Volume : 4 | Issue : 2 | Feb 2015 ISSN - 2250-1991



Research Paper Management

A Study of Knitted Fabric Production On Lean Concepts Based in Tamilnadu

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ABSTRACT

Lean Manufacturing system of production today is well accepted in Apparel Industry in India. Since India is having a lot of potential for cotton fibers , cotton yarn and trained manpower , we need to look into the stiff competition and value added, here knitted fabric contributes 60% of the product value of a knitted garment. The knitted world market contributes USD 300 billion , so the modernization of the knit fabric manufacturing is required. Today in the world market for cotton and cotton blends ,we are competing with the main players like China,Bangladesh,Pakistan, Egypt ,Turkey , Tunisia ,and European Union. At present India's export in knitted garments drastically is reduced due to stiff competition. From Bangladesh which contribute around 23 Billion knitted garment export during 2013-2014, whereas India's Export was 9 Billion only, and the domestic consumption is USD 14 Billion. This study investigates the challenges and potentials due to the application of lean manufacturing system for production of Knitted fabric in Tamilnadu. The objective of study is to put the impact on Lean Manufacturing and key challenges in knitting industry. The case study based research approach is followed .Interviews, observations and archival sources were the source from which the data was collected. The results were calculated of main product categories basedon the volumeand price. For example it was found that the process value added(VA) to Non-Value added (NAV) ratio for JCOL 56(described in detail) the main product is 4.64% and with suggested improvement for waste minimization ,it was found that the ratio could be improved to 9.37%.Therefore improving the process would bring a lot of financial and non-financial gains as well as the lead time reduction which is a key factor in reducing the operational cost.

KEYWORDS Leanmanufacturing, productivity, textile knitting.

1. Introduction.

"Lean manufacturing is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. Working from the perspective of the customer who consumes a product or service, value is defined as any action or process that a customer would be willing to pay for" Michel Gouse[1] describes. Basically, lean is focusing on giving higher value with less work. Lean manufacturing is a process management philosophy derived mostly from the Toyota ProductionSystem (TPS) Toyota Motor Corporation [2], Identified as 'Lean' only in the 1990s Womack & Jones [3]. It is well known for its focus on reduction of the original Toyota seven wastes to improve overall customer value, but there are different arguments on how this can be best achieved. The steady growth of Toyota, from a small company to the world's largest automobile manufacturer, is simply because of this high focus. The main objective of this study is to increase the current output level of the company. This was followed by a set of secondary level goals which include reducing the cost of operation, optimization of labour allocation, creation of improved production planning & scheduling system, improvements of WIP between production processes and improvements to the factory layout with less or no capital investments. With the optimized working conditions of the workers and changes made in the working environment will eventually result in the workers' well-being and their job satisfaction which in turn will lead to a significant increase in the factory's overall productivity and its output to a significant level in the future as well.

1.1 Background of the Company

The company M/s Rohini Garments (India) Pvt. Ltd, Tirupur started with an initial investment of US$ 4 million and a production capacity of 7,000 Kg per week; they commenced operations in 1992 with an employee base of a mere 40. Today, it has grown into a large organization of a total investment of US$ 200 million and the production capacity up to 250,000 Kg per week with an employee base of 675. The annual turnover today is in excess of US$ 58 million, proving it to be an organization with a potential for growing by leaps and bounds which encouraged us to select this organization for our project [5][6]. Their products include an interesting range of Cottons, Polyesters, Spandex, Lycra, Rayon, Viscose, Modal, and a multitude of such blends.

They also produce single Jersey, Interlock, Fleece, Polar Fleece, Rib, Pique, Structures, Pointelle and Marl fabrics and also a comprehensive Flat Knit section which produces bands & collars, and can accommodate Jacquard and Tipping. Knitted fabrics are divided in to two basic types: weft knitted & warp knitted, weft knitted fabric will divide as single jerseys (which are plain knit & purl) & double jersey (which are rib and interlock), warp knitted fabrics will divide as tricot & Rachel [8].

2. Methodology

The methodology used for presenting the case study is explored in this section. First the research method is explained, followed by a brief description about the lean concepts used. The Methodology used here to find to have a comparison between the conventional system of making fabric production and the improved way by the application of Lean Tools and concepts and application of lean tools such as Just-in-Time production, Continuous flow. Due to these all the seven wastes are being eliminated, and the production flow made clear

2.1 Research Method

The case study based research approach was followed throughout the project which is similar to that used by Kasul and Motwani's [13] study. Interviews, observations and archival sources were the

sources from which data was collected. Interviews were conducted with the operational staff, unit managers and quality managers. In person interviews were conducted with those who were most familiar with the manufacturing process. The other sources of data were unstructured interviews from other management and non-management personnel during the period of this study.

2.2 Summary of Key Lean Concepts

The main concept of lean manufacturing is enriched with many sub philosophies. Here we have summarized those sub philosophies in the context of selected case company.

2.2.1 Just-in-Time (JIT) Production

A system of production that makes and delivers just what is needed, just when it is needed, and just in the amount needed. At the current state mapping process we had observed the work-in-progress levels between every two processes. And some of those WIP got damaged due to dirt, humidity and temperature of the store [9] [12].

2.2.2 Continuous Flow

This refers to producing and moving one item at a time or a small and consistent batch of items through a series of processing steps as continuously as possible, with each step making just what is requested by the next step. It is also called one-piece flow, single-piece flow, and makes one, move one. At the preliminary study we have understood that the company has a very slow moving process due to the nature of the industry. But they also have 4.17% rework level which is well above the normal loss related to the industry. The total number of rework calculated for the 6 months case study period was 215,167 kg [9] [12].

2.2.3 Cycle Time

This is the time required to complete one cycle of an operation in a given work station or a separately identified process. This time includes operating time plus the time required to prepare, load, and unload. The appropriate calculation of cycle time may depend upon context. For example, if a dyeing process completes a batch of 500 kg every twenty minutes, the cycle time for the batch is twenty minutes. However, the cycle time for an individual part is varying with its weight. If we assume that an individual part has average weight of 20 kg, then the cycle time will be one minute [9] [12].

2.2.4 Production Lead Time

This is also known as 'Throughput Time' or 'Total Product Cycle Time'. The time required for a product to move all the way through a process from start to finish is the production lead time. At the plant level this is often termed door-to-door time. The concept can also be applied to the time required for a design to progress from start to finish in product development or for a product to proceed from raw materials all the way to the customer. As the company had WIP between almost all their processes the production lead time was relatively high. This also influenced by the higher amounts of rework levels for specific products. Some of those products cannot get right at first time due to the lack of necessary machine capabilities. The company had to operate with aged machines as they operate in a highly capital intensive industry. So one of the main paths to stay profitable is to reduce defect rate, rework levels and deliver goods on time. On time delivery is crucial in this industry as all of their customers operate in labour intensive production environments, so failure to deliver on time end up with high amounts of financial penalties [9] [12].

2.2.5 Waste Elimination

One of the key steps in Lean and TPS is the identification of steps which add value and which do not waste elimination is classifying all the process activities into these two categories. It is then possible to start actions for improving the value adding activities and eliminating the non-value adding ones. Some of these definitions seem like 'idealist' but this tough definition is important to the effectiveness of this key step. Once value-adding work has been separated from waste then waste can be subdivided into 'needs to be done but non-value adding' waste and pure waste. The clear identification of 'non-value adding work' is critical to identify the assumptions and beliefs behind the current work process and to challenging the reason or reasons behind those activities [9] [12].

The following 'seven wastes' identify resources which are commonly wasted. They were identified by Toyota's Chief Engineer, Taiichi Ohno as part of the Toyota Production System. Overproduction, Unnecessary transportation, Inventory, Motion, Defects, Over-processing and Waiting are identified as the seven wastes. The main method of identification of above wastes is value stream mapping. Reducing or eliminating the current state waste, we plot the future state map [10] [11].

3. Results and Discussion

The company manufactures products with around 1,500 variations. Therefore we had to select the most important products with larger impact through a Pareto analysis (Refer to Table 1). Here we used both length and weight as both these parameters are essential at the quality control Stage. And all the calculations are done for a standard 300kg batch, without reworks. The analysis being done by using pareto chart where the major components of the productivity which taken in to consideration .There are two parameters considered here are percentage of length of the fabric in meters and weight of the fabric in Kilograms.

Table-1Main products according to the Pareto analysis. Source- Knitted Fabric Analysis by using length in meters and Weight in Kilograms in percentage wise using Pareto Analysis.

Sl.no	Product	Family	% Vol(M)	% Vol(Kg)
01	JCOL56	Lycra	11.63%	9.71%
02	ICO220	Hands	9.80%	12.45%
03	IPE012	Polyester	9.09%	6.72%
04	PJCOL56	Lycra	5.84%	4.87%
05	JCO131	Jersey	5.33%	5.85%
06	SDPE050	Polyester	4.36%	3.31%
07	JCOS85	Lycra	3.34%	3.41%
08	JCO054	Jersey	3.01%	2.75 %
09	PJCO240	Jersey	2.90%	2.72%
10	JCOS129	Lycra	2.86%	2.92%
11	JPC011	Polyester	2.73%	2.37%
12	BICO174	Interlock	2.70%	3.23%
13	FCOS57	Lycra	2.45%	3.57%
14	ICO048	Interlock	2.33%	2.41%
15	JCO240	Jersey	2.12%	1.98%
16	JCOS41	Lycra	1.97%	2.25%
17	PICO174	Interlock	1.64%	1.92%
18	JCOS44	Lycra	1.64%	1.67%
19	BJCO054	Jersey	1.60%	1.47%
20	JCO010	Jersey	1.56%	1.09%
21	JCO056	Jersey	1.50%	1.37%
22	JCO231	Jersey	1.42%	1.30%
23	IPE037	Polyester	1.31%	1.05%
Total % of Volume			83.13%	80.39

JCOL56 was running in 77.74% efficiency, but with the recommendations the new process is expected to run in 83.17% efficiency. That is a 5.43% overall productivity improvement. This can be improved further if the current building plan inside the factory premises is modified. The company may opt to implement the recommendations with no or little capital investment first being in line with the corporate objective.

3.1 Waste type 1: Unnecessary Transportation of Goods

The company carries out their operations in three main buildings which are physically separated. So with the process each and every product which is included in the Pareto analysis has to flowthrough these buildings. This has become a huge waste that act as a catalyst for other wastes such as waiting (Refer to Table 2).

Source-The movement of fabric from one process to another process before application of lean and after application of lean and the its distance saving and percentage of reduction.

Table 2: Reduction in Transportation distance between departments

Department / Location	Transport ation				
From	To	Present	Future	Saving	Percentage Reduction
RMS	Knitting	380 m	140 m	240 m	63.16%
Knitting	Preparation	170 m	130 m	40 m	23.53%
Preparation	Dye House	280 m	180 m	100 m	35.71%
Preparation	Finishing	280 m	170 m	110 m	39.29%
Finishing	Dye house	30 m	30 m	Nil	0%
Finishing	Printing	215 m	115 m	100 m	46.51%
Finishing	FGWH	280 m	280 m	Nil	0%
Total		**1635m**	**1045m**	**590m**	**36.09%**

With respect to the current system and layout the process is engaged with 57.51% more transportation in total, than the proposed layout even though some constraints were kept untouched during the development. Even though the main calculations were carried out considering JCOL56 standard size 32 roll batches, the feasibility of the layout was checked by applying different product into it. This was essential as almost all the products have different material flows through the system. So the following data shows the main products according to the product groups/ families (See table 3). During this study a maximum value and a minimum value were considered as the material distance depending on the position of the machines used inside the finishing department.

Source- Transportation of different types of fabricfor finishing

Table 3: Transportation variations inside the finishing department

Product	Present (m)	Proposed (m)	Saving			
	Max	Min	Max	Min	Avg.	%
JCOL56	590	510	430	360	155m	28.18
ICO220	410	330	380	310	25 m	6.76
IPE012	410	330	380	310	25 m	6.76
PJCOL56	620	540	530	460	85 m	14.66
PJCO240	440	360	410	340	85 m	21.25
BICO174	410	330	380	310	25m	6.76

3.2 Waste type 2: Overproduction

In the case study scenario an overproduction was clearly identified and quantified in the knitting department. The department produces at their operating capacity irrespective of the delivery date to the customer and they sometimes create an unnecessary pull at the beginning of the process due the massive capacity they are operating with.

Source-The existingcapacity of the machine, operating capacity and its percentage.

Table 4: Types & total capacity available at the knitting department

Type	Qty	Machine Capacity (month)	Operating Capacity (month)	Operating Capacity (%)
Fleece	16	60,000 kg	20,000 kg	33.33
Interlock	47	210,000 kg	110,000 kg	52.38
Jersey	62	350,000 kg	260,000 kg	74.29
Rib	51	220,000 kg	80,000 kg	36.36
Terry Jersey	50	280,000 kg	180,000 kg	64.29
Flat Knits	34	N/A	N/A	N/A
Total	**260**	**1,120,000 kg**	**650,000 kg**	**58.04**

But they have to produce in advance in order to facilitate higher customer demand for specific products in certain months which are identified according to the six months sales forecast.

For example, if many of their customers place orders for Fleece to deliver after six months, knitting department cannot face that demand with the available capacity. In that case they have no options other than developing an inventory in between the knitting department and the preparation department. However the time in the store as an inventory can be reduced because at the moment they keep a stock of 35 inventory days in average.

Source-The over production made during the periodin rolls, weight percentage of the monthly capacity.

Table 5: Overproduction quantities in themonth of March 2014.

Product	Rolls	Weight (kg)	Percentage of the monthly capacity
ICO48	755	15,100	2.097%
ICO220	105	2,100	0.291%
JCOL56	110	2,200	0.305%
JCOS144	420	8400	1.166%
PJCOL56	160	3200	0.444%
SDPE050	20	400	0.055%
SDPE021	35	700	0.097%
TPE477	45	900	0.125%
TPE488	40	790	0.109%
TPE514	115	2300	0.319%
Total	**1805**	**36,090**	**5.002%**

3.3 Waste type 3: Inventory

At the present stage the case study company operates with inventory buildups in between all the processes. And according to the information collected during the study, the company cannot completely eliminate inventory in between processes as this is not a continuous production line. So in order to have a smooth production they had to keep a batch sized inventory in between all the processes. By reducing the inventory levels the company can save huge amount of space inside their factory premises.

Table 6: (Source)Waiting time related to six major products

Product	Present (m)		Proposed Savings			
	Max	Min	Max	Min	Average	Percentage
JCOL56	590	510	430	360	155m	28.18
ICO220	410	330	380	310	25 m	6.76
IPE012	410	330	380	310	25 m	6.76
PJCOL56	620	540	530	460	85 m	14.66
PJCO240	440	360	410	340	85 m	21.25
BICO174	410	330	380	310	25 m	6.76

3.4. Waste Type-4 Storage

The following table shows the saving on space in current, future and its savings in percentage wise.

Table 7: Storage space reduction in each department

Department	Current (m2)	Future (m2)	Saving (m2)	Saving as a percentage
Knitting	150	80	70	46.67%
Preparation	2800	840	1960	70%
Dye house	300	150	150	50%
Finishing	1800	1080	720	40%
Printing	60	60	Nil	0%
Brushing	600	450	150	25%
RMS	1800	1200	600	33.33%
FGWH	1800	600	1200	66.67%
TOTAL	**9270**	**4420**	**4850**	**52.32%**

3.5. Waste Type-5 Defects

As all external failures are considered in the defects section, in this section only internal failures were considered for over processed products within the period. The following table summarizes the main defects that occur in the production process (Refer to Table 9).

Source- The knitted garments defects after lean implementation.

Table8: Main defects identified and reworked, according to the Pareto analysis.

Defect	Rolls	Kilos	Percentage
Stain	1538	30647	11.42%
Off shade	1182	23537	8.77%
Length shrinkage	1174	23376	8.71%
Low GSM	1122	21286	7.93%
Oil	842	17019	6.34%
Ash	733	15114	5.63%
Rough handle	596	11909	4.44%
Pressure mark	593	11845	4.41%
Chemical mark	533	10994	4.10%
High GSM	515	9856	3.67%
Narrow width	377	7504	2.80%
Unlevel	333	6804	2.54%
Dirty & stain	336	6546	2.44%
Pleats	268	5279	1.97%
Softener mark	241	4778	1.78%
Migration	226	4523	1.69%
Bad selvedge	209	4150	1.55%
Total	**215167**		**80.19%**

3.6 Waste type 6: Waiting

Several waiting points were identified throughout the process during the study. Below mentioned data briefs the total time related calculations of selected six major products (See Table 10). With the solution the company can clearly eliminate the type 2 muda (Non value adding – non essential activities) from the production process. But still almost all products have approximately 10% VA time. For example JCOL 56 is still engaged with 90.27% NVA time.

Table9: Waiting time related to six major products

Product	CurrentState	FutureState				
NVA (Days)	VA (Hours)	Type 1+2Muda	VA (Hours)	Type1 Muda(Hours)		
JCOL56	30	31.91	688.09	15	31.91	328.09
ICO220	44	25.16	1030.84	15	25.16	334.84
IPE012	35	26.08	813.92	15	26.08	333.92
PJCOL56	30	35.16	684.84	15	35.16	324.84
PJCO240	40	30.75	929.25	15	30.75	329.25
BICO174	35	25.91	814.09	15	25.91	334.09

3.7 Waste type 7: Motion

As this is a more machine intensive industry savings related to motion is relatively low than a labour intensive industry. However the following motion related data were identified during the study carried out at their premises (See Table 10). Source the motion of fabrics from one department to another department.

Table 10: Process related motion calculation with departmental breakdowns.

Department	Current	Future	Saving	Saving as a percentage
RMS	60 m	55 m	5 m	8.33%
Knitting	10 m	5 m	5 m	50%
Dye House	105 m	105 m	Nil	0%
Printing	30 m	30 m	Nil	0%
Finishing	141 m	98 m	43 m	30.5%
FGWH	15 m	15 m	Nil	0%
Other	7 m	5 m	2 m	28.57%
Total	**368**	**313**	**55**	**14.95%**

4. Conclusion

The existing system in Tamilnadu need to be changed with lean manufacturing concept to save the basic cost of the knitted fabric production. All the above data shows that with lean concept there is a huge saving on all operations in knitted fabrics production.

5. Future Scope of the Study

The future scope of the study is needed to conducted in all over Tamilnadu to eliminates all the production and process loss .Also to increase the profitability by reducing the process time, defects and other extra non-value added process .

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