Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2018, 5(4):405-411**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Cellular Manufacturing System Implementation: A Case Study of Nail Production Company

Okpala Charles Chikwendu, Chukwumuanya Emmanuel Okechukwu, Aguh Patrick Sunday

Department of Industrial/Production Engineering, NnamdiAzikiwe University, P.M.B. 5025 Awka, Anambra State, Nigeria

Abstract The paper examined the challenges that led to low profitability, high scrap rate and production cost in a nail manufacturing company. The results which revealed the wastage of floor space and unplanned plant layout, as well as the wastes of waiting, transportation, excess inventory, and unnecessary movement in the shop floor led to the need for Cellular Manufacturing System (CMS). Referred to as a stepping stone to attaining world class manufacturing repute, CMS which is an application of Group Technology (GT) is a tool and technique of Lean Production System (LPS) that optimizes performance measures like lead time, unit cost, throughput, cycle time, productivity, etc. through enhanced work cells design. After the first three months of the successful implementation of CMS in the company, the resulting improvements for raw materials, work in progress, lead time, manufacturing space, late orders, defects, and scraps were $43,935, $37,650, 3 days, 223 square meters, 26 days, 42.9%, and 40% respectively. Also, the outstanding improvements recorded in throughput or average number of orders concluded per month after the implementation of CMS which enhanced the company's overall profitability is a direct reflection of the benefits of the manufacturing system. Due to the outstanding improvements that led to the reduction in the wastes that were inherent in the nail manufacturing company, as well as the attendant increase in the firm's goodwill and profitability, the paper concluded by advocating the implementation of CMS to manufacturing companies that are bedeviled by similar production challenges.

Keywords Cellular Manufacturing System, Lean Production System, Group Technology, nail production, shop floor, machine, wastes, plant layout

1. Introduction

To ensure timely delivery of customers' ever-changing demands and customization, Lean manufacturing companies ensure the provision of flexible and functional layouts that incorporate quick changeover techniques, as plant layout design and materials' flow play a vital role on manufacturing processes performance.

Acknowledged as one of the remarkable technological innovations for enhancing throughput and competitiveness, Cellular Manufacturing System (CMS) which is an application of Group Technology (GT) philosophy, is a tool and technique of Lean Production System where machines and equipment are properly arranged in order to enhance the steady and uninterrupted movement of materials and tools, through the process of production without undue stoppages and time wastage. It is a manufacturing approach that enables manufacturers to drastically reduce the wastes of waiting, movement, and transportation, as workstations and equipment are properly organized in sequence that enhances the continuous flow of inventory without delay.

Bhat [1], noted that CMS is a production approach that helps in the manufacturing of diverse products with minimal wastes, as equipment and workstations are arranged in a sequence that encourages a smooth flow of

materials and components through the process, with minimal transport and delay. It enables companies to be more efficient and competitive by the drastic reduction of production wastes and lead time, save factory space that could be employed for other value adding processes, and also promote continuous improvements.

Levinson and Rerick [2], observed that "it is only by relating each machine with the others in such a way that production will follow in straight lines without confusion, can the highest economy operation be attained." As depicted in Figure 1, Cellular Manufacturing does not allow easy accumulation of inventory as materials are immediately processed one after the other.

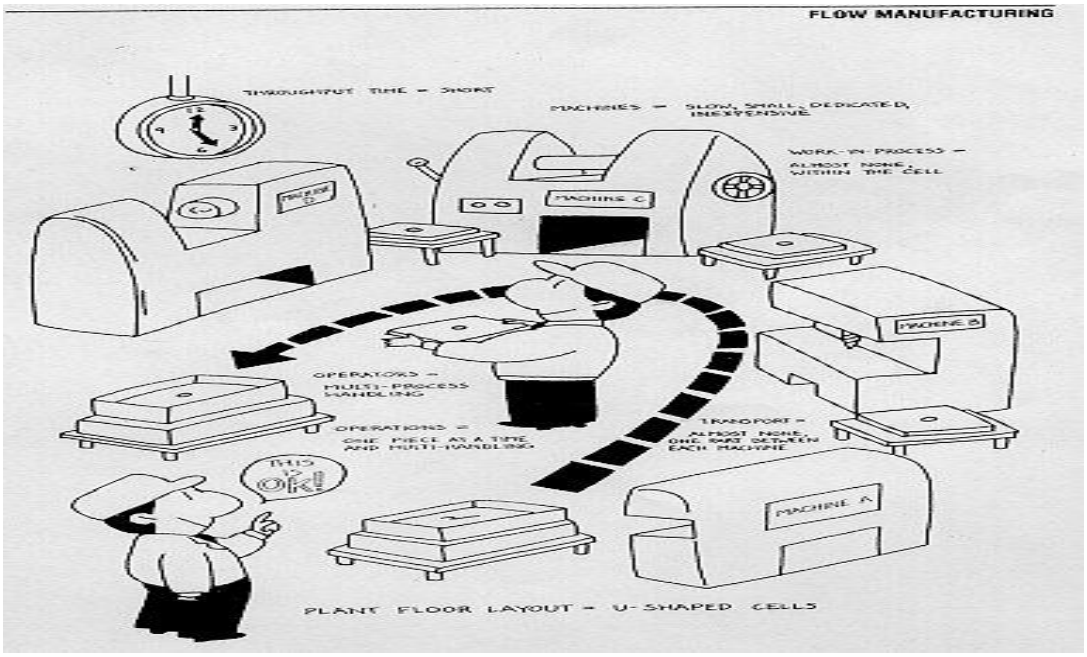

Figure 1: A Cellular Manufacturing plant [3]

According to Inman [4], CM is a hybrid system that links the advantages of a job shop with the product layout of the continuous flowline, as the cell design provides for quick and efficient flow, and the high productivity associated with assembly lines. However, he noted that it also provides the flexibility of the job shop, allowing both similar and diverse products to be added to the line without slowing the process.

2. Benefits and Limitations of Cellular Manufacturing

Cellular manufacturing provides manufacturers an ample opportunity for the integration of the operative of functional layouts with productive product flow layouts, as major systems of production can be divided into cells that comprise of minor subsystems of workstations. Lopez [5], noted that "in cellular manufacturing, products with similar process requirements are placed into families and manufactured in a cell consisting of functionally dissimilar machines dedicated to the production of one or more part families." She noted that by grouping similar products into families, the volume increases justifying the dedication of equipment, thereby enabling cellular manufacturing to warrant much more flexibility than a pure product-flow layout.

The importance of the application of CMS is that it makes electronic layout less complicated thereby allowing for cheap transporting equipment like the conveyors, unlike the functional layout that requires forklifts and very costly automation. The main benefit of Cellular Manufacturing is that it assists organizations to reduce the overhead cost, as an individual worker can monitor and manage series of machines and equipment in a production channel. Also it encourages flexible manufacturing as well as reduces the wastage of shop floor space.

Felix [6], observed that the application of CMS minimizes product movement as well as materials, equipment and labor during the manufacturing process, and that by reducing cycle times and material handling, these cells help shops more easily to meet customer demands regarding cost, quality and lead times. He explained that this is because CMS brings together all of the elements needed to produce a part in one central location, and

typically consists of the machine tools and tooling as well as any automation elements and supplies and the personnel who will oversee the process.

By decreasing the wastes of movement, transportation and waiting through a well-organized layout design, machinists are restricted from unnecessary movements for inventory and further value addition in the work stations, as the required materials and machines are provided close by, thereby enabling a firm to easily attain customer satisfaction in terms of quality, timely delivery, and cost effective.

According to Ihueze and Okpala [7], the main benefit of CMS is that it assists organizations to reduce the overhead cost, as an individual worker can monitor and manage series of machines and equipment in a production channel, as it encourages flexible manufacturing as well as reduces the wastage of shop floor space. However, they regretted that many manufacturers are very reluctant to fully change over to cellular layout in their shop floors, due to its high set up cost, as well as their unwillingness to cease production during the setting up period.

By reducing defective products and scraps that are the consequence of incessant product changeovers, CM decreases wastes that are inherent in manufacturing processes. It also leads to manufacturing cost reduction by reducing the following: material handling, lead time, inventory, tooling and fixtures, as well as setup time. Other benefits include enhanced market response, customer satisfaction, and dependable delivery promises.

With increase in profit at the center of CM, other benefits as shown in Figure 2 include reduction in work in progress inventory, improvement in machine utilization, and improved morale of workers.

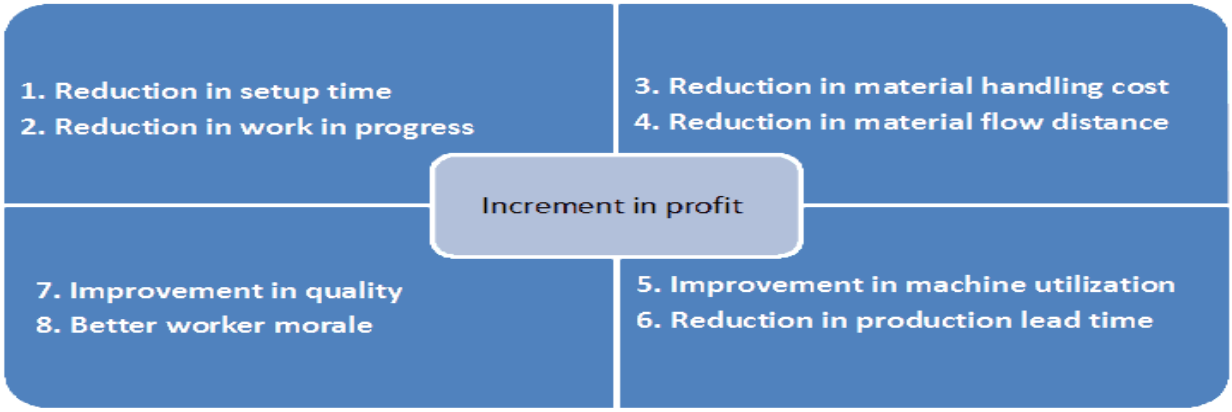

Figure 2: Benefits of Cellular Manufacturing

Although the numerous benefits of CMS have been outlined, there are some limitations associated with implementing the manufacturing strategy. Just like in product flow layout, the breakdown of a machine or equipment often results to stoppage of work in the cell. Also, to ensure high profitability and reduced product cost, large quantity of products are processed in CMS to reduce the expense of purchasing expensive machines, thereby leading to the risk of over-production which is a major waste in Lean Production System of manufacturing.

Other limitations of CMS implementation include: high setup cost, problem of production control, redundancy of non-major machines and equipment, low machine utilization, difficulties in batch size selection and load balancing, and decline in job satisfaction as a result of decline in variety of products that are processed.

3. Nail Production Process

Established about a decade ago and located in the city of Onitsha - South East Nigeria, Company X is an engineering manufacturing company with a wide range of hard ware products. For the purpose of the paper, the research was restricted to the nail production section of the organisation. Several visits to the nail department by the research team revealed that the company's manufacturing processes are bedevilled and characterized by wastes, despite their claim of practicing Lean Production System. To return the department to a profit making venture once again, a detailed research and painstaking analysis were made.

Although nails are manufactured from aluminium, stainless steel, brass, nickel, zinc, silver, copper, as well as iron, the company's main raw materials are low carbon steel, and aluminium. It was observed that the nails are

manufactured from metal wire coils, where the wire is processed by a nail making machine that churns out an average of 13 nails per second. For enhanced strength the nails are later twisted, formed, cleaned, and sometimes coated before packaging.

Figure 3: Metal wire coils

Company X gets their supply of the major nail raw material – cold drawn bright wire from their suppliers in round large bundles as shown in Figure 3. The manufacturing commences with fixing of one end of the wire into a wire stand with the other end in rollers for strengthening, after which a grip pulls the wire to the desired nail sizes. Before the automated cutting of the nail to the desired size by a cutter/grinding machine, the nail head is inserted into the movable mould's rem, where the punch fixed to the head-making mould hits it hard to form the nail head; thereafter the nail is detached from the wire by a mechanized trigger.

At the end of the machining process, the nails are later loaded into a tumbling barrel with iron balls and hot caustic soda for remoulding and polishing, the silvery nails glister after the polishing operation as shown in Figure 4. They are later packaged in 25 kilogram bags for onward delivery to the customers.

Figure 4: The polished nails

Apart from the wire nails making machine that manufactures nails of different sizes, the wire stand, the cutter/grinding machine, and the tumbling barrel, the other machines employed by the company in the manufacturing of nails of various sizes are sharpening mill – for sharpening the steel head before they are fed into the wire drawing machine, the nail knife grinder – for sharpening the grinder, and the butt welding machine – for welding the wire whenever it breaks during drawing.

4. Implementation and Results

4.1. Implementation

Apart from low staff morale that resulted from little or no incentives and the production of low quality nails, the other factors that led the company's management to seek for consultancy services from the research team are low profitability, high defects/scraps rate, and high manufacturing cost. However, the team realized that other issues that impede the firm's success include: wastage of shop space, unplanned plant layout that led to the

wastes of waiting, transportation, and unnecessary movements at the shop floor, waste of excess inventory, low productivity, and low machine utilization.

Having identified the wastes inherent in the company's nail production processes despite their claim of practicing Lean Production, the team insisted on complete overhaul of their manufacturing processes as Lean manufacturing is not a haphazard implementation of just one or two lean tools. Despite their fear of high set up cost, the company's leadership was later convinced on the need to commence CMS in their nail department, in order to complement the other tools and techniques of Lean manufacturing which the company had already adopted.

To successfully implement the recommended CMS, the Group Technology (GT) was adopted, as it categorizes and group identical parts together in order to enhance design and production due to their similarities. As shown in Figure 5, the adopted cellular layout provides a well-organized footing for job shops to design and align the shop floors distinctly from the regular traditional workstation.

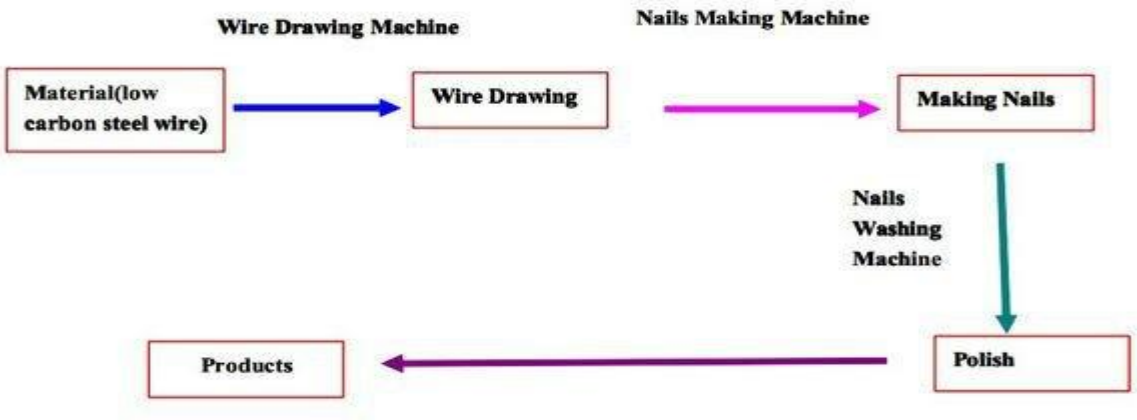

Figure 5: The Flow Chart of Nail Making

Setting up of the optimal cellular layout as shown in Figure 6 reduced the space between cells thereby reducing the wastes of transportation, and movement, as well as handling, which will eventually result to decrease in production costs. The redesigned floor layout is also expected to present for smooth flow of products to shipping, as shipping is positioned nearby the cells in an efficient flow.

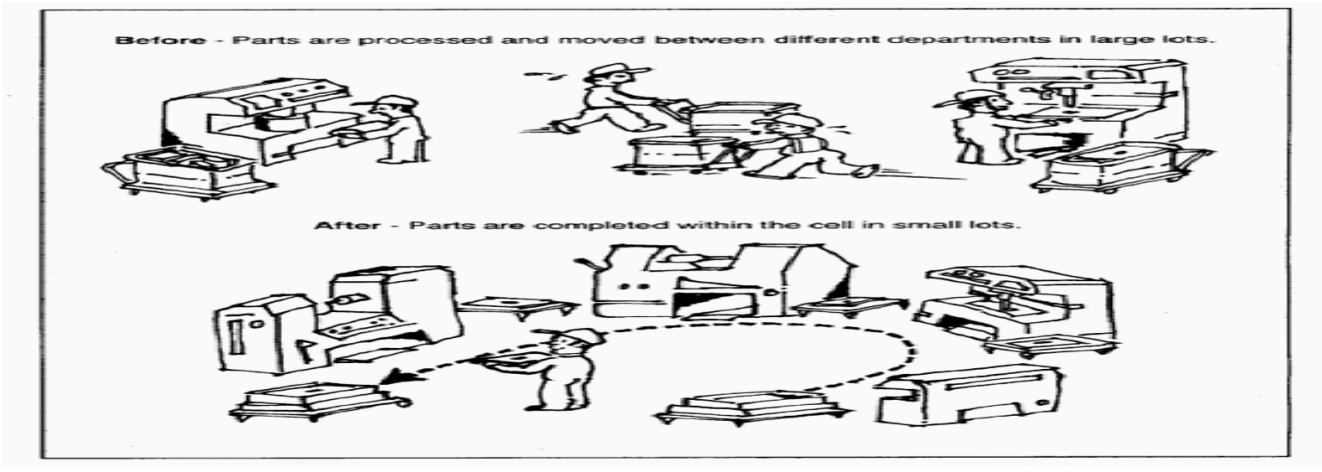

Figure 6: The Former Layout versus an Optimal Cellular Layout

Apart from ensuring that the entire workforce participated in the CM introduction, sound streamlined trainings were also organized for them. According to Irit and Jones [8], cross-training which leads to multi-skilling has been found to have a significant impact in the success of Cellular Manufacturing, as it enhances teamwork and employees awareness to probable quality problems that may arise from machine setup and operation.

Factors that were addressed before the implementation of the manufacturing system in the company include: empowerment of a properly trained staff, improvement of the company's relationship with the suppliers for better synergy and enhanced delivery schedules, and the establishment of continuous improvement culture in the establishment.

4.2 Results

After the first three months of the successful implementation of CMS, the company recorded remarkable accomplishments. As shown in Table 1, some of the results include outstanding reductions in inventory, lead time, late orders, defects, scraps, direct labour, and manufacturing space.

Table 1: The Benefits of CMS after the First Three Months of Operation

Criteria	Before CMS Implementation	After CMS Implementation	Resulting Improvement
Raw materials	$66,850	$22,915	$43,935
Work in Progress	$56,250	$18,600	$37,650
Finished goods	$74,000	$27,433	$46,567
Lead time	6 days	3 days	3 days
Late orders	33 days	7 days	26 days
Defects	7%	3%	42.9%
Scraps	5%	2%	40%
Direct labour	8	5	3 employees
Manufac. Space (Square meter)	380	157	223

The monthly throughput or average number of orders concluded per month before and after CMS implementation are shown in Tables 2a and 2b respectively.

Table 2a: Average concluded number of orders per month before CMS Implementation

Nail Specification	September 2017	October 2017	November 2017
Cooper nail	38	40	36
6 inches nail	56	54	57
4 inches nail	51	51	50
2 inches nail	58	60	61
1 inch nail	38	39	38

Table 2b: Average concluded number of orders per month after CMS Implementation

Nail Specification	December 2017	January 2018	February 2018
Cooper nail	46	50	52
6 inches nail	63	58	75
4 inches nail	50	56	54
2 inches nail	67	71	73
1 inch nail	37	44	43

The remarkable improvements recorded in throughput or average number of orders concluded per month after the implementation of CMSis a direct reflection of the benefits of the manufacturing system.

5. Conclusion

Cellular manufacturing as a tool for achieving a world class manufacturing status was briefly reviewed and applied to company X in Onitsha, Anambra State. A study made on company X in Onitsha revealed that wastes abound in the company's production line. Consequently, adoption of group technology was recommended as an initial step to successfully implementing CMS in the company.

As part of the efforts made while introducing CM to the company, the researchers ensured that the entire workforce of the company participated in all the workshops organized for them. After the first three months of

successfully implementing CMS in the firm, among the results recorded include outstanding reductions in inventory, lead time, late orders, defects, scraps, direct labour, and manufacturing space.

The major challenge encountered during the implementation were stoppages as a result of machine breakdowns, however it was later resolved by the introduction of Total productive Maintenance. Also, the bottleneck experienced at the polish section was resolved with the introduction of double shifts at the tumbling barrel.

By reducing the production cost, the company was able to increase its profitability after the CMS implementation, and most importantly, by increasing throughput and lead time reduction, it was also able to achieve customers' satisfaction, which will ultimately lead to repeat purchases and increase in market share.

Due to the outstanding improvements that led to the reduction in the wastes inherent in the nail manufacturing company, and the attendant increase of the firm's goodwill and profitability, the implementation of CMS is advocated to manufacturing companies that are bedeviled by similar production challenges.

References

[1]. Bhat, S. (2008), "Cellular Manufacturing – The Heart of Lean Manufacturing" [Online]. Journal of Advances in Production Engineering and Management, 3(4).

[2]. Levinson, W. and Rerick, R. (2002), "Lean Enterprise: A Synergistic Approach to Minimizing Waste" ASQ Quality Press, Milwaukee, USA

[3]. Hiroyuki, H. (1998), "JIT Factory Revolution: A Pictorial Guide to Factory Design of the Future" Productivity Press, Massachussets, USA.

[4]. Inman, R. (2017), "Cellular Manufacturing" [Online]. Assessed on 7 April 2018, from http://www.referenceforbusiness.com/management/Bun-Comp/Cellular-Manufacturing.html#ixzz5BzhVJEKt

[5]. Lopez, L. (1997), "Design and Implementation of Cellular Manufacturing in a Job Shop Environment" [Online]. Assessed on 7 April 2018, from https://ocw.mit.edu/courses/sloan-school...manufacturing.../alvarez_thesis.pdf

[6]. Felix, C. (2016), "Advantages of Cellular Manufacturing" [Online]. Assessed on 7 April 2018, from https://www.productionmachining.com/columns/advantages-of-cellular-manufacturing

[7]. Ihueze and Okpala (2014), "The Tools and Techniques of Lean Production System of Manufacturing" International Journal of Advanced Engineering Technology, vol. v, iss.iv

[8]. Irit, A. and Jones, M. (2008), "Lean Supply Chains, JIT and Cellular Manufacturing – The Human Side" Journal of Issues in Informing Science and Information Technology, vol. 5