# Computer Integrated Manufacturing Implementation: Benefits and Challenges

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***Abstract:*** **- Toady's manufacturing companies are competing on the international marketplace. Therefore, to remain relevant, they are embracing production philosophies that will enable them to increase their throughput, profitability, and flexibility, by achieving quick response to changes in production, products, process, and equipment. One of such philosophies is Computer Integrated manufacturing (CIM); a manufacturing strategy that integrates CAD/CAM to automate flexible manufacturing, by synchronizing robots, inventory handling processes, work cells, and storage facilities. This paper provided a detailed definition of CIM, before listing the three decisive strategies for its successful implementation, after which the impact of the manufacturing strategy in Electronics Development Institute (ELDI) in Awka – Nigeria was examined. The numerous benefits of the manufacturing process which include but not limited to quicker responses to data-changes for manufacturing flexibility, increased flexibility towards introduction of new products, improved accuracy and quality in the manufacturing process, and improved quality of products were also discussed in detail. After listing the challenges of successful implementation of the manufacturing strategy, the paper noted that the suitability of CIM to the entire aim and objectives of a manufacturing company must be duly considered before the adoption of the production strategy, to ensure that it offers the firm the much needed competitive advantage.**

***Keywords:*** **manufacturing, computer integrated manufacturing, enterprise resource planning, quality, flexibility, accuracy, setup time**

## I. INTRODUCTION

To compete effectively in the ever-increasing global competition, manufacturing companies must endeavor to continuously improve the quality of their products and manufacturing processes. Other improvement areas include throughput, flexibility, as well as reduction in production cost, inventory, and wastes. This explains the need for Computer Integrated Manufacturing (CIM), which has numerous software packages to enable manufacturers to address the aforementioned challenges.

As a major factor in productivity improvement, competence, and cost reduction in manufacturing, CIM is a production strategy that in terms of material and information, enhances the overall performance of a production company through the integration of different software packages. It appreciates that the various stages of product design and manufacturing are interconnected and can be accomplished more successfully by the application of computers, by seamlessly passing the different data needed for different applications from a software to another.

According to Gunasekaren (1997), CIM is the architecture for integrating the engineering, marketing, and manufacturing functions through information technologies, as it entails the incorporation of all the business processes from supplier to end consumer, and can be used as a strategy for Enterprise Resource Planning (ERP) for business-wide level of integration. CIM entails the integration of subsystems like product design, business planning, production process planning, monitoring systems, as well as process automation and controls, to achieve a whole,

Turek (2017), noted that CIM is a system that consists of software that covers many business processes which include integration of automated assignment and reporting of factory floor operations through machine and material handling equipment sensors and software, and also covers enterprise resource planning modules in a manufacturing operation like design, purchasing, inventory, shop floor control, Material Requirements Planning (MRP), customer order management and cost accounting.

The theory of manufacturing data management is the core of CIM information resource management which comprise of both tangible (hardware like computers, printers, communication and storage devices, terminals etc.) and intangible (the information to be processed) aspects. Embracing relevant manufacturing tools like Concurrent Engineering, Flexible Manufacturing, Quality Assurance Scheme, Total Quality Management, etc., CIM applies different methods and approaches to attain enhanced product quality and manufacturing flexibility, reduction of cost, lead time, as well as enhanced manufacturing processes.

As shown in Figure 1, the major elements of CIM include: manufacture, finance, information, marketing, product design, Planning, purchase, etc.

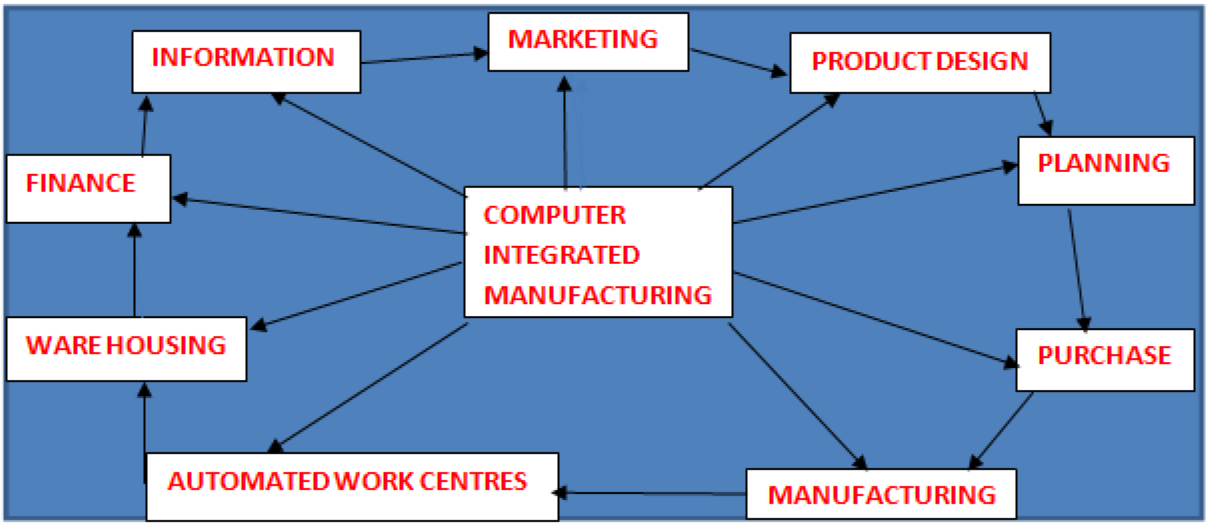


Figure 1: The major elements of CIM

The establishment of automated manufacturing processes through the integration of computers via closed-loop control routes enables CIM to streamline and fasten manufacturing processes, thereby leading to less mistakes and defective products, and the integration of financing, advertisement, marketing, distribution, and accounting to manufacturing.

## II. CIM IMPLEMENTATION AND BENEFITS

The CIM implementation strategy entails three decisive steps: the assessment of the manufacturing company to determine its strengths and weaknesses, the simplification of the entire process in order to determine and possibly eliminate all the wastes that are inherent in the manufacturing process, and purchase and application of hardware and software for the production system.

All functions within a manufacturing facility, such as a factory ranging from manufacturing to distribution can be automated using the CIM system. Here, every process from the production line to the storage and distribution is carefully monitored to ensure maximum efficiency throughout the entire manufacturing process.

According to Masood and Khan (2004), the aim of CIM "is to provide the computer applications and communications needed to bring about the integration (with matching organizational changes) that will allow a company to take advantage of these new capabilities."

They listed the following as the benefits of its implementation: creation of a truly interactive system that enables manufacturing functions to communicate easily with other relevant functional units, accurate data transferability among the manufacturing plant or sub-contracting facilities at in-plant or diverse locations, faster responses to data-changes for manufacturing flexibility, increased flexibility towards introduction of new products, improved accuracy and quality in the manufacturing process, improved quality of the products, control of data-flow among various units, and maintenance of user-library for system-wide data, reduction of lead times which generates a competitive advantage, streamlined manufacturing flow from order to delivery, as well as easier training and re-training facilities.

Also, Abdulghafour (2016), explained that CIM incorporates a common database wherever feasible, and communication technologies to integrate design, manufacturing and associated business functions that combine the automated segments of a factory or a manufacturing facility, as it reduces the human component of manufacturing, and thereby relieves the process of its slow, expensive and error-prone component. He pointed out that it stands for a holistic and methodological approach to the activities of the manufacturing enterprise, in order to achieve vast improvement in its performance.

*The Impact of CIM on the Rate of Quality Production in Electronics Development Institute (ELDI)*

The manual and CIM Ac stabilizer rate of production at ELDI for two different years are depicted in tables 1 and 2 respectively.

Table 1: Manual Ac Stabilizer Production Rate in ELDI (Source: Godwin and Ogbodo 2010)

| **Sample** | 1 | 2 | 3 | 4 | 5 | X | x/n = X | R | X-x =D | S |
|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 5 | 4 | 8 | 11 | 5 | 33 | 6.6 | 7 | 26.4 | 697.96 |
| Feb | 6 | 5 | 8 | 4 | 7 | 30 | 6.0 | 4 | 24 | 576 |
| Mar | 8 | 9 | 9 | 6 | 7 | 39 | 7.8 | 3 | 31.2 | 973.44 |
| Apr | 2 | 1 | 2 | 3 | 2 | 10 | 2.0 | 2 | 8 | 64 |
| May | 5 | 4 | 7 | 8 | 1 | 25 | 5.0 | 6 | 20 | 400 |
| Jun | 7 | 6 | 5 | 6 | 7 | 31 | 6.2 | 2 | 24.8 | 615.04 |
| Jul | 4 | 5 | 7 | 8 | 4 | 28 | 5.6 | 4 | 22.4 | 501.76 |
| Aug | 5 | 2 | 1 | 5 | 2 | 15 | 3.0 | 4 | 12 | 144 |
| Sep | 5 | 6 | 4 | 3 | 8 | 26 | 5.2 | 5 | 20.8 | 432.64 |
| Oct | 6 | 4 | 6 | 3 | 1 | 20 | 4.0 | 5 | 16 | 256 |
| Nov | 1 | 1 | 1 | 1 | 2 | 6 | 1.2 | 1 | 4.8 | 23.04 |
| Dec | 5 | 7 | 3 | 6 | 4 | 25 | 5.0 | 4 | 20 | 400 |

Table 2: AC Stabilizer Production rate in ELDI with CIM(Source: Godwin and Ogbodo 2010)

| Sample No | 1 | 2 | 3 | 4 | 5 | x | X =X | R = x/n | D | $D^2$= S |
|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 43 | 42 | 46 | 49 | 43 | 223 | 44.6 | 7 | 178.4 | 31826.56 |
| Feb | 44 | 43 | 46 | 42 | 45 | 220 | 44.0 | 4 | 176 | 30976 |
| Mar | 46 | 47 | 47 | 44 | 45 | 229 | 45.8 | 3 | 183.2 | 33562.24 |
| Apr | 42 | 43 | 40 | 45 | 43 | 213 | 42.6 | 5 | 170.4 | 29036.16 |
| May | 43 | 42 | 45 | 46 | 44 | 220 | 44.0 | 4 | 176.0 | 30976 |
| Jun | 45 | 44 | 43 | 44 | 45 | 221 | 44.2 | 2 | 176.8 | 31187 |
| Jul | 42 | 43 | 45 | 46 | 42 | 218 | 43.6 | 4 | 114.4 | 30415.36 |
| Aug | 43 | 40 | 41 | 43 | 40 | 207 | 41.4 | 3 | 165.6 | 27423.36 |
| Sep | 44 | 44 | 42 | 41 | 46 | 217 | 43.4 | 5 | 173.6 | 30136.96 |
| Oct | 42 | 42 | 44 | 41 | 44 | 213 | 42.6 | 3 | 170.4 | 29036.2 |
| Nov | 45 | 45 | 43 | 40 | 46 | 219 | 43.8 | 6 | 175.2 | 30695.0 |
| Dec | 45 | 45 | 41 | 44 | 42 | 217 | 43.4 | 4 | 173.2 | 299982 |
| | | | | | | | 523.4 | 50 | | |
| | | | | | | | 12 | 12 | | 336263 |

Calculations for the control limits for X, R, and S-chart

For X Charts:

Upper Control Limit, UCL X = X + $A_2R$

Lower Control Limit LCX = X $-A_2R$

For R Chart

Upper Control Limit, $UCL_R$ = $D_4R$

Lower Control Limit, $LCL_R$ = $D_3R$

For S Chart

Upper Control Limit, $UCL_S$ = $B_4S/2$

Lower Control Limits, $LCL_S$ = $B_3S/2$

## III. RESULT

In the past, during the manual Ac stabilizer production rate, ELDI had a lot of postponed orders due to delay in production. However, with the implementation of CIM in stabilizer manufacturing, remarkable boost in production rate has been recorded. Here, the control charts are used to monitor outputs or inputs of the process, which produces the products, in order to ensure customer satisfaction.

The control charts which depicts the old and new scenarios in the manufacturing company are shown in figures 2 to 7.

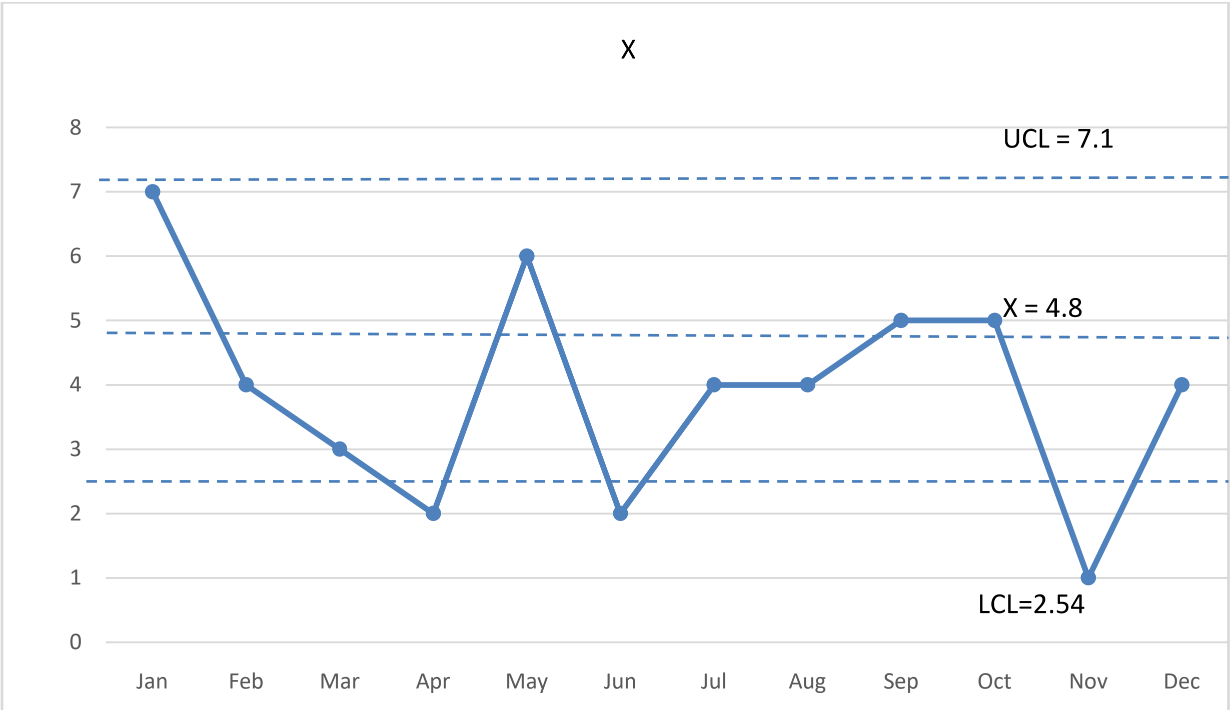


Figure 2: X – Chart for during manual production

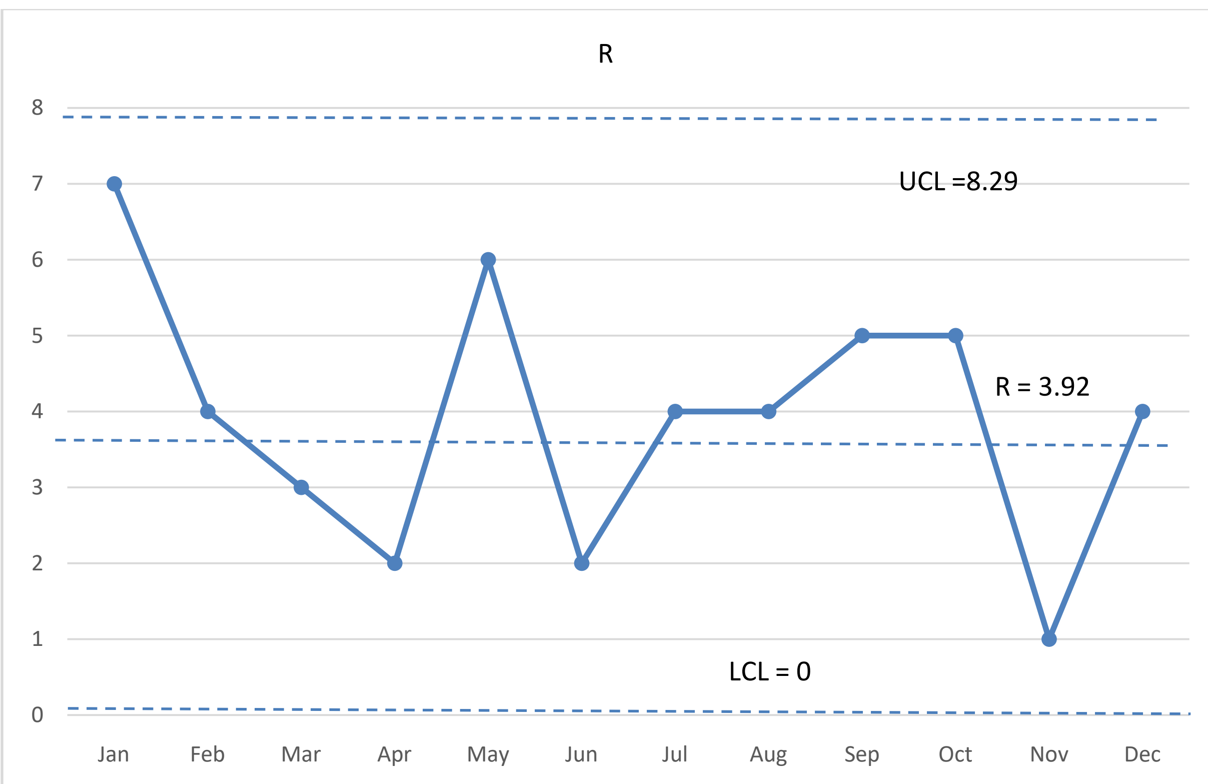


Table 3: R – Chart during manual production

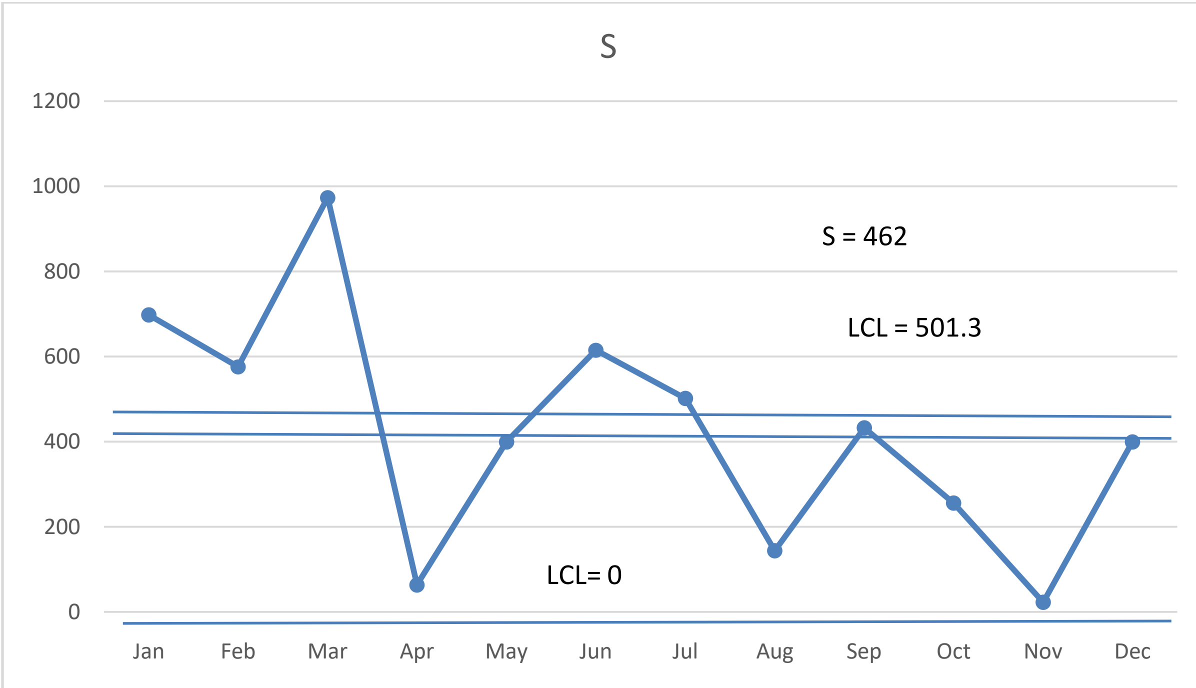


Figure 4: S –Chart during the manual production

The X, R, and S charts depicts the out of control in production with a Peak in March from the S chart; which indicates the upper control limit. This explains why the company's management decided to look better manufacturing strategy, which enabled them to implement CIM in their company.

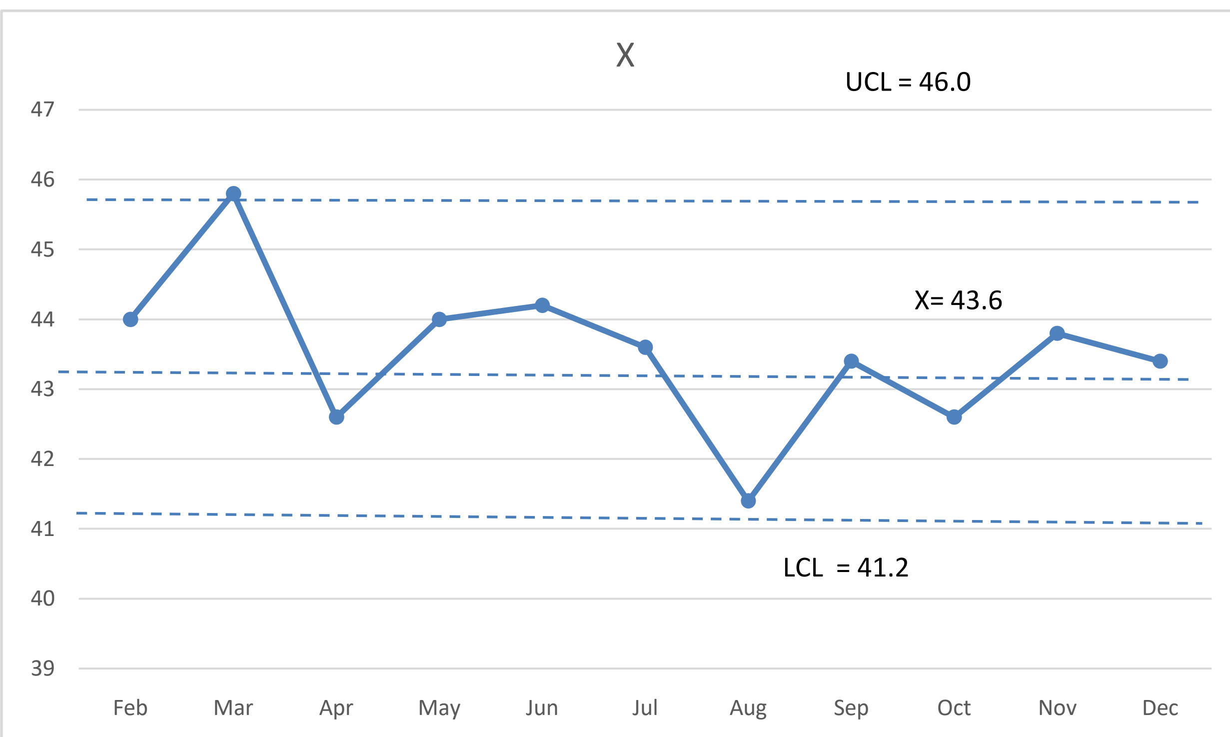


Figure 5: X – Chart after the CIM implementation

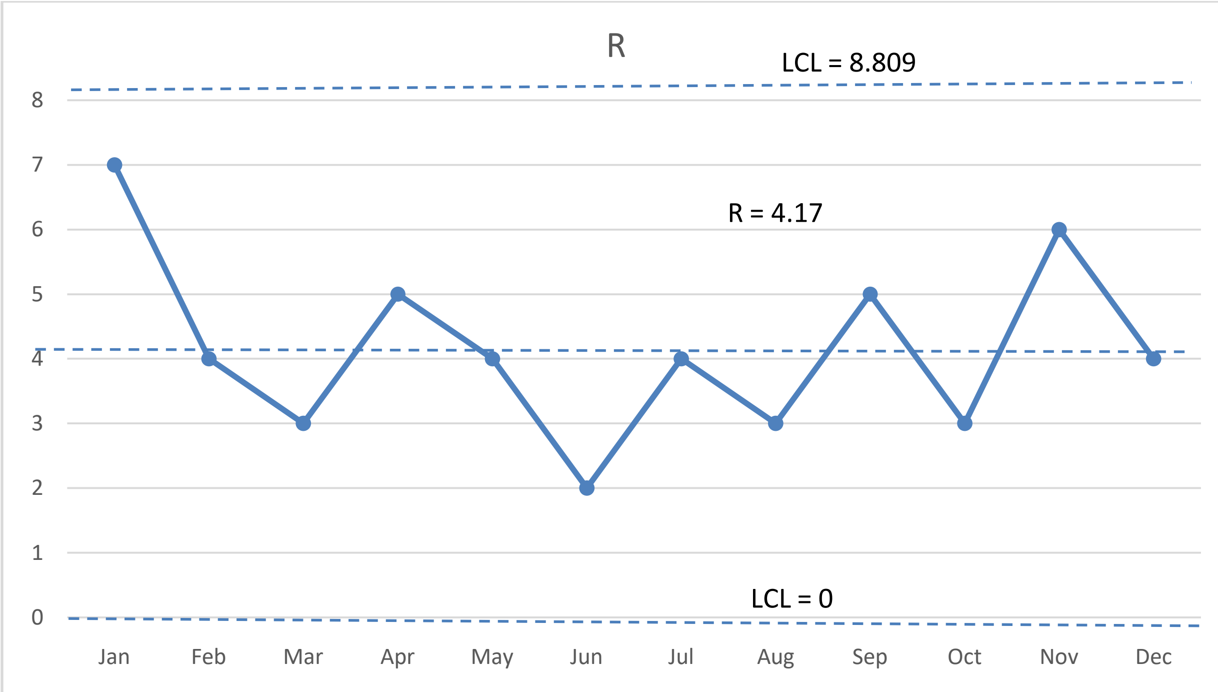


Figure 6: R – Chart after the CIM implementation

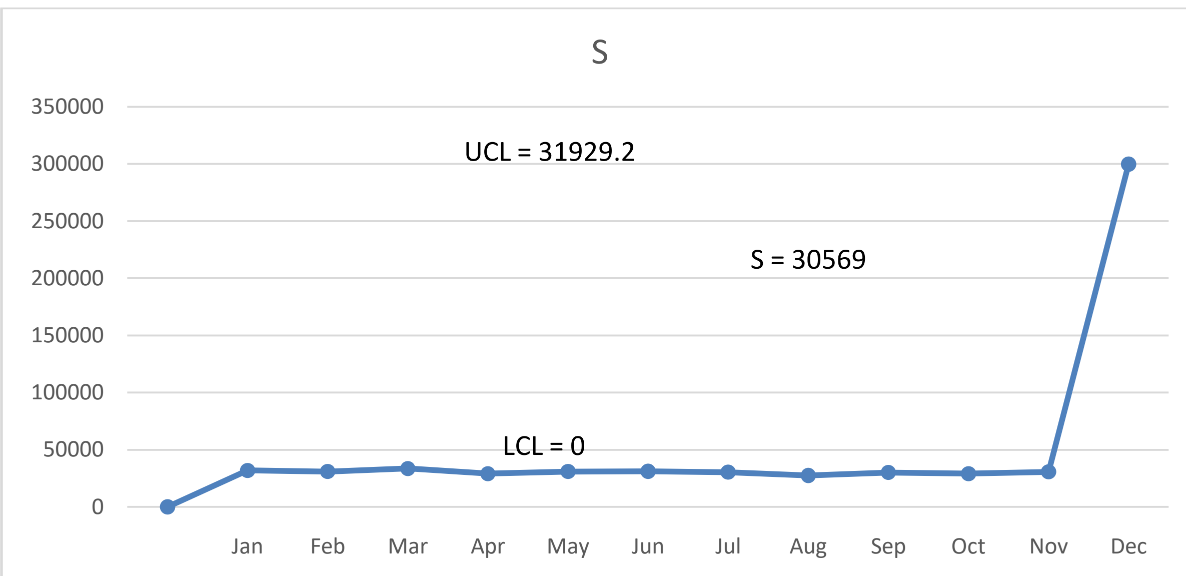


Figure 7: S –Chart after the CIM implementation

After the CIM implementation in the company, the X, R and S charts show processes in control, with highest rate of production (45.8) falling under the upper control limit. Since the processes are in control, the company was able to increase throughput, and also meet up with the customers due date. Hence, the relevance of CIM implementation.

The benefits of CIM include the following:

Cost reduction: with the application of CIM, the effective use of capital resources that arose from the automation of works leads to reduction of wastes and cost of production.

Increase in throughput: the reduction in lead time and product development cycles, as well as improved capital and staff resource utilization which are the hallmarks of CIM implementation, leads to considerable increase in throughput.

Improved quality: in today's manufacturing, where efforts have shifted from achieving customers' satisfaction to exceeding their expectations, CIM which is geared towards the reduction of design and manufacturing wastes, leads to improved quality of manufactured products.

Inventory Reduction: improved degree of integration and flexibility in CIM implementation ensures reduction of excess inventory.

Due to the very important role that CIM plays in the economy of a manufacturing company, Singh (2016), explained that it is for making manufacturing decisions and ensuring that a manufacturing plant maintains correct inventory levels, as plants that integrate the manufacturing process are also able to increase manufacturing efficiency and also enhance scheduling flexibility in the long term. According to him setting up a CIM proves beneficial in the long run because there is little downtime associated with these systems, as its set-up time is lower than alternative systems, which reduces the non-operation time between successive workstations on the line.

He listed the following as the major benefits of CIM implementation.

Error Reduction: Once part, bill of material, inventory and operational information achieve a very high level of accuracy, CIM can perform functions with minimal human intervention and then report on the results automatically, thereby reducing errors.

Speed: CIM environments reduce the time it takes to perform manufacturing fabrication and assembly, thereby allowing faster flow of product to customers and increased capacity.

Flexibility: CIM systems are designed to be entirely paperless, which eliminates the barriers to changing operations. This flexibility, combined with the speed it can be accomplished, allows companies to quickly react to market conditions and then revert to former settings when market conditions change.

Integration: CIM provides a degree of integration that enables the flexibility, speed and error reduction required to compete and lead markets. This is because integrating factory floor operations with enterprise software enables employees to do higher value functions for their firms.

The other benefits of CIM are depicted in Table 3.

Table 3: The Benefits of CIM Implementation. Source: Bakerjian and Cubberly (1989)

| **Reduction in engineering design cost** | **15-30%** | **Increased productivity of production operations (complete assemblies)** | **40-70 times** |
|---|---|---|---|
| **Increased product quality as measured by yield of acceptable result** | 2-5 times of previous level | Increased productivity (operating time) of capital equipment | 2-3 times |
| **Increased capability of engineers as measured by extent and depth of analysis in same or less time than previously** | 3-35 times | Reduction of work in process | 30-60% |
| | | Reduction of personnel costs | 5-20% |

Riley and Cox (1998), pointed out that the implementation of CIM addresses some organizational need such as faster time to market; reduced lead times; lower labor costs; or productivity improvements, as inherent in the CIM application are outlined metrics which allow the manufacturing company to assess whether or not the organizational needs are being achieved.

Also, in their study, Masood and Khan (2004), explained that the benefits of CIM Include: the creation of a truly interactive system that enables manufacturing functions to communicate easily with other relevant functional units, accurate data transferability among the manufacturing plant or subcontracting facilities at in-plant or diverse locations, quicker responses to data-changes for manufacturing flexibility, increased flexibility towards introduction of new products, improved accuracy and quality in the manufacturing process, improved quality of the products, control of data-flow among various units and maintenance of user-library for system-wide data, reduction of lead times which generates a competitive advantage, streamlined manufacturing flow from order to delivery, as well as better training and re-training facilities.

## IV. CHALLENGES OF CIM IMPLEMENTATION

Although the successful implementation of CIM leads to reduction of production cost and enhancement of quality and throughput, it is quite expensive to execute and also entails full commitment of the entire workforce. The suitability of CIM to the entire aim and objectives of a manufacturing company must be duly considered before the adoption of the production strategy, in order to ensure that it offers the firm the much needed competitive advantage.

According to Snyder and Cox (1989), due to the fact that factory automation and integration is a continuous process that requires support from all functional areas, a production firm must first define its specific short- and long-term needs as well as goals before attempting the implementation CIM, as there are many key issues and problem areas that must be addressed if the implementation is to be successful.

Despite the outlined benefits of successful CIM implementation, some of its challenges include the following:

Management's commitment: as the introduction of CIM is quite expensive to execute, it requires the total commitment of a company's management, for the provision of funds and other logistics required for its successful implementation.

According to Attaran (1996), for many manufacturing firms, despite the enormous resources and efforts spent on factory automation, CIM still remains an unfulfilled promise, as executive ignorance and lack of top management support are major barriers to its application. He concluded that this is because CIM is not a quick-fix program that gives an immediate success, but a long-term strategic process that entails a lot of hard work.

Inadequate Strategic Planning: the inability of some manufacturing companies to first of all articulate a comprehensive plan that addresses the firm's strategic needs, before embarking on CIM implementation results to failures. Qadri, Sreshth, and Khandelwal (2015), observed that the success of CIM requires deliberate and careful planning of the technical element in conjunction with training from day one, as lack of understanding of the technology and suitable infrastructures to support the new technology, inappropriate matching of technology to organizational strengths and weaknesses will all contribute to top management's failure to appreciate the benefits of the manufacturing approach.

Organizational culture: For a successful CIM implementation, the entire company's structure should be completely overhauled in order to enhance cooperation and sharing of ideas and information among the various units.

Lack of proper integration: The concurrent integration of the entire parts of an organization during the application of CIM at distinct levels is sine qua non to achieving the benefits of the manufacturing strategy. The integration encompasses the following: product design, procurement, manufacturing processes, products, information and inventory flows, planning, delivery, etc.

Inflexible Organizational structure: flexible organizational structures that are not rigid promotes successful CIM application in manufacturing companies. For a successful CIM implementation, the entire company's structure should be completely overhauled in order to enhance cooperation and sharing of ideas and information among the various units.

Other challenges of successful CIM implementation include: inadequate knowledge of long-term business goals, lack of required technical skills, obsolete equipment, insufficient database, etc.

## V. CONCLUSION

Defined as a system that consists of software that comprise numerous business processes which include design, procurement, control of shop floor, manufacturing processes, inventory, delivery, etc., the benefits of CIM include flexibility, facilitation of concurrent engineering, improved throughput and speed of production, lead time and error reduction, as well as enhanced integration. It is an operational tool that if properly implemented, will provide a new dimensions to competing, quickly introducing customized high quality products and delivering them with unprecedented lead time, swift decisions and manufacturing products with high speed.

The benefits of the manufacturing process include: flexibility, facilitation of concurrent engineering, improved throughput and speed of production, lead time and error reduction, as well as enhanced integration.

Based of the complex nature of the implementation of CIM, manufacturers are advised to implement it different stages like feasibility study, entire and elaborate system design, procurement, application, operation, and maintenance, in order to achieve the numerous benefits of its successful implementation.

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