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Application of Lean Six Sigma for Sample Checking Audit Procedure Process Improvement in the Apparel Sector in Sri Lanka

Sanduni Sulakkhana[1], RASA Perera[2#]

[1]*Hela Intimates, Narammala*
[2]*National Institute of Business Management, (NIBM)Kurunegala Campus*

[#]shahein.aruna@gmail.com

Abstract: Lean Six Sigma has become a well-known tool to improve operational excellence in manufacturing as well as service organisations. Lean Six Sigma generates a significant positive contribution to an organisation's performance in improving processes by reducing cycle time and waste in the process. This study is focused on real practical scenario of Hela Intimates (Pvt) Ltd, Narammala which is having lengthier time periods for the Acceptable Quality Level (AQL) Audit procedure than the Standard Operating Procedure time periods. This is a qualitative and quantitative research in nature. The main research objective of this study is to improve the process quality by reducing the current cycle time using Lean Six Sigma of the Acceptable Quality Level audit process of the sample checking process at Hela Clothing Ltd Narrmmala. Both primary and secondary data are used to reach the study objectives. Two thousand three hundred and twenty-six AQL audits in the month of June are considered for the sample. Cluster sampling method under Probability sampling method is used to draw the sample and the direct observation method is used to gather AQL audit cycle time. In addition to that, three auditors are interviewed in order to identify the waste types in the AQL process. To analyse the data, Lean Methodology and DMAIC methodology which is used under Six Sigma is used. Under this methodology Process control chart, Non-value-added activities calculations, descriptive statistics and Perato chart are considered to analyse the data. To analyse the interview data, the contents and pattern matching method is used. The results of the analysis revealed that the present AQL Audit process is stable and yet the process can be improved further. Based on its AQL audit procedure, cycle time is reduced to 35 minutes from 45 minutes and it is a 22% process improvement from the current process by using Lean Six Sigma methodology. Therefore, it clearly evident that Lean Six Sigma can be used as a process improvement tool for apparel sector in order to meet customers' requirements.

Keywords: Lean Six Sigma, Process improvements, Cycle time

Introduction

Business organisations in globalized market are marching towards to improve the business processes to address the customers' requirements by reducing the waste and adding value in producing high quality products with fewer defects with customer focus in lower cost.(Itkin, 2008; Chee, 2008, Kaushik et al 2012). They are using many business strategies such as Lean manufacturing, Six Sigma, Blue Ocean theory to overcome this business competitiveness in this highly modern competition in this market place. Six Sigma is an asset of Statistical tool , which is a process driven approach used to process improvements reducing the defect in an

organizational process focusing the customers' requirements in greater value (Kwak and Anbari 2006 Goh and Xie 2004, McAdam and Evans 2004). Lean thinking is a set of methodologies developed in Japan which aim for maximizing the value of the product, based on value addition of the process and elimination of waste.The term Lean is defined in many ways by many lean philosophers and all are discussed with the view point of eliminating waste in the system (Womack et all 1994, Bhasin and Burcher 2006 Aitiken et al 2002). Taiichi Ohono 1988 highlights that the main objective of this practices is to increase the production efficiency by consistently and thoroughly eliminating the waste. Further Taiichi Ohono discussed about the method to identify forms of waste in organization with his "Seven waste" model called is as "seven MUDA" which become cardinal approach in academic and industries. Seven ways of waste sources identified by Taiichi are transport, inventory, motion, waiting, over processing, over production, and defects. Recently another waste type was added to this cluster, called non-utilized talents of employees. Mura means lack of uniformity or non-uniformity, inequality and business process improvement method based on Just in Time method which indicated keeping less inventory or no inventory. The waste Muri means unreasonableness or impossible in production which can be eliminated through the standardized work. According to Stolzer and Halford (2004) studies, they have identified that this application is more sophisticated and relevant to gain more return on investment of particular air carrier organization. (Prasad et al 2012)

The blend of these two are called Lean Six Sigma(LSS) which generate considerable amount of Contribution to the organisations and Industries are widely use it as one of the business improvement methods. (Nonthaleerak & Hendry, 2006; Schroeder et al., 2008).

LSS methodology is primarily driven through the application of the five stage six sigma DMAIC approach which stands each letter respectively Define, Measure, Analysis, Improve and Control. These five stages are defined my many researches. (Antony 2006) identified Define stage is as the identification of the problem, scope of the work effort of the project team. Measure stage is defined as measuring the current process of performance of problem identified company. Analysis stage is defined as the process of analysis the current performance data by using statistical analysing tools. Improve stage is defined as improve the process stages by selecting proper and critical solutions based on analyzed data. Final stage control of Six Sigma methodology is defined as maintain and improve the process. All the Lean and Six Sigma tools are comprised by the DMAIC methodology toolkit and the success of them depend on ability to use these toolboxes in a systematic and disciplined manner.

This DMAIC process is widely used methodology to quality improvement and it can be extended to total quality Management (TQM) (Black and Reverer 2006).DMAIC framework is practically validated to provide significant positive contribution towards the both operational and environmental benefits (Ruban, Vinodh and Asokan 2017). This methodology was successfully applied to Indian automotive component manufacturing firm by the research team of (Ruban, Vinodh and Asokan 2017) and resulted positive overall performance and the environmental performance by reducing of defects and reducing process variation. It will lead to the leads to reduction in consumption of raw materials, energy, and reduced scrap which in turn reduces the overall environmental impacts.

They have taken the environmental benefits by improving the process and it provides path to this study to apply DMAIC methodology for process improvement. (Psychogios 2010) identified that lean Six Sigma practices can be applied in airline services industry to avoid unnecessary mistakes and costs provoked by employees which can led to continuous improved programs which is one of the main goals in air industry as well as ground process.

It is highlighted that Lean Six Sigma can be applied into any organizations(Mahanthi and Antony 2005) and it generated significant advantages to the field of Healthcare Sector (Laureani, Brady, & Antony, 2013), construction sector (Van den Bos, Kemper, & de Waal, 2014) and, education sector. (Thomas et al., 2015).According to (Laureani, Brady, & Antony, 2013) they applied Lean Six Sigma to the Irish hospital in Ireland and get generated more benefits such as better operational efficiency, higher process quality, improved cost-effectiveness and better value for money in every departments in the hospital in shorter time period. According to (Van den Bos, Kemper, & de Waal, 2014) they applied Lean Six Sigma to the Dutch constructions company and resulted that lean manufacturing system reduced the throughput time speed, and impact of it, in terms of project completion.it discussed that DMAIC process of the Six Sigma contributed to reduce the Lead time of the constructions projects. Therefore, it provides the basis for the reduction of the process time of this study. Also (Thomas et al., 2015) applied this Lean Six Sigma to the in an aerospace manufacturing company and resulted time reduction of 20.5%, improved on-time-in-full delivery to customer by 26.5%, reduced value added time by 5% and reduced Non-value added time by 44.5%. Also, estimated financial savings of over £2 Million are proposed.in improving the production process by eliminating waste and reducing the lead time this research paper provides better foundation on it.

Therefore, previous researchers found that applying Six sigma in any organization can improve their busines process to address the customers' requirements. Hela Narammala pvt ltd also looking for the process improvement in their AQL audit procedure because it is a critical issue of having a lengthy process time compare with the standard operating procedure. This research paper address the requirements of the producers' quality perspective of process development to enhance the customers' satisfaction.

Study Objectives

Hela clothing (pvt) ltd is a apparel industry which is manufacturing global recognized apparel brands. Their process time of the Acceptable Quality Level (AQL) audit procedure is lengthier than the Standard Operating Procedure.It is nearly Fourty five minutes in average per garment. Thus, when we consider about the total orders of the Organization it is a huge waste and the cost for the organization. Therefore, organization is looking for the methodology to improve the business process by reducing the process time of AQL Audit procedure. Based on the literature review, it provides better foundation of Lean Six Sigma to apply to the process by reducing waste.

Therefore, The main objective of this study is to improve the process quality by reducing the current cycle time using Lean Six Sigma of the Acceptable Quality Level audit process of sample checking process at Hela Clothing Ltd Narrmmala.

Methodology

This is a qualitative study in nature. Number of monthly AQL audits conducted in last six months (Jan - Jun) in the year

2019 is considered as population of the study. Within the considered time period of six months fourteen thousand two hundred forty five AQL audits have carried out. Month of June is selected for the sample by using Cluster Sampling method under Probability sampling method is used to draw the sample. Two thousand three hundred twenty six AQL audits conducted in the months of June is considered as sample size of the study.

Both Primary data and Secondary data are used to reach the study objectives. Number of audit failures are taken from the system and The cycle time taken to proceed the AQL audits are manually calculated by using stop watches. Direct observation method is used to gather data. And three auditors are interviewed to identify the waste types in the AQL process.

To analyses the data, Lean Methodology and DMAIC methodology which is used under Six sigma is used. DMAIC is the problem-solving which has five-phase Define, Measure, Analyze, Improve and Control for improving existing process problems with unknown causes. Measure stage is used to measure the current process of the performance. By using statistical tools and quality tools, quality problem is analyzed in the stage of Analysis. In the Improve stage the current process is improved by selecting critical solutions for the quality issue. Control stage highlights to maintain the improved process and leads to continues improvement.Under this methodology Process control chart, Non-value added activates calculations, descriptive statistics and Perato chart are considered to analyses the data. To analyses the interviews information Conents and pattern matching method is used

Analysis and Discussion

Kanban system under Lean philosophy and DMAIC Process under Six Sigma is applied to reach the study objectives. Current status of the Acceptable Quality Level audit process is as follows. It takes 45 minutes of working process. Table no 01 is the summary of the average time that the current process is performing.

Table no 01 Activities and current time performing- Appendix no 01

As per the AQL process the following wastages are identified through the direct observations.

Transportation waste occurs when there are unnecessary movements of products and material. Due to the improper placement gap between of packing table and the AQL table. Transportation waste was observed. It was observed.

Inventory waste is the excess products and materials which are not being processed When the packer offer the AQL audit beyond the order AQL of the carton.Motion is the unnecessary movements by people materials etc. when the ready to the audit they need style files and other detail files. When they haven't specific place to keep the above mentioned files it creates unnecessary movements. Due to this issues in the audit process the gap between AQL table and the AQL room, motion waste can be observed through the unnecessary long distances travelled by the auditor.Waiting time occurs when time is wasted waiting for next audit. Waiting time can be observed when the auditor waiting for next audit, Andon lights on but not ready the audit. Wait for a period of timeOver processing happens when more work is been performed than what is really required. Therefore over processing waste did not prevail in the observation time.

Figure no 01 Highlights the current Analysis System chart of Audit procedure.

Figure no 01- Current Analysis of the process- Appendix no 02

To make the better understanding about the customer requirements across the process, Kanban System was used. Interviews ideas were analysed and they were highlighted in Table no 02

Table no 02- Analysis of Kanban system- Appendix no 03

Six Sigma Methodology Application

Define Stage

Reduce the current cycle time of the Acceptable Quality Level audit process of sample checking process using Lean Six Sigma up to 35 min at Hela Clothing Ltd Narrmmala.the total time reduction is expected to 22% from existing time period.

Measure Stage

Two types of variables are thoroughly drew into attention such as Number of audits fails and Time taken to process the AQL audit. Number of audits conducted during the sample time period and the pass and fail audits were the measureable units of the variable in order to identify whether the process is stable before reducing the AQL audit time of the process. Minutes were considered as measureable units of the variable, Time taken to process the AQL audits in order to identify the Non value added activities to reduce the cycle time.

Current average cycle time was discussed in the table no 01. And the defects calculation was identified as follows, Six sigma DPMO (Defects per Million Opportunities) was calculated under Six Sigma Methodology.

$$\text{DPMO} = \frac{Total\ Defects}{Total\ Opportunities} * 1000000$$

(Mcadam,Evans 2004)

134 audits were failed (time) during the period of Jan – July 2019 and total opportunities identified were 14245. Therefore DPMO is calculated as

$$\frac{134}{14245} * 1000000 = 9406.8$$

Current sigma level identified the Six Sigma level (Mcadam,Evans 2004) is between 3.8 to 3.9.

The DPMO for the month of June is as follows, 27 audits time failures for the 2326 AQL audits $\frac{27}{2326} * 1000000 = 11607.9$.

Current sigma level identified the Six Sigma level table (Mcadam,Evans 2004) is between 3.8 to 3.9.

Analysis Stage

Total AQL audit failures in the period of January to June in 2019 is recorded as 1% of total audits and it is shown in figure no 01. It is due to the Random variation of the process.

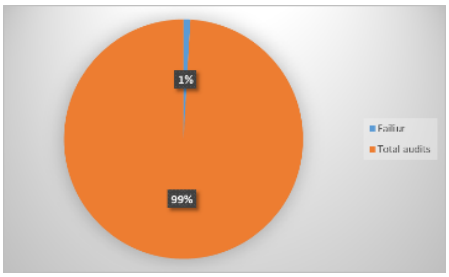

Figure no 01 – AQL audit faliures from Jan - June

It was confirmed by the data analysis of the Total AQL audit failures in the month of June 2019.

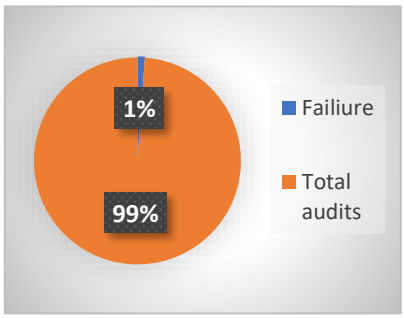

Figure no 02 – AQL audit faliures in the month of June

To clarify the process stability np Control chart is constructed.np chart is used that the observation data was attributes data. By using observation data it was constructed to identify the current process. Np chart of the data is shown in Figure no 03

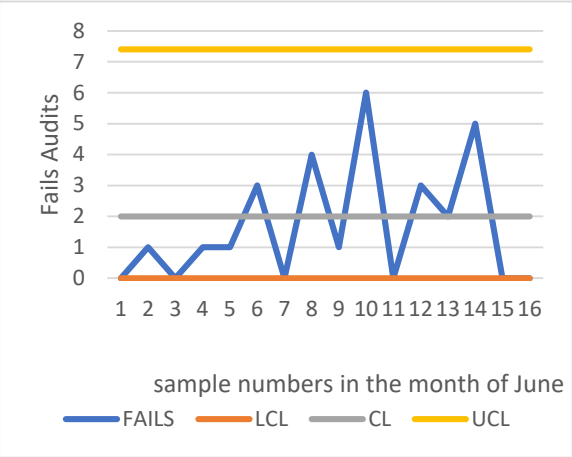

Figure no 03 – np chart for the AQL audit procedure

All the sample points were between the upper control level and the lower control level and it can be concluded that process is under control. no any assignable variation in the process. To check the stability of the process in total population Pareto Analysis is conducted. It is shown in the Figure no 04. It highlights that the process is under control without having Assignable variation in AQL Process in population time period. Therefore further improvements can be done to the process.

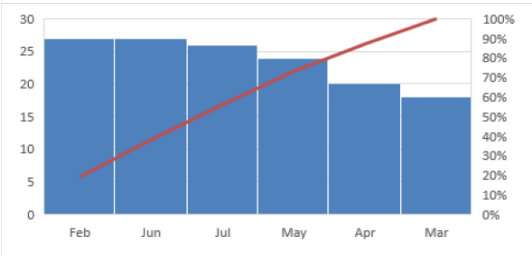

Figure no 04– Pareto Analysis

Non value added time for the total AQL procedure is attached in the Table no 03. If the activity or the time can be eliminated or shifted or not generating value to the process, it is defined as non-value added times in activities for this study

Table no 03-Non value Added activities calculations Appendix no 04

Improve stage -

Non value added calculations were done in order to identify the improvement area of the process. Therefore waste types in the process identified under Lean philosophy was considered for the improvements. Time for the activity numbers 04 05 06 are critically reduced by eliminating time and time for the activity numbers 10 11 12 are critically change with allocating more time for it. Table no 05 highlights the time comparison between previous and redesigned new process after applying Lean Six Sigma.

Table no 04- Comparison between the previous and redesigned process- Appendix no 05

Figure 05 highlights that the redesigned system of the process.

Figure no 05 –Redesigned process Appendix no 06

Layout changes has done to achieved the target foolowing Figures no 06 and 07 highlighted and previous redesigned layouts of the process.

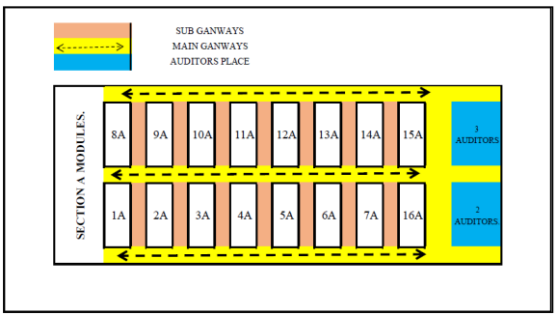

Figure no 06 – Current process layout

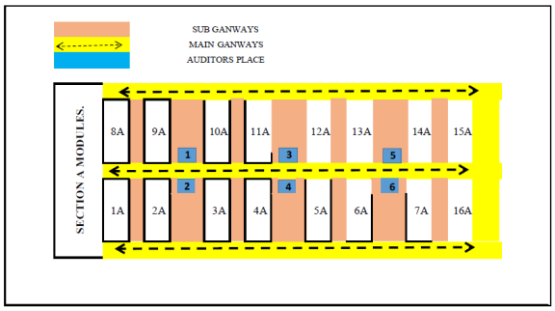

Figure no 07 – Current process layout

Control Stage -

Under this stage following control methods are suggested to follow the process in future activities. Before get the audit

arrange all necessary document to the AQL table and keep under the table.

- Remove poly bags with hanger.
- Arrange AQL table near the packing table of the line.
- Get the audit before seal the packs.
- Arrange packing trims information sheet and keep with the auditor.
- The records are taken from the ISO 9001:2015 records files and the process is identified through the inspections.
- For the control purpose which leads for the continual improvement following documents will be used.
  (System audit)
    - Internal audit.
    - Inspections
    - Ideas from Team AQL auditor and the QAGL.
    - Observations

Conclusion

DMAIC Methodology provides better foundation to identify the process issues and help to improve the process by reducing the cycle time. Analysed data indicate that the AQL Process of the company is running in stable position without having the assignable variation within the study time periods. Therefore future improvements can be done to the process as it was stable.

Expected time to reduce the cycle time is 22% from the current process and it is operating between 3.8 to 3.9 Sigma levels in with 9406.8 Defects per million opportunities under Six Sigma calculations.

After critical analysis of time calculation of process activity observations The Total Cycle time of the AQL audit procedure was reduce up to 35 minutes from 45 minutes by applying Lean Six Sigma methodology.

According to (Zasadzień 2017) studies, they applied Six Sigma methodology a maintenance process in Poland and improve the process in significant amount. They successfully applied DMAIC methodology for process improvement.Also (Thomas et al., 2015) applied this Lean Six Sigma to the in an aerospace manufacturing company and resulted time reduction of 20.5%, improved on-time-in-full delivery to customer by 26.5%, reduced value added time by 5% and reduced Non-value added time by 44.5%. Therefore It is a significant amount of 22% of cycle time reduction of AQL Audit procedure at Hela Intimates(Pvt) Narammala.

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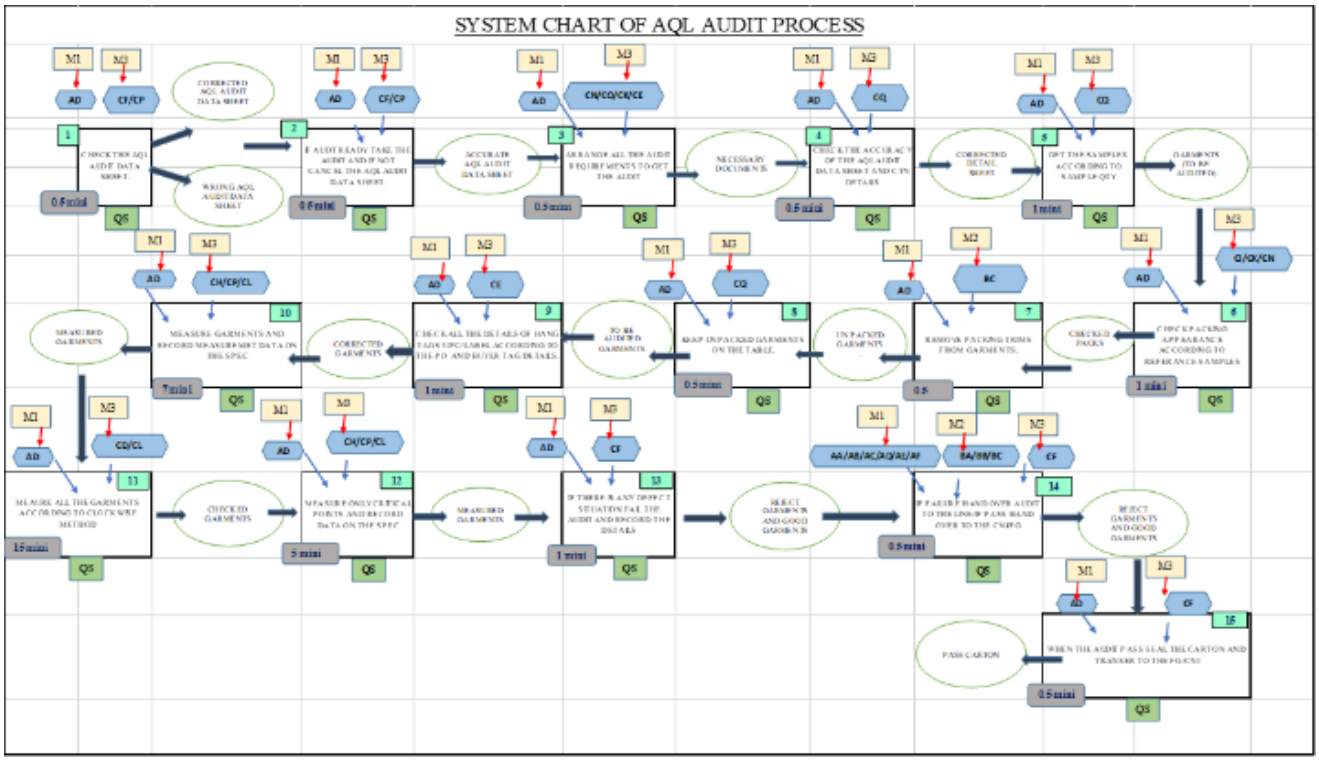
Appendix

Appendix no 01 - Table no 01
Table no 01 Activities and current time performing

No	Activity	Time	
1	when the andon lights on(orange color for aql audits)go to the sewing line and check the aql audti data sheet.	0.5	mini
2	when the audit is ready arrange the requirements to take the audit or when the audt is not ready cancel off the andon light and cancel the record in the aql audit data sheet.	0.5	mini
3	arrange all the audit requirements to get the audit (teck pack/style file/packing sample/production sample/buyer tag file)	2	mini
4	check the accuracy of aql audit data sheet and CTN details (time/qty)	1	mini
5	get the garmemnt from the carton according to the sampling plan.(32 pcs for 180 pcs)	1	mini
6	check the packing appearance/packing trims according to the style file and approved trim card.	2	mini
7	remove hangers and poly bags boxes of selected garments.	2	mini
8	keep aside all removed trims and placed unpacked garments on the aql table to get the audit.	2	mini
9	check the all details of hang tags,upc and the label according to the approved po sheet and buyer tag.	2	mini
10	randomly select 01 garment from each 12 garments and get the full measurement and record only one mesuremnt on the spec sheet.	7	mini
11	check the all other garments according to the clock wise checking method and strickly point out the constructions and the sewing defects of the selected garment.	15	mini
12	randomly select 01 garment from each 06 garments and get the critical measurement and record 03 mesuremnt on the spec sheet.	6	mini
13	in this audit if there is any damages beyond the sampling plan audit is fail.if it is fail record the failure in the pre delivery audit sheet and the aql data sheet.same as the process when audit pass.	2	mini
14	in the failure hand over the fail carton to the line and inform the in line auditor to recheck.(team leader/in line auditor/examiner/qa gl/production gl/	1	mini
15	when the audit pass seal the carton and hand over the carton to cni team with the signature of aql auditor.	1	mini
total time		45	mini

Appendix no 02
Figure no 01- Current Analysis of the process



Appendix no 03-
Table no 02-Analysis of Kanban System

No	Activity	Quality standards.
1	When the Andon lights on (orange color for aql audits) go to the sewing line and check the aql audit data sheet.	Accuracy of the data sheet and the audits of right qty and right quality.
2	When the audit is ready arrange the requirements to take the audit or when the audit is not ready cancel off the Andon light and cancel the record in the aql audit data sheet.	Accuracy of the data sheet and the audits right qty.
3	arrange all the audit requirements to get the audit (teck pack/style file/packing sample/production sample/buyer tag file)	According to customer style file all the packing trims should be correct. Correct standards.
4	check the accuracy of aql audit data sheet and CTN details (time/qty)	According to customer needs ctn details should be correct. Right quality
5	get the garment from the carton according to the sampling plan.(32 pcs for 180 pcs)	According to sampling plan received from the customer 32 pcs for 180 pcs carton and there should not be any defects for the 32 pcs. right qty
6	Check the packing appearance/packing trims according to the style file and approved trim card.	Sewing trims should be correct according to the customer trim card. right quality
7	Remove hangers and poly bags boxes of selected garments.	It should necessary remove all the packing trims before audit.
8	Keep aside all removed trims and placed unpacked garments on the aql table to get the audit.	Prevent from mix up. Right quality and right process.
9	Check the all details of hang tags, upc and the label according to the approved po sheet and buyer tag.	Accuracy of the all details related to po sheet.
10	Randomly select 01 garment from each 12 garments and get the full measurement and record only one measurement on the spec sheet.	For check correct measurements. Right product
11	Check the all other garments according to the clock wise checking method and strictly point out the constructions and the sewing defects of the selected garment.	For accuracy.
12	Randomly select 01 garment from each 06 garments and get the critical measurement and record 03 measurement on the spec sheet.	For accuracy.
13	In this audit if there is any damages beyond the sampling plan audit is fail. If it is fail record the failure in the pre delivery audit sheet and the aql data sheet. Same as the process when audit pass.	Customer specification.
14	in the failure hand over the fail carton to the line and inform the in line auditor to recheck.(team leader/in line auditor/examiner/qa gl/production gl/	Necessary to recheck and re audit before transfer to the cni area.
15	When the audit pass seal the carton and hand over the carton to cni team with the signature of aql auditor.	Customer specification due to accuracy of the audit details.

Appendix no 04

Table no 03- Non value added time calculations

No	Activity	TIME in min	VA time in min	NVA time in min
1	when the andon lights on(orange color for aql audits)go to the sewing line and check the aql audti data sheet.	1	0.5	0.5
2	when the audit is ready arrange the requirements to take the audit or when the audt is not ready cancel off the andon light and cancel the record in the aql audit data sheet.	1	0.5	0.5
3	arrange all the audit requirements to get the audit (teck pack/style file/packing sample/production sample/buyer tag file)	2	0.5	1.5
4	check the accuracy of aql audit data sheet and CTN details (time/qty)	6	0.5	5.5
5	get the garmemnt from the carton according to the sampling plan.(32 pcs for 180 pcs)	15	1	14
6	check the packing appearance/packing trims according to the style file and approved trim card.	7	1	6
7	remove hangers and poly bags boxes of selected garments.	2	0.5	1.5
8	keep aside all removed trims and placed unpacked garments on the aql table to get the audit.	2	0.5	1.5
9	check the all details of hang tags,upc and the label according to the approved po sheet and buyer tag.	2	1	1
10	randomly select 01 garment from each 12 garments and get the full measurement and record only one mesuremnt on the spec sheet.	2	2	
11	check the all other garments according to the clock wise checking method and strickly point out the constructions and the sewing defects of the selected garment.	1	1	
12	randomly select 01 garment from each 06 garments and get the critical measurement and record 03 mesuremnt on the spec sheet.	1	1	
13	in this audit if there is any damages beyond the sampling plan audit is fail.if it is fail record the failure in the pre delivery audit sheet and the aql data sheet.same as the process when audit pass.	2	1	1
14	in the failure hand over the fail carton to the line and inform the in line auditor to recheck.(team leader/in line auditor/examiner/qa gl/production gl/	0.5	0.5	0
15	when the audit pass seal the carton and hand over the carton to cni team with the signature of aql auditor.	0.5	0.5	0
	Total time	45	35	10

Appendix no 05

Table no 04- Comparison between the previous and redesigned process

No	Activity	Actual Time(min)	Expected time(min)
1	when the andon lights on(orange color for AQL audits)go to the sewing line and check the AQL audti data sheet.	1	0.5
2	when the audit is ready arrange the requirements to take the audit or when the audt is not ready cancel off the andon light and cancel the record in the aql audit data sheet.	1	0.5
3	arrange all the audit requirements to get the audit (teck pack/style file/packing sample/production sample/buyer tag file)	2	0.5
4	check the accuracy of AQL audit data sheet and CTN details (time/qty)	6	0.5
5	get the garment from the carton according to the sampling plan.(32 pcs for 180 pcs)	15	1
6	check the packing appearance/packing trims according to the style file and approved trim card.	7	1
7	remove hangers and poly bags boxes of selected garments.	2	0.5
8	keep aside all removed trims and placed unpacked garments on the AQL table to get the audit.	2	0.5
9	check the all details of hang tags,upc and the label according to the approved po sheet and buyer tag.	2	1
10	randomly select 01 garment from each 12 garments and get the full measurement and record only one measurement on the spec sheet.	2	7
11	check the all other garments according to the clock wise checking method and strickly point out the constructions and the sewing defects of the selected garment.	1	15
12	randomly select 01 garment from each 06 garments and get the critical measurement and record 03 measurement on the spec sheet.	1	5
13	in this audit if there is any damages beyond the sampling plan audit is fail.if it is fail record the failure in the pre delivery audit sheet and theAQL data sheet.same as the process when audit pass.	2	1
14	in the failure hand over the fail carton to the line and inform the in line auditor to recheck.(team leader/in line auditor/examiner/qa gl/production gl/	0.5	0.5
15	when the audit pass seal the carton and hand over the carton to cni team with the signature of AQL auditor.	0.5	0.5
	Total time	45	35

Appendix no 06

Figure no 05 –Redesigned process