IMPACT: International Journal of Research in Engineering & Technology (IMPACT: IJRET)
ISSN(E): 2321-8843; ISSN(P): 2347-4599
Vol. 2, Issue 6, Jun 2014, 73-78

THE EFFECT OF 1 SIGMA JUMP IN APPAREL MANUFACTURING

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ABSTRACT

6σ is one of the most common terminologies used in industries focusing on process improvements, although in the apparel sector this is still a grey area. A brief study was done on how the sigma value is calculated and its correlation with Yield %. An attempt was made to calculate the Yield % within the organization which is number of units leaving the process right first time / number of units produced. VSM approach was made to identify the Yield % from raw materials in-house to shipment. This VSM for quality was done for various styles and the through put yield was as low as 26.9% to maximum of 30.69%. Referring to Motorola six sigma table the yield indicated that the manufacturing process was at 1 sigma level.

Study revealed that the primary problem evident was "not being right the first time ". There were significant costs incurred and reflected in **Poor quality costs** or **cost of poor quality** (COPQ). COPQ was evident in external failure, internal failure and appraisal cost due to process inefficiencies, multiple inspection levels, rework and substandard products shipped leading to claims and discounts. Future state of 1 sigma jump was defined and the corresponding yield was defined. By obtaining a 1 sigma jump the yield % increased from 31% to 69%. There was considerable reduction in rework cost, other tangible benefits obtained were reduction in head count, WIP, floor space, throughput time, Outgoing quality level and reduction in overtime. Implementing LEAN SIX-SIGMA to obtain 1 sigma jump will have help Apparel Industry to gain a competitive advantage.

KEYWORDS: VSM Approach, CSVSM, COPQ, Poor Quality Costs

INTRODUCTION

What is 6 Sigma Value?

σ is statistical measure of variation or in other words standard deviation, most commonly used in the six sigma world. To understand the application of σ in the real world of apparel manufacturing a simple case study is presented below to determine the sigma value. Consider a shirt is being manufactured in an assembly line and garments are measured at the end of the line. Chest measurement specified by the buyer is 36' with a tolerance of +/- ½'. This means that the upper specification limit is 36.5' and the lower specification limit is 35.5'. 20 garments are selected randomly, measured and noted as below.

Garment Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Average	Standard deviation
Chest Measurement	35 3/4	36 1/4	36 5/8	35 5/8	36 5/8	36 3/8	36 1/4	36	35 3/4	35 3/4	36 3/8	36 1/2	36 5/8	35 3/4	36 3/8	35 1/2	35 7/8	36 1/2	36 3/8	36 3/8	36 1/6	3/8

Upper specification limit	36 1/2
Lower specification limit	35 1/2
Average	36 1/6
Standard deviation	3/8
Sigma level (z) for meeting USL	0.9
Sigma level (z) for meeting USL	1.8

Formula used: z score = (Specification Limit - Observed averge) / standard deviation

Figure 1

Above illustration reveals that the z value or six sigma score is less than 1 for meeting the garment specifications [lowest of 0.9 and 1.8 considered]. Referring to the table below, 1 sigma level indicates that the yield would be 30.85%. The probability of customer meeting the specification is 31%. On the other hand reaching 6 σ level means that the first pass yield would be 99.99967% and there would be only 3.4 defects in a million opportunities.

Table 1

Yield %	DPMO	Sigma (Z Score)
30.85%	691500	1
69.15%	308500	2
93.32%	66800	3
99.38%	6200	4
99.977%	230	5
99.99967%	3.4	6

**** Source:** Motorola six sigma table with 1.5 sigma shift

MEASURING THE YIELD ACROSS THE THROUGH PUT

In order to find out the yield % within the organization current state value stream map (CSVSM) for quality was done. First pass yield measured as the number of units leaving the process right first time / number of units produced. RTY or rolled through put yield is obtained by multiplying the first pass yield of the various processes.

The CSVSM for Quality or CSVSMQ was done from customer order receipt till shipment. The FPY was captured for each of the processes which include, FPY of style folder from Marketing to Preproduction execution, marketing to stores, planning to preproduction execution, FPY of fabric audit, cutting, sewing, embroidery, Sewing inline and end line first pass, finishing first pass yield, internal & external audit first pass yield.

Challenges faced were data was insufficient, incorrect or not available, first pass yield was not being measured at many places. Data collection plan was put in place, check sheets for data collection was designed [ref appendix 1], data validation and consolidation was done the CSVSM was obtained as below.

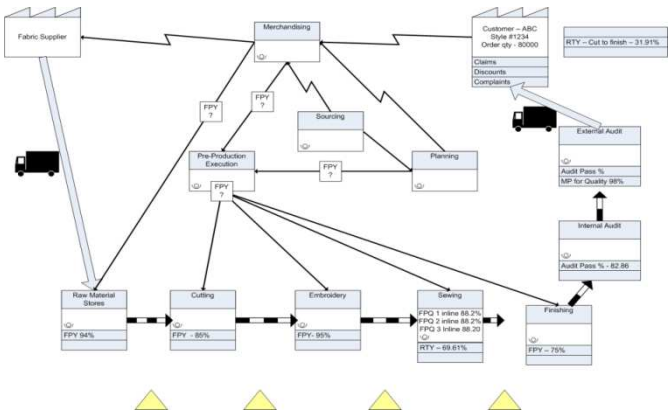

Figure 2

CSVSMQ revealed that the first pass yield in fabric audit was 94%, cutting 95%, embroidery 95%, sewing 69.61%, finishing 75%, internal audit 82.66% and external audit 98%. RTY calculated was 0.94*0.95*0.95*0.6961*0.75*0.8286*0.98 which was yielding to 31.91% RTY. The clear inference from this was that 64% of the units were being reworked at various processes and clearly reflected the built in inefficiencies of the processes.

The exercise of CSVSMQ was done for 5 more styles and results achieved even worse. RTY for process was as low as 26.9%, 29.64%, 28.67%, 29.07% &30.69%. Referring to the Motorola six sigma table a yield of 30% clearly indicates that the manufacturing processes is at 1 sigma level.

NECESSITY TO IMPROVE

When the CSVSMQ was done the primary problem evident was "not being right the first time" and these costs were reflected in **Poor quality costs**. **"Poor quality cost" or "the cost of poor quality"** represent "the difference between the actual cost of the product or a service and what the reduced cost would be if there was no possibility of sub standard service, failure of products or defects in their manufacture**"** (Campanella, principles of quality costs). COPQ has four major components which are external failure costs, internal failure costs, appraisal cost and prevention costs.

Due to internal process inefficiencies the product gets checked many times at various stages of the processes. In spite of multiple inspections and continuous rework there is huge risk of substandard product getting shipped to the customer. This could lead to customer complaints, discounts, huge charge backs and loss of good-will with the customer. These costs have a direct impact on **external failure cost** which is a component of COPQ or cost of poor quality.

The RTY of the process was 31.91%, which means that 70% of the production units will be reworked at various stages of process with a huge **internal failure cost** associated a. Industrial engineering study reveals that it takes 3- 5 times more time to rework a product than to make it the first time, also the skill required is much higher.

Study revealed that nearly 14%-18% of the manpower employed is quality checkers and auditors and another 7% of manpower used in managing and monitoring the rework process. These costs are classified under **appraisal costs**. One keen observation to make is that the **prevention cost** is very less compared to other costs. This clearly reveals that little efforts are being made in order to prevent the defects from occurring rather than efforts are made to check and correct the defect after being made.

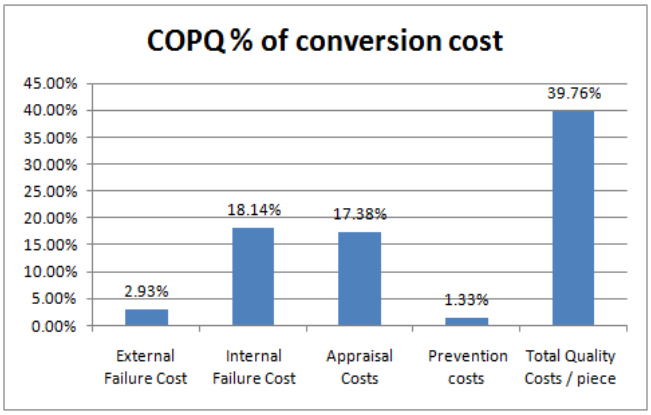

Figure 3

A typical COPQ chart in apparel manufacturing setup is illustrated above. It is clearly revealed that due to low first pass yield the COPQ or cost of poor quality is 40% of Conversion cost. On the other hand there is peer pressure on the apparel industry for

- With the Profit margins shrinking by the day,
- Cost reduction pressures from customer's increasing by the day,

- Rising competition
- Highly fluctuating dollar value

Hence there was a need for improving the process efficiency and improve the first pass yield across throughput processes.

DEFINING FUTURE STATE VALUE STREAM MAP FOR QUALITY WITH 1 SIGMA JUMP

Referring back to Table 1 six sigma table, 1 sigma jump would mean process shift from 1 sigma level to 2 sigma level, in other terms the yield % is improved from 30.85% to 69.15%. A simple table is formulated below to define the future state. It is very important that the process owners are involved when setting the future state level. In this case study since the fabric was being sourced first pass of fabric was not considered in scope. However to achieve higher levels of sigma it is mandatory that every process is improved.

Table 2

Process	Current state with 1 sigma level	Future state with 2 sigma level (1 sigma jump)	Improvement %
Desired Rolled throughput yield	31.91%	69.06%	116.43%
First pass of style folder from marketing to PPE	not measured	100%	
First pass of style folder from PPE to production	not measured	100%	
First pass of fabric	94%	94%	0.00%
First pass cutting	85%	98%	15.29%
First pass sewing	69.61%	85%	22.11%
First pass finishing	75%	90%	20.00%
First pass internal audit	82.86%	98%	18.27%
First pass external audit	98%	100%	2.04%

RESULTS

What Does 1 Sigma Jump Mean in Financial Terms

In order to understand the impact of 1 sigma jump a simple case study is presented below:

In this case study 1200 machines was considered working on 8 hours shift, the average SMV of garment was 12 minutes working at 50% efficiency. Average output per month is 600,000 at rate of 24000 pieces per month.

Lean Six Sigma Approach with **DMAIC** methodology was used to improve the process stability and in turn improve the first pass of each of the processes. Few projects demanded use of lean tools such as **Kaizen approach** which was applied in all projects, SMED or single minute exchange of dies to improve change over process, AM or autonomous maintenance and 5S widely used in reduce stain and damage project.

Reduction in Rework Cost by Improving the First Pass Quality

First project was launched in sewing where the Lean six sigma methodology was used to improve the first pass of sewing from 70% to 85%. Within 3 months there was consistent improvement the first pass and rework had consistently come down. Efforts were made to measure the financial benefits which revealed as annualized savings **of 63 lacs**. With such startling revelations improvement projects were launched across the throughput and results were achieved as below.

Improve First Pass of Cutting by 50%: Cutting FPQ was improved from **85% to 93**% with a financial benefit of **Rs.20.16 lacs per annum.**

Reduce Stains and Damage by 50%: Stains were reduced from **25% to 12.5%** with annual savings of **Rs.31.5 lacs per annum. Damages** reduced from **9% to 4%** with annual savings of **Rs.15.12 lacs per annum.**

Improve First Pass of PPE: First Pass of Inputs to Production was improved from **91% to 100%** with annual benefits of **Rs.40.5 lacs per annum** which directly reduced downtime in sewing and finishing.

Improve Change over Process to Improve RTY of Sewing during change over from **65% to 80%** with annual benefits of **Rs.40** lacs which is benefited by reduction in rework from sewing to finishing, air shipment due to poor quality.

Reduce Fabric Dead Stock: Fabric Dead Stock was reduced from **2.25% to 1%** with annualized savings of **Rs.90 lacs per annum.**

Reduce Garment Dead Stock – Implementation of KanBan with Quality. Garment dead stock was reduced from **2.5% to 1.0%** with annualized saving of **Rs. 1.94 crores.**

Elimination of Packing Errors: Implementation **reduced packing errors** from **4000$ to 1000$ per month** with annual savings of **Rs.22.3 lacs.**

Other Tangible Benefits

Reduction in Head Count Leading to Reduction in Appraisal Costs: As a by-product of the implementation of above six sigma projects there was considerable reduction in Head count of Checkers, Quality controllers. Before implementation of the project the Checkers and Quality controllers put together were **420 associates** which was reduced to **252 associates** with a annualized saving of **1.51 crores**.

Reduction in WIP: With improvement in processes and quality, effective implementation of KANBAN the WIP in the line was brought down from **28/machine to 12/machine**. The total WIP of sewing was **33600 pieces** which was reduced to **14400 pieces** (for a 1200 machine factory).

Reduction in Floor Space: With the improvement in quality and elimination of check points there was considerable reduction in space. Due to improvement of first pass quality, PPE, change over processes many operations were deskilled or eliminated. There was reduction in helping operations, NVA operations and line length reduced from **42 workstations** to **32 workstations**. **Finishing was made online** and was no longer a separate department. WIP or work in progress in line was reduced and centre table was removed. Production floor area (cut sew pack) used for 1200 machines reduced from **180000 sq ft to 120000 sq ft. 60000 sq ft** accounted to annualized savings of **Rs.86.4 lacs** at Rs.12/sq ft rent.

Reduction in through Put Time: Throughput time was reduced from **4800 minutes to 1440 minutes**. This was measured by tracking the time taken for a fabric to move across the value stream from Fabric store to finished good storage area. After project implementation the same product took 3 days from 11 to 12 days previously.

OQL (Outgoing Quality Level): The external audit pass % was improved from 85% to 98% with considerable reduction in rescreens.

Reduction in Overtime: Overtime was 10% of wages before implementing the project mainly due to low

productivity as a resultant of poor quality, shipment delays. Overtime was reduced to 5% of wages through process improvements and first pass quality in cutting, sewing and finishing. Overtime was reduced from **Rs.1.68 Crores to Rs.84 lacs per annum.**

Reduction in Customer Complaints and Charge Backs Impacting External Failure Cost: There were frequent customer complaints and charge backs which contributed to a loss of **Rs.1.26 crores per annum**, with implementation of LEAN SIX SIGMA this was brought down to **Rs.64.04 lacs per annum with annualized savings of Rs.62.32 lacs a direct reduction in External failure costs [Project 8 savings included].**

CONCLUSIONS

Most apparel industries are at 1 Sigma level with low first pass in all the processes. Study revealed that RTY is as low as 35% and by implementing Lean six sigma, RTY was improved to 60% which brings the process close to 2 sigma level.

In-spite of having spent on appraisal costs through multiple screening the defective garments was not fully prevented. Substandard products were shipped to the customers, which let the loss of customer goodwill, charge-backs, claims and discounts. This cost which was an ugly cost contributing to 3% of conversion cost. However this poor cost of quality does not include the cost of developing a new customer when the existing customer is lost, reduction in volumes due to poor quality.

After implementation of the projects, the cost saved by reducing the COPQ was 8.11 crores. The other tangible benefits that were obtained were reduction in head count with an annual benefits of 2.94 crores, reduction in WIP from 28/ machine to 12/machine, reduction in floor space from 1.8 to 1.2 lac sq ft and annualized benefit of 86.4 lacs. There was also reduction in throughput time from 4800 to 1440 minutes, OQL increased from 85% to 98%, overtime was reduced from 10% to 5%.

Improved employee satisfaction, improved customer satisfaction and better process control and visibility are Intangible benefits achieved by implementation of the project.

It was clear that by targeting 1 sigma jump by improving the first pass quality across the throughput using lean six sigma methodology there was drastic improvement all processes, also there were huge financial benefits.

With the growing completion in Global market, increasing customer demands, reducing margins, increasing labor and raw material costs, implementing LEAN SIX-SIGMA to obtain 1 sigma jump will have help Apparel Industry to gain a competitive advantage over other countries and increase Exports share. This will help further to create employment opportunities across country and improve Indian Economy.

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