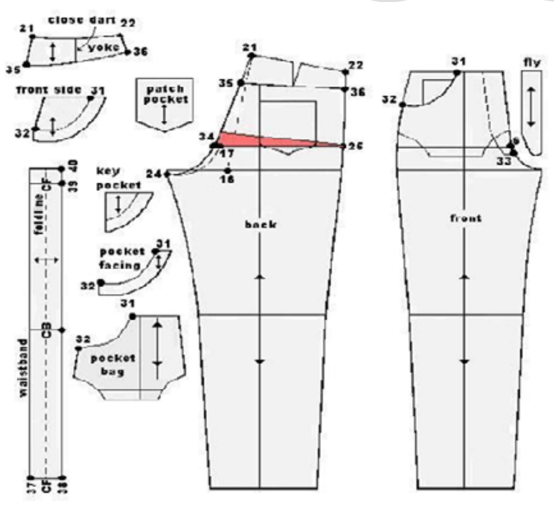

Figure7: The Various Parts Trouser (Pant).

5.2. The Sequential Operation for making one product:

A sequence of operations is involved in making a garment. In bulk garment production, generally a team works in an assembly line (Progressive Bundle system) and each operator do one operation and pass on other operator to do next operation. In this way garment reached to end of the line as a completed garment. In the assembly line after some time of the line setting, it can be seen that at some places in the line, work is started to pile up and few operators sit idle due to unavailability of work.

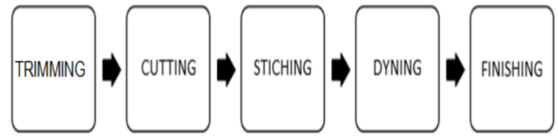

Fig8: The Sequential Operation in Garment Industries.

5.3. Product Assembly Analysis (Conventional/Modular manufacturing):

Number of fabric cut pieces required for making a basic Pant, 21 cut fabric pieces are required.

[i]. Sample calculation for one complete assembly of product (one Pant) in **Conventional Manufacturing:**

Average Number of Parts in one product (Np) = 21

from Equation 2,

Number of modules required for assembly of one product

$N_m = \sqrt{N_{P(0ld)}} = \sqrt{21} = 4.58 \approx 5$ Modules

from Equation 3,

Lead time for complete one product (pant) stitching = 21x10/5+ (5-1) x15=102min., or 1hrs. 42min.

[ii]. Sample calculation for one complete assembly of product (one Pant) by using **Modular Manufacturing concept**:

New number of parts in one product

=0.7*old number of parts=0.7*21= 14.7 or 15 Parts

Number of modules required for assembly of one product $=\sqrt{N_{P(old)}} = \sqrt{15} = 3.87 \approx 4$ Modules.

Lead time for complete one product (one pant) stitching

= 15x10/4+ (4-1) x15=72.5min., or 1hrs13min.

5.6. Results and Observations:

Experiments are conducted for stitching a full shirt with 21 parts. For the conventional stitching the number of modules appears to be 5, with a lead time of 1hour and 42minutes. Using modular concept the parts of the shirt to be stitched are calculated as 15parts with 4 modules only. And the lead time under these conditions is evaluated as 1hour 12 minutes, thus saving further 29 minutes of time.

6. CONCLUSIONS:

The development and application of a modular design for garment manufacturing industry is quite useful, there are three suggested extensions to this work:

(i). A manufacturing modularity measure must be developed to aid the designer in moving towards more modular products;

(ii). A method of balancing the different characteristic modularities should be developed to aid the designer in making modularity decisions; and

(iii).The point of diminishing returns for increased manufacturing modularity should be explored so that the designer knows where to stop increasing relative modularity.

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