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Modular Manufacturing in Garment Industries

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Abstract*— now –a-days global competition in manufacturing and changing customer demand are resulting in a trend towards greater product variety and innovation. Shorter product life cycles lower unit costs and higher product quality (Ralston and Munton1987: Cohen, 1998).a concept of Modular manufacturing to integrate intelligent and complex machines. In large-scale system such as manufacturing system .modularization is indispensable for clarifying logical structure and assuming a high degree of ease of construction. The parts, products and manufacturing equipment as well as the design and operating activity themselves are described in units called modules. A manufacturing system is constructed and operated by combining these building block style. The creation of manufacturing system relies on construction and operating system that enable design and simulation in the virtual world, and production and control in the real world in a unified approach. Hardware modules and software modules and compiled flexibility and hierarchically to fulfill specified tasks. A system in which modular manufacturing as a concept of system integration is applied ready-made garment industries.

Key words—**Product variety, Module, Modularization, Modular manufacturing**

I. INTRODUCTION

Modular manufacturing is based on dividing a certain product into parts, and then manufacturing each part separately. Eventually, these parts are assembled to form the product. Different parts can be manufactured at one place (factory) or at different locations or even in different countries and are assembled together. Modular manufacturing in the industries experienced "the organization benefited overall as the productivity of the line improved by 10%, while labor efficiency improved by 15% and the morale of the employees improved with education, training, open communication and above all, being treated with dignity. Absenteeism had minimal effect on the cell, and employees going on a personal break are supported by the team." It is also emphasized that "any change in the organization stems from top management. and the Commitment from management drives the process of change and nothing can be achieved if management does not support the initiative" Education and training are also being essential: "training of employees in the latest development would enhance employee skills and workers would embrace changes in future open communication apart from building trust among the people which are extremely important". Quality must be designed into the product, not inspected into it. Quality can be defined as meeting customer needs and providing superior value. This focus on satisfying the customer's needs places an emphasis on techniques such as Quality Function Deployment to help understand those needs and plan a product to provide superior value. The benefits of modularization are to be explained to the employees to extract the advantages out of it. The feasibility of applying modularity is an industry is a key factor and it requires rigorous study before shifting for modular manufacturing combinations.

A. The Manufacturing Advantage

Manufacturing is fundamental in providing a competitive advantage to the company. The influence of manufacturing is wide spread and often directly affects the customer. These influences include: high quality production, rapid order fulfilment, keeping delivery promises, timely introduction of innovative new products, providing a range of products to satisfy customer requirements, flexible production volumes and delivery dates to customer demands, and the company's ability to offer products at the right price. The implications of this are that the manufacturing function is central to providing competitiveness and that through a modular strategy, each one of the influences of manufacturing may be facilitated in meeting the five performance objectives of: quality, speed, dependability, flexibility and cost (Slack 1991).
The following manufacturing attributes are

- Quality,
- Speed,
- Dependability,

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- Flexibility and
- cost

A. Quality*:* Products must be produced that meet all of the known requirements and are free from errors. Many initiatives and techniques can be used to provide this capability such as Kaizen, 'right first time' and 'zero defects'. The influence of a modular product, and manufacturing's input into the design help to achieve a high level of quality through modular simplification and parts reduction, ease of assembly, buy in of non-core modules, simplified and reduced verification and test, and the structured approach to the design and manufacture of the product.

B. Speed: A modular approach aids the process of attaining the speed advantage through ease of assembly, reduced tooling requirements, reduced parts inventory, reduced part count, and a reduction in process operations. Modularity also improves the production time by allowing parallel production and test of modules, and also the possibility for late configuration.

C. Dependability*:* Not only should manufacturing be fast, but also be able to keep delivery promises. Thus, manufacturing should be able to meet customer or self-imposed delivery dates with consistency. A modular approach has a number of characteristics that provide this consistency:

- Simplified and flexible assembly implies a consistent throughput
- Modules can be produced in parallel, and configured to an individual order in final assembly
- Modules can be tested prior to final assembly, moving the impact of test upstream
- Products are all analogous, thus production times are similar and new products will be relatively easy to plan, as they will typically be new modules on a common framework.

D. Flexibility: Manufacturing should be flexible in order to vary and adapt to changing customer needs, changes in the production process or supplier changes. Flexibility is a key feature in a modular approach. The use of modules facilitates manufacturing flexibility through the flexibility of the product. A modular design provides manufacturing with the ability to easily meet design changes for customer requirements by meeting specific requirements through a limited number of modules. Thus changes are limited to the manufacturing processes that deal with these modules leaving the rest of the process unaffected. In addition, planned redundancy in modules or interfaces allows for changes with no modification to manufacturing. Finally, a modular approach deals with flexibility up front in the life cycle so changes are anticipated and allowed for.

E. Cost: This means achieving a price that is lower than a competitor can manage. Meaning that resources must be obtained cheaper and they must be converted more efficiently than the competition. A modular approach can influence the cost of a product by allowing suppliers to produce modules that are not core business. Removing needless capability, the burden of investment in technological expertise, and the time and effort in production and test. Secondly, modular production allows the company to meet the previous four performance objectives and through improved quality, faster production and greater flexibility cost can be maintained at a low level.

II. LITERATURE REVIEW

A. Module Definition

Once the agreed schematic elements and interactions are finalized, the elements are ready to be assigned to a module. This process is one that is so case dependent that it must be done purely intuitively by the team. However the LOM should provide a guide to number and complexity of modules. The process is best approached by assigning one element to one module and then grouping where advantageous. [13] There are also a number of factors in deciding if grouping is advantageous:

a. Interactions*:* Some interactions will be more critical than others, and some may be easier to perform over a distance. Any interactions between elements that is critical may benefit from the elements being grouped as May interactions utilising mechanical movement which is not sympathetic to being made to function over long distances. The benefit is also seen in manufacturing as the process will be simplified if complex interactions are not split over module interfaces. Interactions that utilise digital signals can be easily separated and may allow for benefit from being in separate modules, as in multiplexed systems.

b. Geometric location: Integrating elements that require geometric alignment between them will benefit from being in the same module, as control of the alignment is done in a localised area or by a single component. This will influence the ease of manufacture especially in low tolerance areas, and will thus effect quality and repeatability, or reusability of the modules.

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c. Function deployment: When a single element can implement a number of functional elements of the product the elements can be grouped. This simplifies manufacture i.e. design for assembly (DFA) but may inhibit flexibility as integrated elements will be restricted for use in other products. However there is the possibility of redundancy if advantageous.

d. Supplier capability: A regular supplier to the company may have specific expertise, elements in this area may be grouped to utilise the capability of a supplier to the maximum.

Natural Modules: Groups of elements that naturally complement each other and benefit little from being separate are termed natural modules, such as power supply units and electronic packages. They ease the design process and provide additional advantages to manufacturing. They also benefit quality by preventing the split of closely related functions.

e. Core Business: The grouping of elements into modules that contain features, functions and expertise that fall outside of the core business allows them to be provided by a supplier.

Localisation of change: If change is anticipated in certain elements through, wear, use, obsolescence or fashion, these elements should have their own modules, such that they may be altered, replaced or serviced without affecting the whole, as in printer toner cartridges.

f. Configurability: Elements should be grouped such that the company may combine modules in differing ways to provide variety if desired.

g. Standardisation: Elements that may be useful in a range of products should be grouped so that modules can be standard to the product range. These standard modules may form a generic platform or architecture. A generic architecture provides a standard proportion for each product in a family, and introduces benefits for product design and manufacturing through flexibility. In this regard it is recommendation that design of a product should not only include ideas from previously designed products but also bear in mind future products and how they may be integrated with current designs, components, processes, modules, facilities, and tooling etc.

h. Manufacture: Elements that can be combined into a single module by a different manufacturing process such as injection moulding or casting can be grouped, as can elements that require the same manufacturing technique. This can be further extended to the grouping of elements composed of similar materials, not only for ease of manufacture but also for recycling purposes. Elements that can be grouped to provide modules that encapsulate the key features of the product (i.e. not the generic modules) will aid manufacturing if the design allows for these to be introduced to the assembly process late on. This will also speed delivery time as generic architectures can be made up independent of orders and only customised into the ordered products at the last possible moment.

i. Failure modes and effective analyses: If FMEA studies are carried out early on, or previous data is available, the results may be used to group elements with a view to minimising the failures and their consequence.

B. The Modular Design Process

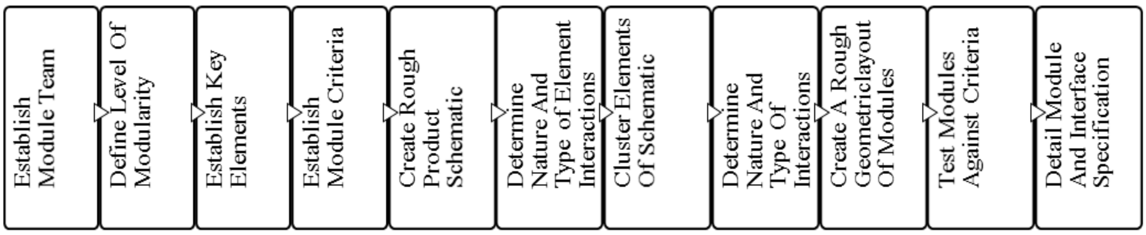

Fig 1: The Modular Design Process

These are requirements upon the system for modular design. It is important that each requirement is determined very carefully as they will have significant impact upon the outcome of the modular design process. It is possible that the source of the requirements will come from many areas, such as; customers, the company's corporate strategy, company departments, and the team itself, all requirements must be collected and considered for the module criteria. The result is a list of module criteria that function as a design specification.

Step-1. Establish Team.

The initial priority is to establish a multi-disciplinary module team to develop the product. Team members must be familiar with product function as seen by the customer and should be aware that modularity is not just decomposition of a product but that the key is to maintain a total view whilst dealing with specific modules. The team must be co-located, properly resourced, allowed to communicate freely and have responsibility for their strategic direction. The module team may be based around a core project team, but for a complex product likely to contain many modules, individual teams may be assigned to individual or small groups of related modules. This facilitates concentration of team members and also allows for parallel working. Each team has a representative that forms part of the main project team. Time must be set aside for regular full project group meetings.

Step-2.Define the Level of Modularity (LOM)

The level of modularity (LOM) must be defined in order to provide a fundamental direction to the process of defining modules. The level of modularity is defined by three factors:

a). Complexity -this is the functional level of modularity for each module. A module can contain anything from a single function to a combination of functions.

b). Resolution - this is the number of modules in the product. The number of modules relate to the complexity, where high numbers of modules will likely have low individual functionality

c). Composition - this is the degree to which complexity varies within a single product, and whether the product is a hybrid of an integrated common modules and variant modules.

Where products with a high LOM exhibit benefits in terms of flexibility, those with a low LOM act as an integrated whole and tend to be products where optimum performance is critical. There are many critical factors in the decision of the level of modularity.

Step-3.Document Key Elements

The documenting of key elements is a process whereby any feature that is important to the product is noted. Key elements may include a particular power supply that is required or desired for some reason, a specific software operating system, a particular product branding to be exhibited, a specific standard or legislated requirement to be met. Though these key elements may appear later in the design brief, the product specification or in the concept designs, this early stage in the actual modularisation phase allows these elements to be considered in the modular scheme. A considerable number of key elements may arise from analysis of existing products (see, Section 5, A6), such as common elements, implementations or modules to become generic throughout the range.

Step-4. Establish the Module Criteria

Module criteria takes the LOM, the key elements, and adds to them specific module requirements. Module criteria are features and functions that are deemed necessary, or essential by the modularity team. Module criteria act as a focus, a reminder and as a benchmark for the design of the modules. Module criteria will be analogous to system and design requirements e.g. can be tested, Self-contained, Clear access, totally interchangeable. Traceability and weighting (e.g. mandatory, important, and desirable) should be indicated against requirements. This allows actions to be traced to requirements and also trade-offs to be made if required.

Step-5. Create a Rough Product Schematic

Having determined the requirements these are then translated into an initial form for the product. This is done through a diagrammatic representation which represents the agreed understanding of the constituent elements of the product. A schematic is developed using a familiar technique such as FAST diagrams (functional analysis).

Step-6. Determine Nature And Type of Element Interactions

Interactions between elements are determined to understand the implications of manipulating the elements. The interactions are defined using the product element interaction chart.

Step-7. Cluster Elements of the Schematic

Once the agreed schematic elements and interactions are finalised, the elements should be assigned to a module. This process is one that must be done purely intuitively by the team but there are a number of points that can be used for guidance. The level of modularity that was defined earlier provides a guide to the number of modules that will be acceptable. The easiest process is to start with a schematic of one element per module and then group elements where advantageous.

Step-8. Determine Nature And Type of Module Interactions

Once a satisfactory grouping of elements into modules has been performed the nature and type of interactions between modules must be identified. It cannot be taken that the interactions will purely be combinations of those between elements determined previously. The interactions that we are considering here are those at a higher level than the element interactions and will arise due to the physical implementation of the functional elements or due to the geometric arrangement of the modules. These interactions will probably not appear on the schematic and must be identified to ensure that any detrimental effects may be removed.

Step-9. Create A Rough Geometric Layout Of Modules

Once the elements of the schematic are grouped into modules and the interactions determined, a geometric layout should be created using drawings, CAD, or foam mock-ups. This model forces the team to consider if the

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groupings can be realised geometrically, and to optimise the manipulation of the modules with respect to the interactions, and to many of the criteria highlighted in the grouping of elements. As with the schematic a number of layouts should be made in order to try out differing solutions. Depending on the results of these layout trials, the process of grouping the elements may have to be revised.

Step-10. Test Modules against Criteria

Having determined the rough module list, modules are tested against the criteria defined earlier. This acts as a check to ensure all desirable criteria are included or considered in the module design. This is especially important in complex products where addressing the details may make the team lose sight of the overall desires. Those modules not meeting the criteria must be looped back and the process performed again. Any particularly advantageous grouping that is in conflict with criteria may also require the criteria to be addressed. If modules contradict a nonessential criteria there may be compromise in the interest of the overall product.

Step-11. Module and Interface Specification

When the grouping of elements has formed modules, the modules have been checked against the criteria and the interactions between modules defined, detail specifications must be drawn up for both the modules and the interfaces. These specifications will form part of the standard product design specification but will document the detail regarding a modular architecture.

Interactions documented in the specifications are very important and may be used to structure and manage the remaining development activities. Modules that have many interactions should be developed by a single or few groups that are closely tied. Modules that have few or no interactions can be developed by an independent team or by an outside supplier. If a module is to be developed in isolation there must be strict specification of interfaces with other modules. A number of general good practice points should also be considered.

- Modules should be as simple as possible whilst adhering to the specification.
- Modules must use as many standard parts and subassemblies as possible.
- Modules must be testable independently.
- Separate specifications should be drawn up for each module.
- Use should be made of bought in modules when a module falls outside of the core business.
- Modules should always bear in mind ease of manufacture and assembly.
- Modules should be capable of assembly without adjustment.
- Modules should make use of standard locating features.
- Modules should make use of existing standards, wherever they are appropriate.

C. MODULAR PRODUCT DESIGN TECHNIQUES

1. Fractal Product Design:

The principles of the fractal factory can also be applied to the design process in terms of design fractals which co-exist, self-organise and self-optimise to achieve a common goal, that of customer satisfaction. They may be further applied to the product structure. Fractal product design is based on a product structure composed of product fractals. Product fractals are independent modules with a precisely defined functionality. Product fractals are also self-similar in terms of having standard mechanical and information interfaces. Thus product fractals may have dissimilar components and structures, but will maintain the same inputs and outputs (Warnecke, Schneider, and Kahmeyer 1994). The IPA has developed a five step approach to fractal product design and is currently being implemented into a number of industrial projects.

A. Product analysis: Analysis of product range, product structure and functional structure.

B. Conceptual design of alternative product fractals: Development of alternative fractal product structures and morphological documentation of alternatives.

C. Conceptual design of fractal interfaces: Development of alternative standardised interfaces for product fractals.

D. Fractal assessment and validation*:* Quantified assessment of the developed product structures with respect to: function, quality, manufacturing, assembly, disassembly and recycling.

E. Fractal redesign and optimisation: Redesign and optimisation of the developed product fractals based upon classical redesign tools including: DFA, DFM, FMEA, and QFD.

2. Modular Function Deployment

Development of product modules has been carried out by a Swedish partnership of the Department of Manufacturing Systems at the Royal Institute of Technology, and the Institute of Production Engineering Research, in Stockholm. The results from a study of seven companies who had changed from an integrated product to a

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product divided into modules proved to be encouraging enough to develop a method for identification of modules (Erlandsson, Erixon and Östgren 1992). The study concluded that there were six reasons for modularising a product:

1. Development. Parallel design of modules, simplified planning, use of carry overs.
2. Manufacture. Common modules, rationalised material handling, reduced rework.
3. Product variants. Variant modules allow adaptation of products for customer requirements.
4. Purchasing. Ability to buy in complete modules, reduced logistics costs.
5. Exchangeability. Upgrade, maintenance and rebuild all simplified.
6. Miscellaneous. Possibility for simpler recycling, and parallel manufacture.

The method consisted of seven stages and was carried out by a team who developed two QFD matrices and a Pugh (1990) concept selection matrix (Figure 2. -Erixon & Östgren 1993). Having identified modules, interfaces were identified and the most suitable modular groupings were selected and modules and interfaces analysed using DFA. A later development was used to synchronise the planning of product introduction with manufacturing system changes. This enabled a long term strategic product assortment to be defined (Erlandsson & von Yxkull 1993).

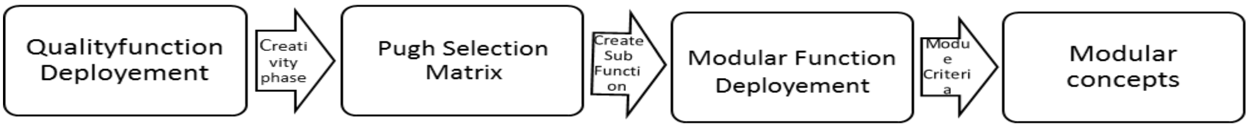

Fig 2. The Method for Developing Modular Concepts

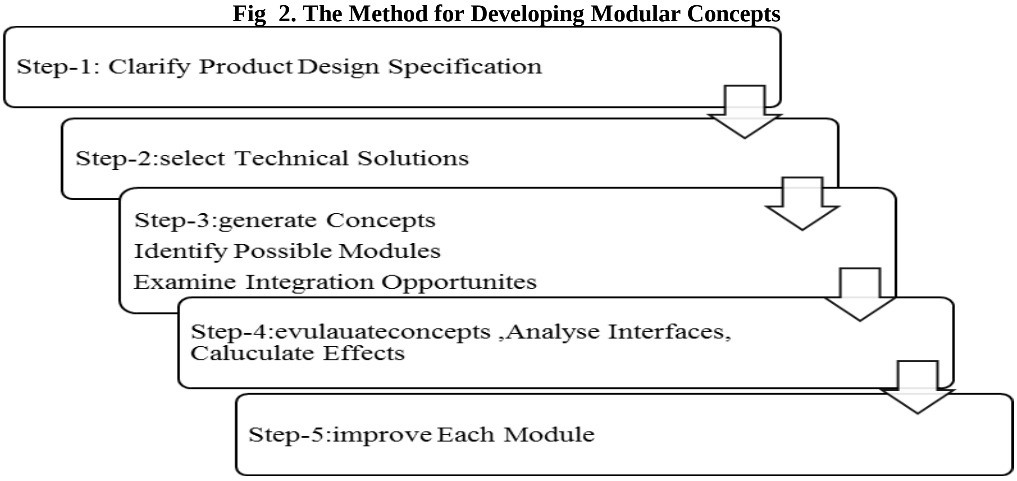

Fig 3. Design for Modularity - MFD Flowchart

After completion of stage 3 and the MIM, modular concepts are evaluated against the so-called universal virtues - cost, time, quality, efficiency, flexibility, risk and environment (Olesen 1992) Including lead times in development and assembly, development, system and product cost, quality, development capacity, variant flexibility, service, and recyclability. The metrics are used as a benchmark for a good modular design and centre on the number of parts Np, modules Nm, average part assembly time Tnorm, and interface time Tint in the new product. For a new product objectives are:

$$N_P = 0.7 * \text{Old } Np \ldots\ldots \quad (1)$$

$$N_m = \sqrt{N_P} \ldots\ldots \quad (2)$$

Where

0.7=A Relevant objective for a new concept 70%

N_p = number of parts in average product

N_m = number of modules in one product

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Lead time in assembly is provided by the following equation:

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

$$\text{Objective} = 20 \sqrt{N_p} - 10 \ldots\ldots\ldots\ldots\ldots (4)$$

Where

N_p =number of parts in average product

N_m =number of modules in one product

T_{norm}= average part assembly time (common average part assembly time is 10 seconds)

T_{int} = interface time

[*The above formulas Reference from*

The MEC also provides nine rules of thumb (below) to support the search for the best modular concept. Stage 5 completes the process by application of DFMA evaluations to each module.

- Ensure that every new variant of a module can be used in several product variants.
- Minimise the value: [Nm * total modules for all product variants (Nmtot) * ∑Tint].
- Refine interfaces to minimise final assembly time, aiming for 10 seconds per interface.
- Maximise the share of separately tested modules.
- Maximise the share of carry-over modules and purchased modules.
- Limit the number of different materials in a module (material purity).
- Do not divide a function in two or more modules (functional purity).

III. METHODOLOGY

A. DESIGN METHODOLOGY FOR MANUFACTURING MODULARITIES

It is important to view manufacturing modularity from the standpoint of creating more modular products. This is quite different from designing products with interchangeable or reconfigurable parts. It is also quite different from maintaining form/function independence. Modular design techniques are the crux of this research. It is the goal of modular design to group all attributes with like processes into a single module and decouple them from all other attributes and processes. Creating modular products involves making sure that, at each level of abstraction, the product's attributes are as independent from one another as possible for each level of abstraction of the manufacturing tasks. If a dependency does occur, it should occur within a module. In addition, within a module, every manufacturing process should be similar for every attribute. Part of the goal of modular design for manufacturing involves a one-to-one form/process relationship (independence).This includes maintaining both form/form and process/process independence as well as the relationship between the two. Another aspect of modular products is the similarity of how the module and its components are manufactured (similarity) (Gershenson, 1996-2). Similarity is another perspective on the independence between form and process. For each part of the form (module), the entire module must undergo the same manufacturing processes. The last aspect of modular design is minimizing the different types of interfaces (interchangeability). This is more easily done and common in industry today. Following are definitions and examples of the three facets of modular product design:

a) Attribute Independence: Component attributes have fewer dependencies on attributes of components outside of the module, called external attributes. If there are dependencies, there should be fewer of them and they should

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be dependent to a lesser degree. Attribute independence yields form independence which enables modularity. Attribute independence allows for the redesign of a module with minimized effects on the rest of the product. This makes a product more agile in meeting changing requirements

b) Process Independence: Each manufacturing process of each module has fewer dependencies on the processes of external components. This requires that the manufacturing processes (including all tasks) that a module undergoes are independent of the processes undergone by external components and modules. Once again, any dependencies that do exist are minimized in number and criticality. E.g., two cast parts which are pressed together while still hot to strengthen the connection. If the process of one part changes so that there is a different cooling time, the process of the other component must change so that they can be pressed together at the same time. Processes independence allows for the redesign of a module in isolation in the manufacturing process of a product should change.

c) Process Similarity*:* Group components and sub-assemblies which undergo the same manufacturing processes into the same module where possible. This minimizes the number of external components which undergo the same processes and creates a strong differentiation between modules. E.g., reinforced plastic components for a motorcycle such as rear forks, rear swing arm, wheel and discs can be chopped fibers, woven fabric, continuous lengths of fiber, or a slightly twisted fiber. For design, manufacturing is currently one of the most influential parts of the life-cycle and because it has the largest body of knowledge. Both of these factors facilitate developing a sound methodology. In addition, understanding manufacturing modularity is, in itself, a useful end. Products which are modular in terms of manufacturing have decreased set up costs and decreased change time, better utilize production resources, and decrease scheduling complexity.

IV. MODULAR MANUFACTURING IN READYMADE GARMENT INDUSTRY: A CASE STUDY

The exploratory research which was conducted to understand the characteristics of the Labour market in the selected RMG centres is based on the sample survey in the SMO (Sewing Machine Operator) Training Centres. There were two sets of samples, from RAYAGADA AND PARALAKHEMUNDI

a) The preliminary step was to get the views on the industry from all stakeholders, and to get their ideas on the kind of skills that they find in short supply in their respective Labour market. 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 industry associations formed the sampling frame for selecting the units for the research, also supported by inputs from committed local trade unionists who are in the process of organizing the ready-made garment workers. A pre-tested data capture format was used for collecting information from them.

b) For the research 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. The findings also provide feedback as to the awareness levels of workers regarding other social issues, their attitudes towards organizations of Labour for attending to their common problems and human rights, their expectations regarding such organizational activities, etc.

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

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- **Pre-Production Processes** - Pre-production process includes sampling, sourcing of raw materials, Approvals, PP meeting etc. Read this for further reading on pre-production processes.
- **Production processes** - Production processes are cutting, sewing etc.
- **Post production processes** - thread trimming, pressing, checking, folding and packing, shipment inspection etc. Instead of making a single process flow chart, I have made one chart for major processes and two separate charts for cutting room processes and finishing processes for detailed process chart.

A. The various parts of shirt

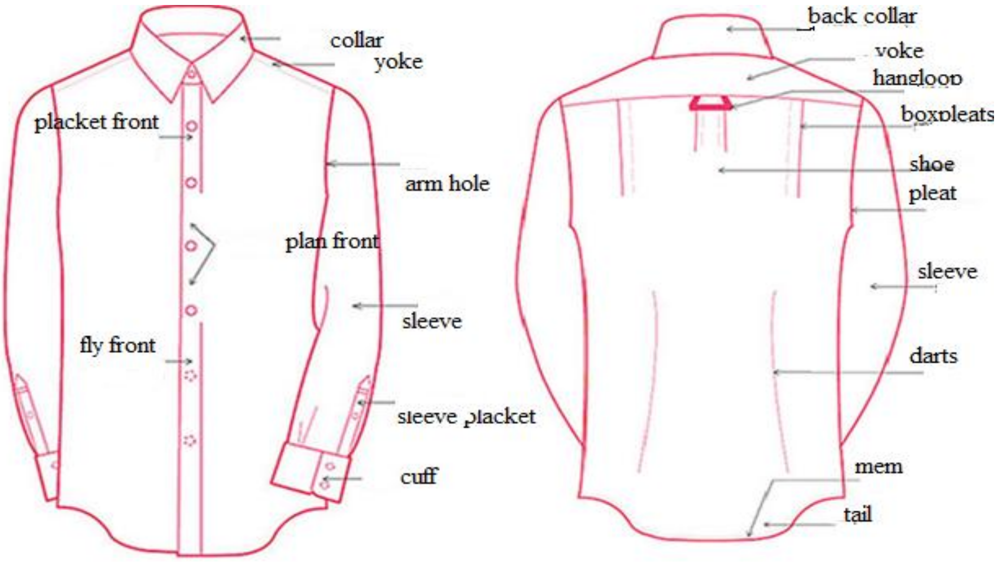

Fig 5: The Anatomy of a Full Shirt [14]

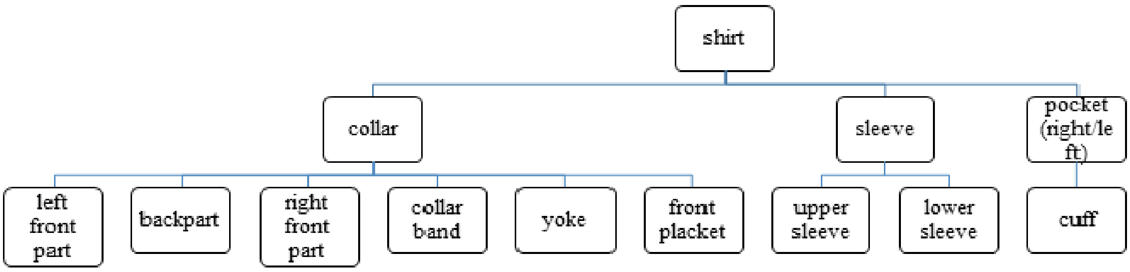

Fig 6:The Hirerchy of A Basic Shirt

V. THE SEQUENTIAL OPERATION

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 give it 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 is found that at some places in the line, work is started to pile up and few operators sit idle due to unavailability of work.

Fig 6: Modular manufacturing implementation process in RMG industry

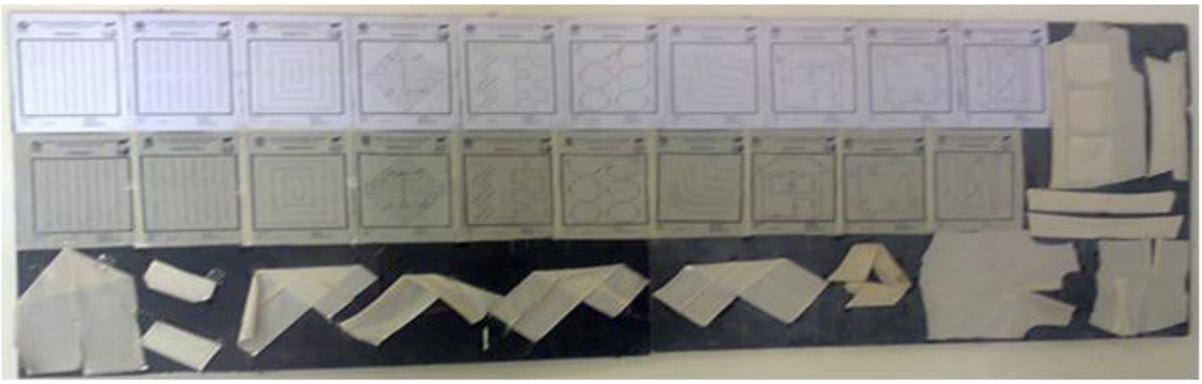

Fig 7: No. of fabric cut pieces required for a basic shirt for making a basic shirt

Fig 8: Different Modules in Garment Enterprises

A modular production system is a contained, manageable work unit that includes an empowered work team, equipment, and work to be executed. The number of teams in a plant varies with the size and needs of the firm and product line. Teams may be used to perform all the operations or a certain portion of the assembly operations depending on the organization of the module and processes required. Before a firm can establish a modular production system, it must prioritize its goals and make decisions that reflect the needs of the firm. With a team-based system operators are given the responsibility for operating their module to meet goals for throughput and quality. The team is responsible for maintaining a smooth work flow, meeting production goals, maintaining a specified quality level, and handling motivational support for the team. Team members develop an interdependency to improve the process and accomplish their goals. Interdependency is the relationship among team members that utilizes everyone's strengths for the betterment of the team.

A. Product Assembly Analysis (Conventional/Modular Manufacturing)

No of fabric cut pieces required for a basic shirt for making a basic shirt, 21 cut fabric pieces are required

a) Sample calculation for one complete assembly of product (one full shirt):

From Equation 1

$$N_P = 0.7 * 21 = 14.7 \approx 15$$

From Equation 2 Objective /goal

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No of modules required Nm = √ NP=√21=4.58≈5 Modules

From Equation 3

Lead time= 21x10/5+ (5-1) x50=218min., or 3hrs. 63 min.

From Equation 4 Objective = 20 √ Np – 10 = 20√ 21 – 10 = 81.65min. Or 1.35 hr.

b) Sample calculation for one complete assembly of product (one full shirt) by using modular manufacturing concept:

New no., of parts =0.7*old no. of parts=0.7x21= 14.7 or 15 Parts
No of modules required =√ NP=√15= 3.87≈4 Modules
Lead time= 15x10/4+ (4-1) x50=187.5min., or 3hrs. 125 min.
Objective = 20 √ Np – 10 = 20√ 15 – 10 = 67.45min.or 1.12hr.

A relevant objective for a new concept is 70% (New Np= 0.7 X old Np), Common average part assembly is 10 minutes (t norm=10min.)10min.operation is easy interface and 50 min. [13]

VI. RESULTS AND OBSERVATIONS

as we were conducted one complete stitching of one fill shirt with no of parts required and calculating time with respect to no of modules by using the above formula and also calculating lead time and as well as goal for stitching time and at the same time by using this new modular design technique we were calculating lead time and the goal for stitching one complete shirt. And through observation we were compare the time taken for one complete assembly of shirt for conventional we got 1hr 35 min. and through modular manufacturing 1hr.12min. So 25 minutes saved by using design of new modules for making one complete stitching shirt

VII. CONCLUSIONS

The benefits of modular design for manufacturing centre around extending the elements of flexibility and economies of scale that modular products have used to greatly increase the end user value. "[I]incorporating flexibility, modularity, and adaptability into design to provide additional freedom to adjust and adapt to change" (Shah, 1996).The benefits of manufacturing modularity include: "streamlined suppliers, reduced inventory, fewer works in process, [and] faster process time..." (Ishii, 1995), as well as component economies of scale, ease of product update, increased product variety from a smaller set of components, and decreased order lead-time (Ulrich, 1991).

While the development and application of a modular design for manufacturing methodology is quite useful on its own, there are three suggested extensions to this work:

1. A manufacturing modularity measure must be developed to aid the designer in moving towards more modular products;
2. A method of balancing the many different characteristic modularities should be developed to aid the designer in making modularity decisions; and
3. 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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