# USE OF CAD AND CAM IN APPAREL MANUFACTURING – A MULTIFACETED APPROACH[1]

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**ABSTRACT**

*Manufacturing industries globally depend on productivity of their processes to create products that can meet the requirements of the customers in the affordable price range.*
*Productivity means producing the maximum output using minimum inputs. The implementation of an integrated CAD/CAM manufacturing system has several benefits which include improved productivity, shorter lead times, reduced personnel requirement, easy customer modifications, improved accuracy of design, reduced costs in the manufacturing process and so on. This article aims at highlighting the use of CAD in apparel manufacturing industry with a multifaceted approach. It focuses in issues related to adoptability this technology in terms of strengths and opportunities along with the challenges faced. An attempt has been made to relate various factors, which come into play for the technology adoption with the help of technology adoption model.*

**Keywords:** *CAD, CAM, TAM, Apparel manufacturing, Technology adoption*

## INTRODUCTION

Garmenting activities are, by and large, said to be labour intensive. In other words, it means that the amount of labour required is huge in garment manufacturing/apparel firms. The labour-capital ratio in apparel sector is 0.85 (Das et al, 2009). While this might be true at the industry level, especially at the firm level at the different garmenting stages, the capital-labour composition would differ in pre-sewing, sewing and post sewing activities after the process of automation since the 1990s. But adoption of improved technology is a complex issue which includes the pattern of ownership and management, the existing utilization of capacity, the requirements and availability of manpower along with the willingness to take risks and other related factors (Society for Economic and Social Transition, 2003). Computer Aided Design (CAD) and Computer Aided Manufacture (CAM) are at the centre of this explosive growth of technology (Konzen& Locker, 2000) as it holds considerable promise for delivery gains in efficiency and quality. CAD is a design tool used for creating garments. CAM is a manufacturing tool that controls automated processes (Gray, 1998; Groover & Zimmers, 1984). CAD/CAM is the application of computers to enhance the manufacture and development of products. The systems allow design to be generated rapidly and adjusted equally quickly without diminishing creativity that provides better communication and integration between product development systems (Istook, 2000). Today, some of the textile and apparel industries employ computer technologies from management to retail and from design to manufacturing (Yan &Florito, 2002).

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The apparel CAD was incepted in 1970 and has evolved into a powerful tool for product development and manufacture as it has developed from early stages of computer modelling to the modernized concept of CAD integration with CAM (Grolier, 1996). The Apparel CAD has received considerable attention in research over the years (Hardaker & Fozzard, 1998), with an aim of saving on production time and improving quality (Disher, 1991; Gray, 1998; Hunter, King &Lowson, 2002; Bae& May-Plumlee, 2005). Even with automation of the system, the industry will require specialized manual intervention and therefore the need for some experts to operate and supervise systems (Kang & Kim, 2000). It is, therefore, crucial to have systems for developing and harnessing the human resource of the industry to their maximum potential.

Advances in technology and computer literacy in specialized fields are an important consideration for the contemporary industries and institutions of higher learning (Gillespie, 1991). Rapid pace of technological advancement in many industries, including the apparel industry, has forced businesses to demand for a computer- literate workforce (Smith & Necessary, 1996). Studies have shown that there are an increasing number of jobs that require the use of computer technologies (Fraser & Goldstein, 1985, MacAulay, 1993). This is because training and education are influenced by the labour market demand. In today's fast, inter-related and versatile economy, employers are looking for productive employees who are quick, creative, flexible and up-to-date with new technology. Employees with these qualities can keep up with changing systems and techniques in the workplace (World Bank, 1999). Textile and apparel industries that adopt or embrace advanced technology and computerization will gain competitive advantage to carry out collaborative research, design and production, marketing and networking with international companies.

An interaction with several leading garment manufacturing companies revealed that there was a low adoption of CAD/CAM system in apparel manufacturing sector due to several factors such as lack of trained manpower to manage the improved technology and the wrong perception about the impact of CAD on the manufacturing efficiency. The rate of adoption of CAD has been slow in the Indian Apparel Manufacturing sector even though there have been many studies that prove that a manufacturing unit taking advantage of the technology have shown better efficiency, improved quality in the cutting room, better grading and marking, reduced wastes and significant improvement in productivity and quality leading to reduction in time spent on pattern making, grading and marker making activities.

## EVOLUTION OF APPAREL MANUFACTURING METHODS

In order to understand the need for CAD in the apparel manufacturing industry, it is necessary to be acquainted with the history of apparel cutting and how, over the years, it has reached the current automated state. In the early 19th Century, garments were made on the basis of the demand of the customers by the tailors. This was made possible by the invention of the sewing machines. It was during this time that the Britishers formulated their drafted paper patterns with a standard size set. A gradual rise of the apparel industry was seen during the 19th and 20th Century with new developments in sewing machines, cutting machines, and the manufacturing facilities as well.

Size charts were a major player in the changing mass production scenario. The wars fought in those days demanded size charts for the arm forces. These were then later then extended to many more categories which finally helped in standardising RTW garments (Aldrich, 2004;). The fourteen countries, which include the USA, Canada, Mexico, The UK, France, Spain, Germany, Korea, China and Australia, have successfully completed national sizing surveys and have their own size charts. As for India, the apparel industry uses a tweet version of the size chart of the other countries. For better fitting RTW garments, a project was sanctioned by the Ministry of Textile, government of India, under the Research and Development Scheme to develop size charts based on the body measurements of the Indian population.

The aim of the project, 'India Size', is to measure 25,000 people between the age of 18-65 years in 6 different regions of India using 3D body scanners. The survey includes statically measuring relevant sample size pan country, using technology that is safe for the humans to make the measurements, a non-contact method of taking the measurements and finally analysing the collected data to create the Indian size chart. This again is possible with usage of technologically advanced methods.

Daniel (2012), indicated that CAD/CAM technology appears to be improving. 2D CAD increases communication speed. It also discuss about the issues regarding human interaction, technology education and individual communication enhancements. Charlie (2004) attempted to provide a solution for the design automation of customised apparel products. A surface flattening algorithm was developed to convert 3D designed cloth pieces into 2D related patterns for manufacturing. Chin (2002) presented the key findings on the adoption of automation systems and strategy choices and their reliance to the transformation of apparel operations and business in Hong Kong. Cynthia (2001) evaluates the need for customization or mass customization strategies in the apparel sector. To obtain accurate physical measurements, a basic knowledge and set of skills are required that are not often found in the average salesperson at a retail clothing outlet.

## STAGES OF APPAREL ORDER PROCESSING

- Garment Sampling: it is the process of making a prototype of a garment. The buyer sends a style specification with a sketch of the garment to a supplier's factory prior to production.
- Apparel Merchandising: the merchandising process involves learning the customer's requirements, developing garments based on those requirements, sourcing the required material for production, scheduling and execution of activities, and getting products made as required by the buyers.
- Garment Costing: this process involves preparing a costing sheet and collecting quotations from all the suppliers of raw materials as well as taking into consideration the Cut and Make costs and the factory overheads.
- Order Booking: a factory may get an order for a sample submitted to the buyer or a new design altogether. Once the order is received, the bulk production commences.
- Pattern Making: the initial patterns of a design which are made at the sampling stage wither manually or by using the CAD/CAM system
- Sourcing of fabrics and trims: the process of acquiring all the raw materials required in the production of a particular style or a particular order.
- Fabric inspection: once the fabrics and trims have been sourced, the fabrics need to be checked for faults. This can be done manually or through automatic checkers.
- Textile testing: The quality of the fabric is an important factor for the quality of the garment. Tests are carried out to check if the fabric meets the required specifications and standards for a particular order.
- Production planning and control: This process involves planning of production activities, scheduling of tasks and execution of the plan. To meet the delivery deadline and control unnecessary procrastination in starting the production and other activities, factory prepare production schedule.
- Fabric cutting: the fabric is cut according to the marker prepared during the marker making process. The cutting process involves various sub-processes, such as fabric relaxation, layering, marker making, cutting, sorting and bundling and the numbering of plies. The cutting master makes a marker on the top fabric ply.
- Garment sewing: once the cutting is completed, the cut components are shifted to the sewing section. Here the operators sew the pieces together after which they are checked for any defects. They are then sent for finishing and packaging.
- Garment washing: garments are washed as per the requirements of the buyer. Washing not only mean to clean the garment, it may also entail imparting a certain look to the garment.
- Garment finishing: in this the garment is checked for the final time for any visual defects and measurements. It is then steam ironed and packed as per the packaging instructions.
- Quality Control: Quality checking is performed at each stage of garment manufacture and included the checking of fabrics and trims, the checking of patterns and cut panels, the checking of garments in line and at the end-of-line.
- Shipping: The shipping department initiates the preparation of shipping documents. The final inspection report and final packing list are sent to buyer's merchant. Once factory receive approval of shipment dispatch, they sends the approved shipment to the shipment forwarder.
- Garment printing: Printing can be done in the garment stage as well but is mostly done on knitted and Polo T-shirts.

- Embroidery work: this is a value added process in garment manufacturing which cane done once the panel are cut for stitching or once the panels have been stitched into a garment.

## STAGES OF APPAREL MANUFACTURING INVOLVING MAJOR APPLICATION OF CAD/CAM

The major role played by CAD/CAM are in the below mentioned stages of apparel manufacturing. One needs to understand the importance of each stage in order to appreciate the usage of CAD/CAM there.

Pattern making: The first and foremost stage of garment manufacturing is cutting all the parts of a garment on paper. These are in 2-D format and the exact shape and size of the various parts that are needed to make a particular garment. These are used to guide the person cutting the fabric so as to cut the fabric in the given shape so that when the fabrics are sewn, the 3-D shape of the garment takes place.

Marker planning: Marker making is the systematic arrangement of all the patterns required to make garments of a single size or of multiple sizes. This is done to achieve technical specifications like the drape, appearance, but mostly to reduce the fabric consumption as much as possible. Markers can be made manually but is a tedious process. The garment industry began with marker making on paper and then later shifted to computer aided markers. This process has multiple solutions and is an open process with a possibility to always better the existing solution.

Computer aided design in the cutting room: There are companies across the globe that provides apparel CAD solution. Apparel CAD was introduced in the early 20th Century and there has been rapid growth ever since. Main functions of the complete CAD package are pattern making, digitizing of patterns, pattern grading, and marker making, and plotting. (Glock& Kunz, 2000). The latest versions of CAD are 3D trial process and scanning of patterns by a camera. The functions of apparel CAD systems are:

i. Making the first pattern: The first pattern for a garment style is developed on the computer using the working area provided by the CAD system. With basic training, an operator can start working on a system and gradually learn all the tools as he continues to work on it. It is easier to measure curves accurately and match seams and curvatures if two mating parts using the CAD system.
ii. Digitization of patters: Digitisation is the process of feeding the patterns which are on paper into the memory of the computer using digitising boards and digs pens or dig mouse. These digitised patterns are then available for modifications. However, even this process is getting further automated where companies are coming up with cameras that will scan the paper and make this process easier and faster. Chance of errors in capturing the exact contour of patterns is comparatively less.
iii. Grading: “Apparel Grading is the process of increasing or decreasing the base size pattern according to a set of body measurements and proportion relationships to develop a range of sizes for production”, (Bye et al. 2008). The process, which was done manually before, is now done using the CAD system. With the correct understanding and a fair amount of practice, this can be executed with great precision.
iv. Marker making: This is a simple technique which is extremely useful in easy and fast correction of the marker without the wastage of paper and effort. The computer screen provides a scaled down work area for the operator. The operator can place the patters on the work area and change the positions till he/she is satisfied with the marker area being consumed and the positions of the patterns. In addition to this, CAD system provide the facility for auto makers which are generated by the computers.

## MODELS ENABLING THE STUDY OF TECHNOLOGY ADOPTION

TAM or Technology Acceptance Model theorises that an individual's behavioural intention to adopt a system is determined by two beliefs - perceived usefulness and perceived ease of use. Perceived usefulness is defined as "the degree to which an individual believes that using a particular system would enhance his or her productivity" while perceived ease of use is defined as "the degree an individual believes that using a particular system would be free of effort". Between these two, perceived ease of use has a direct effect on both perceived usefulness and technology usage. In addition, an individual may adopt a technology if he or she perceives it as convenient, useful and socially desirable even though they do not enjoy using the technology.

An extension of this model was proposed, TAM-TAM 2, which encompassed the identifying and theorising about the general determinants of perceived usefulness, that is, subjective norm, image, job relevance, output quality, result demonstrability, and perceived ease of use and two moderators this is, experience and voluntariness. TAM2 presents two theoretical processes social influence and cognitive instrumental processes to explain the effects of the various determinants on perceived usefulness and behavioural intention, and posits that subjective norm and image will positively influence perceived usefulness through processes of internalisation and identification, respectively.

The word manufacturing is derived from the Latin ('manus' = hand, 'factus' =made), and is defined as "the making of goods and articles by hand or, especially by machinery, often on a large scale and with division of labour."

## TECHNOLOGY CHANGE AND MANUFACTURING EFFICIENCY

Jeong-Dong Lee (1998) proposed that the sources of productivity growth can be broken down into two mutually exhaustive components: technological change and efficiency change. Further, Ludovico(1994) mentioned about the impact of new technologies on scale manufacturing industry and shows that there has been a reduction in setting up times and change over costs. While, Walters (2008) reveals a distinction between inherent and integrated benefits from technology. Integrated benefits refer to achievable benefits as a result of technology use in a wider system. The observations also demonstrate that the companies are failing to properly assess the impacts of their technology investments and are not adequately developing internal support.

Taymazshow()observed that there are significant inter-sectoral differences in the rates of technical change and the factors influencing technical efficiency at the plant level. One of the most striking findings of this study is the positive relationship between the plant size and technical efficiency in the cement and motor vehicles industries.

Chia-Hung Sun (2007) stated that in Hong Kong's manufacturing industries, 90% of TFP growth was attributable to technological progress and 10% to technical efficiency improvement. While, Ulrich Doraszelski (2015) concluded that technological change can increase the productivity of the various factors of production in equal terms or it can be biased towards a specific factor. The study directly assesses the bias of technological change by measuring, at the level of the individual firm, how much of it is labor augmenting and how much is factor neutral. Further, Binswanger (1974)expresses that technical change biases have generally been measured in two-factor models using value-added functions. A many–factor generalization of these procedures has various advantages such as Primary factors can be disaggregated into different classes of labour and capital, allowing an investigation of how technical change affects each of the subclasses.

Hao Hong Tan (2008), in his article, 'Cobb-Douglas Production Function', discussed the relationship of an input to outputs. In 1928, Charles Cobb and Paul Douglas published a study in which they considered a simplified view of the economy where production output is determined by the amount of labour involved and the amount of capital invested. Joseph P Kalt(1978) evaluated the technological change factor substitution. In his debate, particular controversy centers around the responsiveness of factor input proportions to changes in factor prices, i.e., around elasticity of factor substitution. Moreover, the topic of aggregate production theory has recently been taking on immediate policy relevance as federal policy makers have begun to respond to claims of an impending "capital shortage."

**TECHNOLOGY UPGRADATION AND EMPLOYMENT GENERATION**

Das et al, (2009) pointed out that there are several factors which inhibit employment generation. One of the reasons for low level of employment generation in the manufacturing sector is low levels of machinery and infrastructural bottlenecks, in addition to lack of a skilled workforce, and rigid labour rules regarding hiring and firing, act as possible deterrents to employment generation in labour intensive firms.

Catherine Morrison (2000) finds that technology has a stronger impact on shifts in labour composition in favour of highly educated workers than trade or outsourcing. Kamal and Ashish Kumar (2013) concluded that information technology is expected to improve the performance of Human Resource Management (HRM) by shifting its focus from administration or personnel management to strategic HRM. The rapid technology changes also ask for HR professionals to get new skills through education, or sourcing HR Professionals who have IT ability.

Acemoglu, Daron(1998)analyses an economy in which profit-maximising firms can undertake both labour and capital augmenting technological improvements. In the long run, the economy looks like the standard growth model with purely labor-augmenting technical change, and the share of labor in GDP is constant. John(1963) put forth the concept of Hicks neutrality in 1932. Hicks-neutral technical change is change in the production function of a business or industry, which satisfies certain economic neutrality conditions. A change is considered to be Hicks neutral if the change does not affect the balance of labor and capital in the products' production function.

David put forth the relation between skill biased technological change and wage inequality. The recent rise in wage inequality is usually attributed to skill-biased technical change (SBTC), associated with new computer technologies. The study reviews the evidence for this hypothesis, focusing on the implications of SBTC for overall wage inequality and for changes in wage differentials between groups.

**STRUCTURAL IDENTIFICATION OF PRODUCTION FUNCTIONS**

Ackerberg D. (2006) explains that production functions are a fundamental component of all economics. The past decades have seen the introduction of a couple of new techniques for identification of production functions. Production functions relate productive inputs (e.g. capital, labor) to outputs. Charles I Jones (2015)views standard production function in macroeconomics as a reduced form and derives its properties from micro foundations. Much of macroeconomic sand an even larger fraction of the growth literature makes strong assumptions about the shape of the production function and the direction of technical change. Further, Gandhi Amit(2011) indicates that the estimation of production functions suffers from an unresolved identification problem caused by flexible inputs, such as intermediate inputs. Gandhi developed an identification strategy for production functions based on a transformation of the firm’s short-run first order condition that solves the problem for both gross output and value added production functions and applies our approach to plant-level data from Colombia and Chile.

The identification and estimation of production functions using data on inputs and output is among the oldest empirical problems in economics. As first pointed out by Marschak and Andrews (1944), a key challenge for identification arises because a firm’s productivity is transmitted to the firm’s optimal choice of inputs, giving rise to an endogeneity issue known in the production function literature as the “transmission bias”. Ulrich Doraszelski(2015) developed a simple estimator for production functions in the presence of endogenous productivity change that allows retrieving productivity and its relationship with R&D at the firm level. Firms invest in R&D and related activities to develop and introduce process and product innovations. By enhancing productivity these investments in knowledge create long-lived assets for firms, similar to their investments in physical capital.

**TECHNOLOGICAL CHANGE AND DISTRIBUTION OF INCOME**

Murray Brown (2013) put forth the reaction between income and technological change. A major obstacle to an understanding of the forces affecting the distribution of income is that much of the theory bearing on the problem has not been susceptible to rigorous tests. The forces which are not adequately quantified are non-neutral technological change, the elasticity of substitution, and the degree of monopoly in products and factor markets. The role of the first two of these forces in determining the distribution of income between capital and labor has been spelled out theoretically in the early 1930's by J. R. Hicks (1932). As is well known, there are two propositions in the neoclassical tradition, which hold that relative shares are the resultant of configurations of non-neutral technological change, the elasticity of substitution, and the labor-capital ratio. The first holds that a factor saving innovation reduces the relative share of income of that factor in all cases. The second maintains that if one factor increases in supply more rapidly than another, and if the elasticity of substitution is less than unity, the relative share of the first factor de-creases. The research added a third proposition: an increase in the elasticity of substitution reduces the relative share of labor provided labor is scarce

## CONCLUSION

CAD/CAM systems in garment manufacturing process give greater flexibility in pattern designing, grading & marker making, reduction in waste, improved quality of cutting room output, reduction in sample making time and significant improvement in productivity and quality. The rapid technological change also helps in greater employment generation and increased income generation.

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