Design and implementation of cellular manufacturing in a sewing floor of a ready-made garment industry

Md. Isanur Shaikh, Md. Enamul Kabir, S. M. Mahbubul Islam Boby, Mostafa Lutfi

ABSTRACT

The existing cellular systems are dedicated to work on parts of few products. In garment manufacturing the lines are temporarily dedicated to manufacture only one product. Presently each garment manufacturing line behaves as one entity, where empowerment, team work are difficult to be promoted. The research proposes a method for introducing cellular manufacturing in an operating sewing floor. By applying cellular manufacturing to produce garments, a factory can reduce costs, improve quality and delivery performance. The new sub-cell concept changes the organizational culture and makes the production lines more flexible through motivated, cohesive team. The operators are motivated with higher earnings through higher productivity and dignity. The research outlines a method designing and implementing cellular manufacturing, and proposes a cellular layout and performance with an example. The conclusions of the research highlight the key lessons for successful design and implementation of cellular manufacturing in a sewing floor.

Keywords: Lean, Lean tools, Cellular manufacturing.

1. INTRODUCTION

1.1 General

Apparel industries are the most important part of the modern civilized world. Most of the apparel industries of Bangladesh are export oriented. Approximately three-fourth of the national export earnings of Bangladesh are contributed by this sector. But the industries are operated in such an environment that they are the victim of low labor productivity, high WIP, low labor utilization and higher manufacturing cost, excessive manufacturing lead times. The most important task for the industry is to reduce the lead time of garment manufacturing. Modular manufacturing is a model for workplace design, and has become an integral part of lean manufacturing systems. Modular manufacturing is based upon the principles of Group Technology. Successfully implementing Cellular manufacturing allows companies to achieve cost savings and quality improvements, especially when combined with the other aspects of lean manufacturing.

- Md. Isanur Shaikh is currently pursuing B.Sc. degree in Industrial Engineering and Management at Khulna University of Engineering & Technology,Khulna,Bangladesh., E-mail:isanurkuet@yahoo.com
- Md.Enamul kabir, S.M Mahbubul IslamBoby, Mostafa Lutfi are pursuing the same degree as above.

The American Apparel Manufacturing Association has defined modular manufacturing as "a contained manageable work unit of 5 to 17 people performing a measurable task. The operators are interchangeable among tasks within the group to the extent practical and incentive compensation is based on the team's output of first quality output". In a modular system, processes are grouped into a module instead of being divided into their smallest components. As a rule, fewer numbers of multi-functional operators work on the machines which are arranged in a U-line. All the operators in the group are responsible for the quality of each item that is produced in the line.

This research explores whether or not cellular manufacturing can help Nibir Fashion Wear Ltd, a highly export oriented garment industry with different international customers and products, to achieve improved performance and customer satisfaction.

1.2 Goals of the Project

This project has dual purposes: learning and improvement. The situation of the Sewing Floor in the present time needs action towards improvement. Any avenue leading toward increasing throughput, lowering costs and improving delivery is welcome. Cellular manufacturing is seen not only as a way to increase the efficiency of the Sewing Floor, but also as a potential new way to "do business." However, before considering cellular manufacturing for the Sewing Floor, it was necessary to identify the following:

- Determination of the present conditions of the Sewing Floor whether it is possible or not possible to introduce cellular manufacturing system.
- Determination of the designing and implementation process of cellular manufacturing system in the sewing floor.
- Designing a cellular layout for the current sewing line and the measurement of performance.
- Some recommendations for successful implementation of cellular manufacturing system in the sewing floor.

2. LITERATURE REVIEW

2.1 General

The following chapter reviews the literature to understand the advantages and limitations of Cellular manufacturing system which is a tool of lean manufacturing. The chapter will give a clear view of the back ground of lean manufacturing and the cellular manufacturing system. The various aspects of the cellular manufacturing system that are useful to RMG industries also revealed by this chapter.

2.2 Introduction to Lean

For the past three decades lean manufacturing has been practiced by organizations to improve their production systems. This concept originated in Japan after the second world war when Japanese manufacturers faced the dilemma of insufficient materials, financial problems and limited human resources[1]. The Japanese could not afford the huge investment to implement mass production systems as practiced by US manufacturers. These conditions resulted in the birth of lean in Japan in the mid-1940s.Toyoda Kiichiro, president of Toyota motor company, Shigeo Shingo and Taiichi Ohno developed a new process improvement philosophy which is known as the Toyota Production System (TPS) or Lean Manufacturing [2]. Womack and Jones summarize five basic lean principles: value, value stream mapping, flow, pull and perfection [3]. The concept of lean is to deliver the final product to the customer at the right time and at the right cost that is specifying value from the customer's perspective Next, is to map the activities as per the sequence of operations that adds value to the given product, i.e., value stream mapping. Lean production follows a single-piece flow pattern where the focus is on creating the continuous and uniform flow of product through the various production activities as it is transformed from raw materials to the finished product, ready to be delivered to the customer, i.e., flow. In order to achieve single piece flow, organizations should first concentrate on the product design and demand, then deny functional departments and batch processing, and finally eliminate any non-value adding process such as scraps, backflows and stoppages. Lean thinking establishes a way to do more with less human effort, less equipment, less time and less space while creating the product exactly as desired by the customers, i.e., pull. Finally, through continuous improvements activities perfection is achieved. The main idea is to minimize wastes or muda (the Japanese's word for waste) in order to increase the efficiency of production system. This means eliminating over production and inventory, unnecessary movement of material, waiting and delays, over processing, unneeded worker motion, and the defects.

In the lean manufacturing concept waste reduction is a vital issue. Lean experts try to identify the wastes and reduce the wastes by using proper tools. So to knowing the lean manufacturing system properly the wastes that are reduced by this system should be known. The types of the waste are given below that are reduced by this concept.

2.2.1 Wastes

Waste or Muda can be termed as any process or activity which does not add value to the product. Identifying the wastes in an industry is very important as this helps in targeting the inefficiencies present in the process and eliminating them. Womack et al have considered seven commonly identified wastes are[2]:

- Overproduction
- Waiting time
- Transport
- Unneeded motion
- Unnecessary processing
- Excess inventories
- Defects

These seven common wastes are very specific to manufacturing or operations activities. In order to get a broader view of non-value added activities to produce a given product, from the starting point to the end point, there is a need to elaborate on these seven wastes. For example, the excess inventory waste can further be sub-divided into raw material, work in process and finished goods inventories which gives broader perspective of wastes in different areas.The tools that are used to remove waste and improve the production system are stated below. These tools are successfully used in Toyota industries which are now known as creator of such concepts [1].

Table 2.1 Common Wastes

Wastes	**Description**
Setup time	Time the manufacturing system is idle due to activities that need to be completed to start the process to manufacture the
Failure time	Time the manufacturing system is idle due to a machine or equipment malfunction
Transportation	Movement of materials to several locations, resulting in longer lead times
Over processing	A manufacturing process that is unnecessary complex and does not add value to the product
Unneeded motion	Movements of people during the production which do not add value to the product
Raw material inventory	Unnecessary storage of raw materials that add cost
Work-In-Process (WIP)	Unnecessary storage of intermediates or semi-finished goods that add cost
Finished goods Inventory	Unnecessary storage of finished goods that add cost
Defects	Error in producing the products or materials, resulting in scrap or rework

2.2.2 Lean Tools

There are number of lean tools than can be used to identify and reduce waste. However, each tool is targeted at one or more specific wastes. For example, the SMED tool is used to target setup time waste. There are more universal tools such as 5S, Visual Control and Standard Work which support other tools in order to increase their efficiency. Table 3.2 describes eleven of the most common lean tools [4].

Table 2.2 Common Lean Tools

Tools	**Description**
Value Stream Mapping(VSM)	A method to map the activities (both value adding and non-value adding) involved in moving the products through the manufacturing process
5S	A workplace organization methodology (the 5S's are "Sort, Straighten, Scrub, Schedule and Standardization")
Visual Control	A technique to make information available at a glance
Standard Work (SW)	A technique for organizing a job such that it can be carried out in best and safest manner
Just-In-Time (JIT)	A strategy to produce the right part in the right place and at the right time
Kanban	A tool used in JIT to control or signal the production or movement of parts
Production Smoothing	A tool to keep production levels smooth or constant from day to day
Total Productive Maintenance (TPM)	A tool for maintenance of equipment or machinery to achieve maximum equipment effectiveness through participation of every employee
Total Quality Management (TQM)	A tool to improve the quality of a product by continuous improvement in the process
Single Minute Exchange of Die (SMED)	A tool to reduce the setup time
Cellular Manufacturing	A proper placement of machines or equipment so that the family of products can be produced in one cell

2.3 Cellular Manufacturing:

The thesis will concern about the last lean manufacturing tool that is Cellular manufacturing system. The Cellular manufacturing system is the concept that is emerged from the group technology. Further about this concept is discussed in the next section

2.3.1 Cellular Manufacturing and Group Technology – an overview

The Group Technology (GT) approach originally proposed by Burbidge in 1971 and Mitrofanove in 1966 has projected the philosophy that exploits the proximity among the attributes of given objects [5]. GT is identified by many researchers as dividing the manufacturing facility into small groups or cells of machines; each cell is being dedicated to a specific set of part types and it is called cellular manufacturing[6,7&8] .Singh depicts the cellular manufacturing as an application of GT in manufacturing[5] while Mahesh and Srinivasan mentions Cellular Manufacturing as one of the primary applications of GT principles, where parts with similar process requirements are placed together into groups called part families[9]. Thus Group Technology and Cellular manufacturing are often refers to similar production environments and Cellular manufacturing is considered to be one of the main techniques towards a lean environment. The benefits of implementing GT is identified by many researchers as to minimize the through put time, improve the quality of the product, reduce the WIP levels and stocks and thereby the cost, improve the deliveries, reduced set-up times and improve productivity level[10,5&11] . Askin and Standridge explained the set up time reduction as an important aspect of GT [7].

2.3.2 The Details about Cellular Manufacturing

Cellular Manufacturing is the application of the principles of Group Technology in manufacturing. Group Technology was proposed by Flanders in 1925 and adopted in Russia by Mitrofanov in 1933 (although the work was translated into English in 1966)[13,14]. Jack Burbidge did much to promote Group Technology in the UK[15]. Although there appear to have been similar applications earlier in history Portsmouth Block Mills offers what by definition constitutes an early example of cellular manufacturing. By 1808, using machinery designed by Marc Isambard Brunel and constructed by Henry Maudslay, the Block Mills were producing 130,000 blocks (pulleys) for the Royal Navy per year in single unit lots, with 10 men operating 42 machines arranged in three production flow lines. This installation apparently reduced manpower requirements by 90% (from 110 to 10), reduced cost substantially and greatly improved block consistency and quality. Group Technology is a management strategy with long term goals of staying in business, growing, and making profits. Companies are under relentless pressure to reduce costs while meeting the high quality expectations of the customer to maintain a competitive advantage. Successfully implementing Cellular manufacturing allows companies to achieve cost savings and quality improvements, especially when combined with the other aspects of lean manufacturing. Cell manufacturing systems are currently used to manufacture anything from hydraulic and engine pumps used in aircraft to plastic packaging components made using injection molding [12].

2.4 Assessment of Cellular Manufacturing

Cellular manufacturing is a new concept .To best utilization of this concept first the existing system's benefits and limitation should be known. Then compare it to the cellular manufacturing system. This chapter discusses the benefits and the limitation of the existing or conventional process structures, making it easier to appreciate the advantage of cellular manufacturing and the situation in which its implementation is desirable. Next it explain the reasons that justified pursuing the design and implementation of a manufacturing in a garment manufacturing line. Finally, a proposal is made on basis of the compare.

3. THE CELL DESIGN AND IMPLEMENTATION PROCESS

3.1 The Cell Design and Implementation Process

Since the goal of the research is to research the acceptability of the cellular manufacturing system in the RMG garment industries as the system is more feasible than the existing line manufacturing technique. From one reference the preliminarily strategy of implement one new concept over the existing system has been described. In the reference A New American TQM11 Shiba et al. refer to two different ways to effect improvement within an organization while incorporating learning: the PDCA cycle (Plan-Do-Check-Act) and the CAPD cycle[16] . The authors explain that the PDCA cycle is most useful in continuous improvement, where the process already exists and the PDCA cycle is run over and over again to eliminate the next most important problem, and thus further reduce the variance of the process and its results. The CAPD cycle on the other hand, is more applicable to planning situations where the target for the next planning cycle is different from the target for the previous one. The letters are transposed to emphasize the control and feedback aspects of the loop and to focus attention on their importance in the planning of the improvement process. Table 3.1 enumerates the steps of the two different cycles and Fig. 3.1 shows the effect of applying and repeating them.

It is worth noting that regardless of what type of cycle is used to drive improvement, there is great challenge in “picking the problem to solve”. Since solutions are rooted on what problems are presented and how, “picking the problem that is most responsible for the variation in results” or “discovering how the process prevents achievement of desired results” are often difficult steps in the continuous improvement process because “the problem” is seldom obvious. Nevertheless, in a fundamental way “picking the problem” determines the direction, quality effectiveness of the improvement.

According to Table 3.1 and Fig. 3.1 the CAPD cycle was the model used to develop the cell design and implementation process. The CAPD cycle lends itself to achieve more radical changes as it actually calls for looking at the big picture and reassessing the goals and processes used to obtain them.

Table 3.1 the PDCA and CAPD Cycles

The PDCA Cycle	
P	Pick the problem that is most responsible for the variation in results, analyze the root causes of the problem, and plan counter measures to fix the root causes
D	Do the improvement
C	Check that the improvement was effective
A	Standardize it as appropriate, and go to the next improvement
The CAPD Cycle	
CA	Discover what is wrong with the previous process that prevents achievement of the desired results; what are the key things to improve for the next cycle
P	Determine what is desired for the future (e.g. what is the next target)
D	Carry out the plan for the year
CA	Check whether target was achieved, and if not, why not (repeat CAPD)

In addition, by following the CAPD model, there is room for rectifying the process and establishing new targets, rather than just refining them. Again, one important feature of both cycles is that they both used feedback to move forward. This is a necessary feature of any process seeking improvement through a new implementation, and it was purposefully included in the cell development process. The Fig. 3.1 represents the cell design and implementation process proposed as a method to introduce cellular manufacturing in an environment where an existing manufacturing layout was. This above described strategy allows for discovering reasons for not achieving desired results and key areas for improvement during the assessment stage (CA step). This stage involves

ISSN 2229-5518

identifying the scopes of this new concept over the existing one. In this stage of the strategy of implementation the area of the all balancing techniques are implemented and what is desired for the future can be determined in the Design and Performance Analysis steps (P step). Carrying out the plan involves implementation of the design and monitoring of the results throughout a period of time to finally (D step) check whether or not the target was achieved, and restart the CA step.

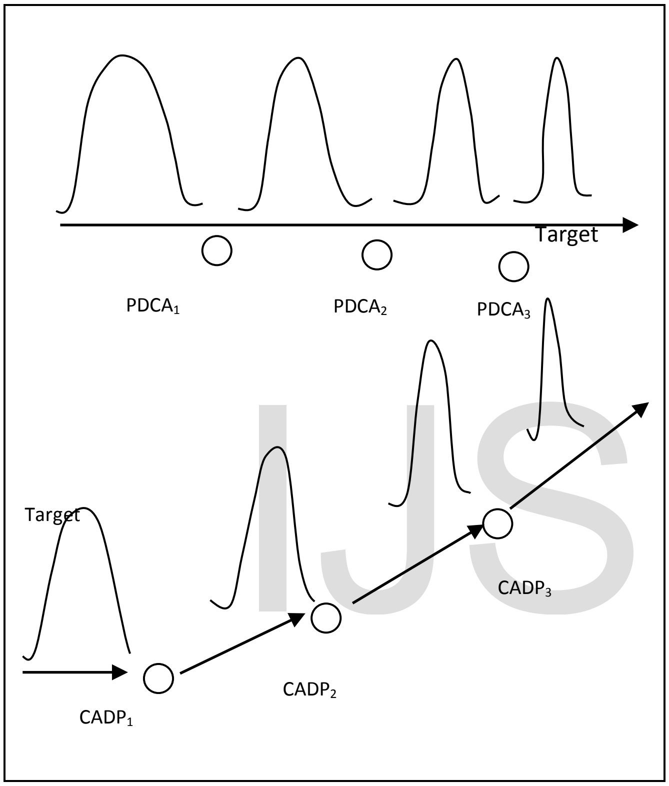

Fig. 3.1 Effect of Repeating the PDCA and

The main tasks of each step of the process are briefly explained below. And after discussing the implementation process, this research will give the quantitative and qualitative factors for applying the Cellular Manufacturing System over the traditional system in to the RMG (Ready-made Garment) industries.

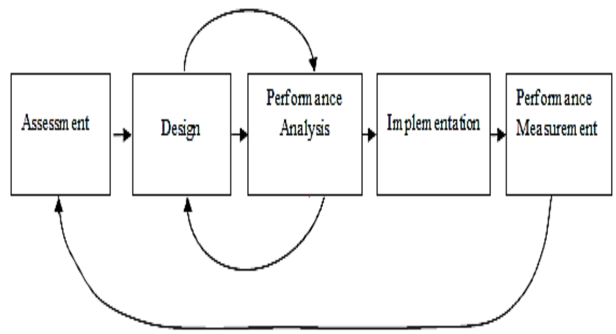

Fig. 3.2 Cell Design and Implementation Process

In the Assessment stage it is very important to obtain an in-depth understanding of current process and the line activities. This assessment should be thorough in covering the different aspects that affect the process, including but not limited to personnel alignment and incentives, manufacturing process, driving metrics, etc. By doing so a baseline can be established this clearly defines "where we are today" and thus facilitates defining "where we want to be tomorrow" and how to get there. In this way, identifying the cell requirements and expectations is a more rational and realistic exercise. This also involves finding scope of all the areas for balancing in the area to minimize the WIP and acquiring a smooth product flow in the Cells.

The Design step requires that information and feedback are solicited from all the functions and or individuals that are part of the process. In addition, it requires that effective methods are used to derive part families and their process. Sometimes an expert is very helpful during this stage of the process to guide the group wisely in determining and demonstrating the attributes of a successful design before a big investment is made in implementing it. During this step, care should be taken to balance the need to minimize the costs of introducing the new cell process in the production environment with the need for using the most effective processes or equipment to do the job. If this balance is not established, the changes proposed may be too small to achieve the desired results or too big to obtain the results at a justifiable cost.

The success of cellular manufacturing is heavily dependent on correct capacity planning to ensure that dedicating the equipment is justified and feasible, and that the work is balanced, so that the cell can perform as expected. The Performance Analysis step is a necessary one to check the assumptions and proposals of the design step and to finalize the performance measurements of the cell. The above Fig. 3.2 highlights the iterative relationship between the Design and the Performance Analysis steps.

The Implementation step requires mobilizing the people that "do the work" to implement the Changes as for the balancing the line. Many companies that have tried to implement to implement the cellular manufacturing but there is a big problem associated with mobilizing people and resources to make the balances. In the RMG garment industries most workers are women and this industries are mostly labor intensive for this one suggestion can be taken from the reference that the author suggests that these kinds of activities that are already in place may offer the a suitable environment to mobilize the resources. Preparation, identification of key players and clear goals will go a long way to ensure the success of the implementation.

Finally, the Performance Measurement step is an ongoing process, where performance measurements are monitored to determine the impact of the change in achieving the expected goals. This step is very important because it establishes the feedback loop needed to identify areas of success and areas where requirements need to be readdressed. In doing so, the CAPD cycle is restarted and continuous improvement is perpetuated.

4. DATA ANALYSIS

4.1 Cost Reduction for the Increased Efficiency

To calculate the cost reduction for increased efficiency, the efficiency of the existing layout and the proposed cellular layout has been calculated first. The following equations are used to determine the line efficiency:

$$\text{Standard Pitch Time (S.P.T)} = \text{Basic Pitch Time (B.P.T)} + \text{Allowances (\%)} \quad (1)$$

$$\text{Target} = \frac{\text{Total Manpower per line} * \text{Total Working Minutes per Day}}{\text{SMV}} * 100\% \quad (2)$$

$$\text{Line Efficiency} = \frac{\text{Total Output per day per line} * \text{SMV}}{\text{Total Manpower per line} * \text{Total Working Minutes per Day}} \quad (3)$$

In Appendix, time study sheet is attached showing the different types of machine used, number of operators, basic and standard pitch time, process name.

Table 4.1 Benchmark Target and Line Efficiency of Existing Manufacturing System

Total Output Per Day	1902	Pcs	
Total Manpower	16		
Working Time	600	Min	
SMV	2.26	Min	
Target /hr	425	100% Efficiency	
	340	80% Efficiency	Benchmark
	170	40% Efficiency	
Line Efficiency	45%		

Table 4.2 Present Capacity of the Existing Manufacturing System

S.N.	Operation	Man Power	M/C Type	SMV (min)	Present Capacity/hr
1	Main label Joint	1	S/N	0.17	353
2	Two Part match	1	M/L	0.2	300
3	Label Sewing & Cut	1	S/N	0.13	461
4	L. Shoulder Joint	1	O/L	0.08	750
5	Thread Cut Fold	1	M/L	0.19	315
6	Neck Piping	1	F/L	0.22	272
7	Thread Cut/Fold	1	M/L	0.2	300
8	Side Seam	3	O/L	0.53	340
9	Shoulder Tack	2	S/N	0.11	1090
10	Thread Cut, Fold	1	M/L	0.09	666
11	Arm Hole Piping	2	F/L	0.23	522
12	Thread Cut & Fold	1	M/L	0.12	500

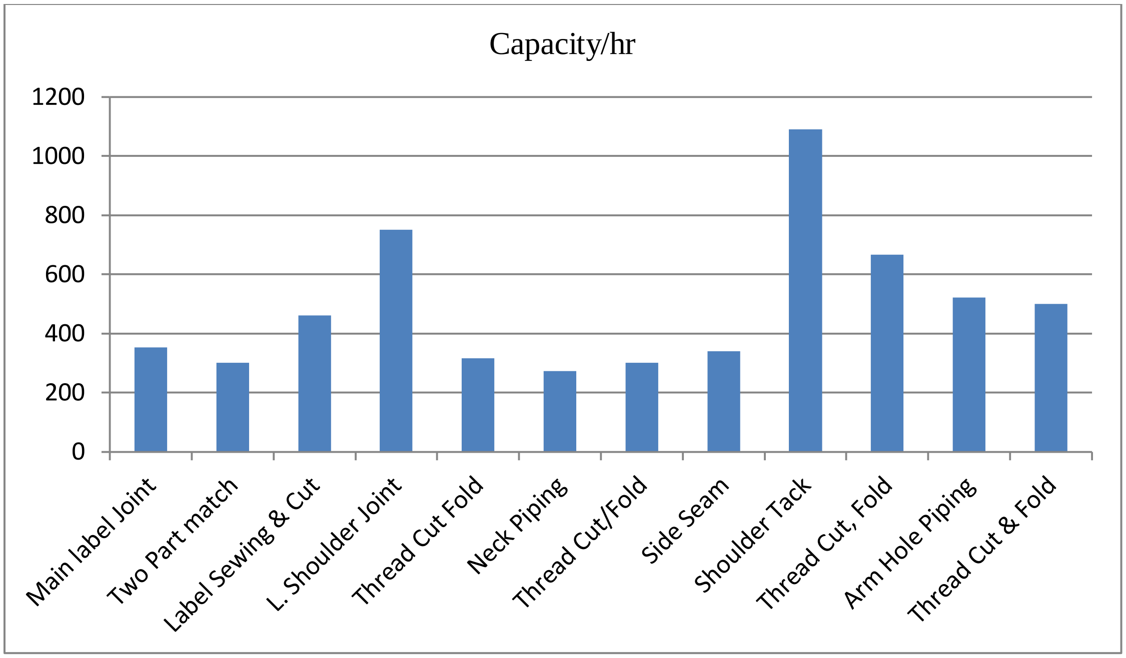

Fig. 4.1 Variation in Each process Capacity per Hour Compare to Benchmark Target per Hour

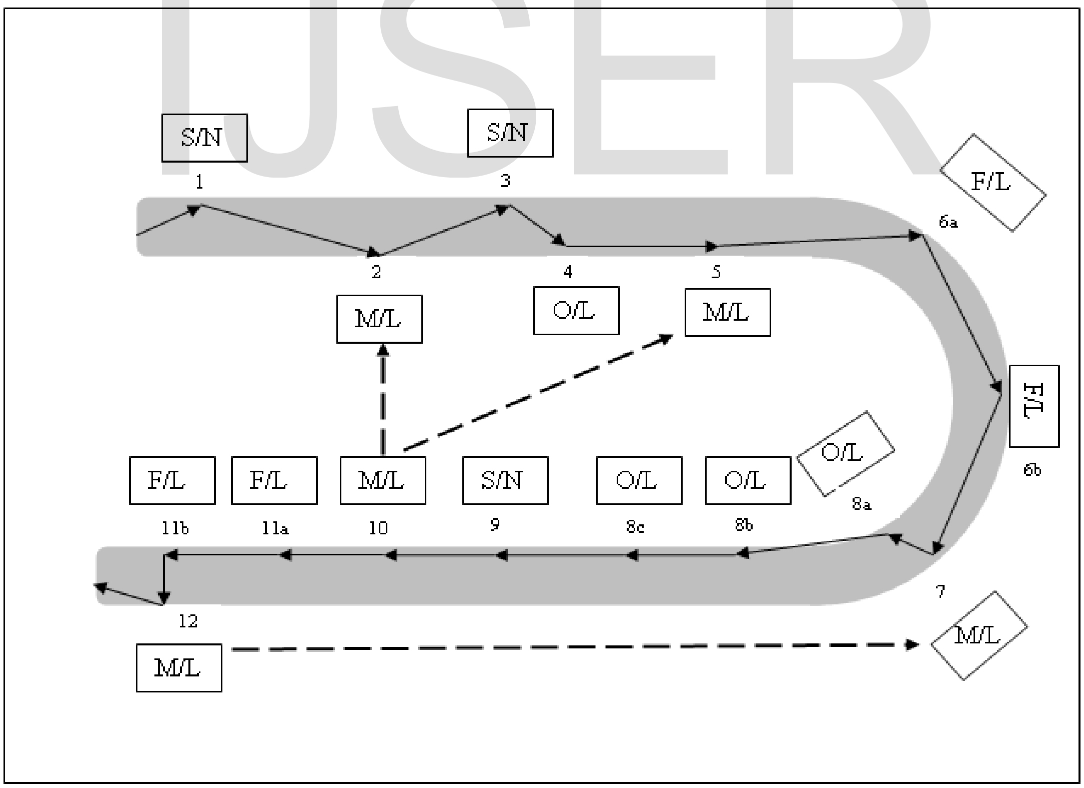

Fig. 4.2 Proposed Cellular Layout for Sewing Line

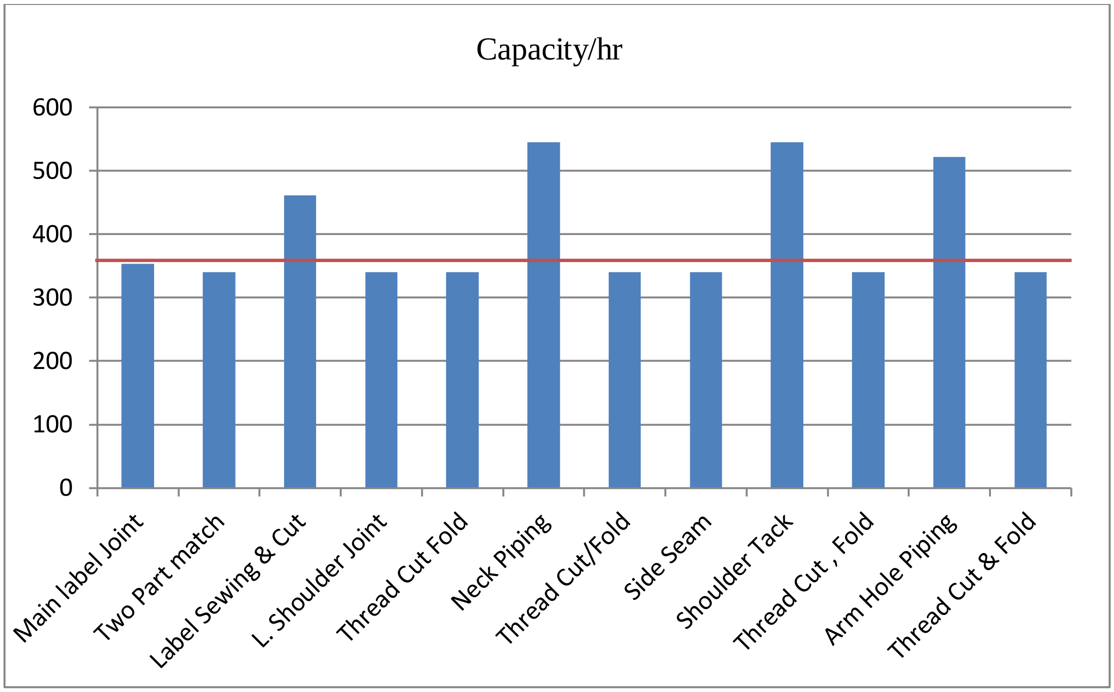

Fig. 4.3 Variation in Each Process Capacity per Hour in the Proposed Layout

Table 4.3 Capacity of Proposed Cellular Manufacturing System

S.N.	Operation	Man Power	Proposed Man Power	M/C Type	SMV (min)	Present Capacity /Hour	Balanced capacity /Hour	Remark
1	Main label Joint	1	1	S/N	0.17	353	353	
2	Two Part match	1	1	M/L	0.2	300	340	
3	Label Sewing & Cut	1	1	S/N	0.13	461	461	
4	L. Shoulder Joint	1	1	O/L	0.08	750	340	Help 5
5	Thread Cut Fold	1	1	M/L	0.19	315	340	
6	Neck Piping	1	2	F/L	0.22	272	545	
7	Thread Cut/Fold	1	1	M/L	0.2	300	340	
8	Side Seam	3	3	O/L	0.53	340	340	
9	Shoulder Tack	2	1	S/N	0.11	1090	545	
10	Thread Cut , Fold	1	1	M/L	0.09	666	340	Share with 2 &5
11	Arm Hole Piping	2	2	F/L	0.23	522	522	
12	Thread Cut & Fold	1	1	M/L	0.12	500	340	Share with 7

Table 4.4 Proposed Output and Increased Efficiency

Total Proposed Output Per Day	2378
Total Operator	16
Working Time	600 Minutes
SMV	2.26 Minutes
Line Efficiency	56%
Line Efficiency Increased	11%

The factory is consisting of fifty lines. The proposed cellular model helps to increase efficiency. For a least amount of increase efficiency causes the reduction of a great amount of cost. The following calculations show that applying cellular manufacturing, the factory can save US$1201200 annually from its labor cost only. The calculations are as follows

Number of operators working in the line = 16
Working time/day = 10 hrs
Total working time/day = 9600 min
Time saving for 1% increase in efficiency from one Line = 96 min
Cost per minute of the factory = US$ 0.07
Cost Saving/day for 1% increase in efficiency from one Line = US$ 7
Total number of lines in the Factory = 50
Cost Saving/day for 1% increase in efficiency from Fifty Lines = US$ 350
Annual cost savings for 11% increase in Efficiency from Fifty Lines = US$1201200
(26working days/month)

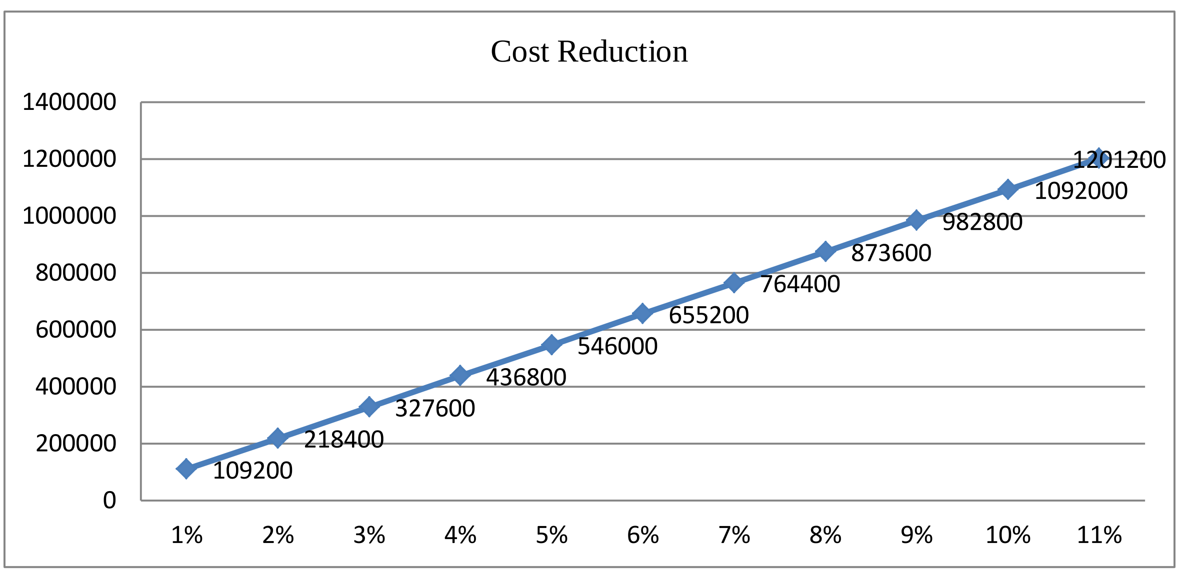

Fig. 4.4 Reduction of Cost with Increasing Efficiency Annually in US$

4.2 Cost Reduction of Supervising

In the existing manufacturing line, there are two supervisors to effectively supervise the operators. But in the proposed cellular layout, as the work stations are closely located, one person can effectively supervise the operators. So the supervising cost is reduced. The calculations are following

Number of supervisors in the existing line
= 2
Number of supervisors in the proposed cellular layout = 1
Number of supervisors reduced per line
= 1
Number of supervisors reduced for fifty lines
= 50
Cost for one supervisor per month
= US$ 115
Cost save due to reduction of fifty supervisor per month = US$ 5750
Cost save due to reduction of fifty supervisor per year = US$ 69000

4.3 Total Cost Reduction

Total cost reduction per year of the proposed cellular model has been calculated from the sum of cost reduction for increased efficiency and cost reduction of supervising. The calculations are as follows

Cost reduction for increased efficiency
= US$1201200
Cost reduction of Supervising
= US$ 69000
Total cost reduction
= US$1201200 + US$ 69000

= US$ 1270200

= US$ 1.2702 Million

5. RESULT AND DISCUSSION

5.1 Result

Cellular manufacturing is a powerful tool of lean manufacturing. In the sewing floor of a ready-made garment industry, there exists an ideal environment to use this tool to obtain the benefits of lean manufacturing. As the lean manufacturing reduces wastes that do not add any value to the product, it helps to reduce the manufacturing cost by increasing the labor utilization. If the labor utilization increases, a factory can save a handsome amount of cost annually; this will help the factory to exist in the competitive business world. The result obtained from this research is that the factory can save cost by applying cellular manufacturing system, by increasing line efficiency and reducing the number of supervisors is US$ 1.2702 Million annually.

5.2 Discussion

Cellular manufacturing not only help to reduce labor cost and supervising cost, but also it will provide the factory other benefits which indirectly reduces factory cost. As well as, it will help the factory solve many problems. The current fluctuation of WIP is seriously high as the bottle necks create vacuums at some of the workstations making WIP zero. When WIP levels increase due to issues on the line e.g. a quality problem, the operators with less WIP or no WIP are expected to help the others in the cell until a preset level is reached, resulting in less WIP fluctuation within the line. This will help return the line to a balanced state before the problem occurred. With reduced fluctuation of WIP the flow becomes considerably smoother. When the flow is smooth gradual reduction in WIP is possible. Presently the size of the garment ply (number of garment pieces in one bundle) is about 100 units. When the ply size is large the total WIP within the line is high, this in itself causes problems at the start of the line and the effects of this are felt through the rest of the process operations. This can be used both as a production line visual control and as a useful metric for meeting reviews. Further reduction of WIP levels should be achieved with Kaizen approach within the sub-cell groups. In a lean environment the control of quality is the responsibility of the operator. The worker must ensure that what is passed to the next workstation is of perfect quality. In order for this to be achieved there are several factors that managers must consider before granting this responsibility. First and foremost management need to ensure that proper training is provided to all its operators and it needs to be consistent to ensure minimal variation of the quality of garments. When the operators feel that the power of work groups and their responsibility and benefited through earning more money at a reduced work pressure, with working no over time, they are motivated. The leaders of the workgroups naturally will try to ensure the quality of sub-assemblies that are passed from their cell to the next cell. If second quality is produced by a certain work cell, the responsibility of the rework is given to the same cell. As the operators are empowered and motivated they themselves balance each sub-cell within the line to achieve their target in the case of a machine breakdown, absenteeism etc.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The goal of the project was twofold: learning and improvement. The authors feel that these objectives have been accomplished. In the sewing floor of a ready-made garment industry is an ideal environment to introduced cellular manufacturing. The cell design and implementation process proposed in this research can be used to implement the cell at the Sewing Floor, and hence the Sewing Floor will begin to realize the benefits expected from the cell. The cellular layout for the sewing line and its performance has been determined in this research work.

6.2 Recommendations

The authors offer the following recommendations for successful implementation of cellular manufacturing system in the sewing floor as key lessons learned from the research-

Do not underestimate the importance of analysis:

A successful implementation requires thorough analysis. When introducing a cell in an already existing Sewing Floor, managers may decide to rely on their own knowledge and experience rather than on data and analysis to determine cell capacity. While knowledge and experience are extremely important, without analysis it is impossible to synthesize the data into useful information to support decisions. Furthermore, analysis encourages the exploration of different scenarios and these iterations yield a more robust design.

People can make it happen:

Analysis is necessary but not sufficient. Participation from people across the organization facilitates and enhances the design; and it is people that implement the design. Ensure that input from as many of those who will "work and live within the cell" is obtained prior to implementation; it will make the implementation process much smoother.

Break down the functional barriers:

Cellular manufacturing requires communication amongst and between the operators and the functional support personnel to support rapid problem solving and results. The culture of an already existing Sewing Floor may not support the kinds of interactions and relationships that support cellular manufacturing. Managers should be aware that the introduction of cellular manufacturing can potentially require changes to the organizational culture.

From a broader perspective, through the study and observation the authors became keenly aware of the importance of communicating a vision and goals throughout the organization. They now believe that this is one of the most difficult challenges for managers, and that it is work that is never done. The vision and goals of the organization need to be communicated not only through the words, but also reinforced through the actions of the organization's leaders and through the incentives offered to the employees. Another important challenge in a ready-made garment manufacturing organization is the need to understand and manage capacity. Although MRP and MRP II systems have been immensely useful in the manufacturing environment, they are not able to support many of the capacity loading decisions that are made on a day to day basis. Managers need to develop the skills within the organization to manage capacity as effectively as possible given the tools available. Capacity planning in a manufacturing environment is a complex problem, but the success of a manufacturing organization is tied to its ability to match the required resources to the available capacity as efficiently as possible.

7. REFERENCES

[1] Ohno, T. (1988). *Toyota production system: beyond large-scale production.* Cambridge,MA, Productivity Press.

[2] Womack, J.P., Jones, D.T., & Roos, D. (1990). *The machine that change the world*. New York, Free Press.

[3] Womack, J.P., & Jones, D.T. (1996). *Lean thinking: banish waste and create wealth in your corporation*. New York, Simon & Schuster.

[4] Abdulmalek, F. A., Rajgopal, J., & Needy, K. L. (2006). *A classification scheme for the process industry to guide the implementation of lean*. *EngineeringManagement Journal, 18(2),* 15-25.

[5] Singh, N. (1993), *Design of cellular manufacturing systems*, European Journal of Operational Research 69, pp.284-291.

[6] Nicoletti, S., Nicosia, G., Pacifici, A. (1998), *Group Technology with flow shop cells*,University of Roma, Italy.

[7] Askin, R.G., Standridge, C. R. (1993), *Modelling and Analysis of manufacturing systems*, Hamiton Printing, USA, pp.163-165.

[8] Buffa, E.S., Sarin, R.K. (2002), *Modern Production operations and management*, 8th edition, Gopsons Paper Ltd., India, pp. 484, 672-674.

[9] Srinivasan (2002), *Increment cell formation considering alternative machines*, International Journal of Production Research, vol. 40, No. 14, 3291-3310.

[10] Burbidge, J. (1979), *Group Technology in the Engineering Industry*, Mechanical Engineering Publications LTD, London, pp. 60-68, 103-105.

[11] Wemmerlov,U., Hyer, N.L., (1989), *Cellular manufacturing in the U.S. industry : a survey of users*, International Journal of Production Research, Vol. 27, No.9, pp1511-1530.

[12] Wikimedia Foundation Inc, 2010, *Cellular manufacturing*, viewed 28 April 2011, <http://en.wikipedia.org/wiki/Cellular_manufacturing>

[13] Flanders, R. E., 1925, *Design manufacture and production control of a standard machine*, Transactions of ASME, 46, 691-738.

[14] Mitrofanov, S. P., 1966, *The Scientific Principles of Group Technology*, National Lending Library for Science and Technology, Boston.

[15] Burbidge J.L. (1978), "*Principles of Production Control*", MacDonald and Evans, England, ISBN 0-7121-1676 5550-5.

[16] Shiba, S., Graham A. and Walden, D., 1993, A New American TQM, Four Practical Revolutionsin Management. Portland, OR, Productivity Press.

ISSN 2229-5518

APPENDIX

Appendix: Time study sheet showing total operator with standard minute value.

Cycle Time-Study Sheet													
Buyer	H & M		Item	TANK-TOP			Line	52 B			Dept		
Order	943450		Style								Date	18-04-11	
				Observed time									
S.N.	Operation	M/C Type	Man-power	1st	2nd	3rd	4th	5th	Average CT sec	Average CT min	Rating %	Basic Time	SMV
1	MAIN LABEL JOINT	S/N	1	12	13	11	11	13	12	0.20	70	0.14	0.17
2	TWO PART MATCH	M/L	1	14	12	13	12	12	12.6	0.21	80	0.17	0.20
3	LABEL SEWING & CUT	S/N	1	7	8	7	7	8	7.4	0.12	90	0.11	0.13
4	L. SHOULDER JOINT	O/L	1	4	5	4	4	5	4.4	0.07	90	0.07	0.08
5	THREAD CUT FOLD	M/L	1	13	10	11	12	12	11.6	0.19	80	0.15	0.19
6	NECK PIPING	F/L	1	11	12	12	11	11	11.4	0.19	95	0.18	0.22
7	THREAD CUT/FOLD	M/L	1	12	13	13	12	12	12.4	0.21	80	0.17	0.20
8	SIDE SEAM	O/L	3	33	32	33	34	33	33	0.55	80	0.44	0.53
9	SHOULDER TACK	S/N	2	6	6	6	6	7	6.2	0.10	90	0.09	0.11
10	THREAD CUT , FOLD	M/L	1	4	5	6	5	5	5	0.08	90	0.08	0.09
11	ARM HOLE PIPING	F/L	2	12	14	12	13	12	12.6	0.21	90	0.19	0.23
12	THREAD CUT & FOLD	M/L	1	8	8	9	8	7	8	0.13	75	0.10	0.12
13			16										2.26
14	Total Manpower	16	Working	10									
15	SMV	2.26	Achieved Producti	1902									
16	Efficiency	45%											