DETERMINING THE STATISTICAL PROCESS CONTROL LIMITS FOR UNCERTIFIED SRI LANKA STANDARD (SLS) BOXES OF MATCHES IN SRI LANKAN MARKET

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ABSTRACT

Quality control limits through Statistical quality control charts are used to control the quality of the process in product manufacturing. It can be used to determine whether the manufacturing process is operating according to the desired quality standards. Manufacturing boxes of matches should be in appropriate quality as it is considered the safety consuming item. This paper addresses the main objective of determining the statistical quality control limits for uncertified Sri Lanka Standards (SLS), boxes of matches manufactures in Sri Lanka". Sub research objective is "to determine whether SLS Uncertified Boxes of matches are Really safety related to its production process.". 1135 sample units of match sticks were used for the study using 25 samples for the study. Primary data were gathered using direct observation method from uncertified Sri Lanka Standards box of matches manufacturers regarding the considered quality characteristics in both variables and attributes in product. Eight quality dimensions such as the number of matches in a box, ignition and burning, afterglow, length of splint and match head, bending strength, were the considered quality characteristic of the boxes of matches. These quality characteristics were taken from SLS recommendations. Statistical Quality control equations, Statistical quality charts were used to analyse the data. Lower control and upper control levels of the characteristic of the SLS uncertified match boxes are as follows. Length of Splint 30.7 mm -34.8mm, length of the head 3.3mm -3.5mm, Burning time 13.8sec – 17.8 sec, Bending strength 35.1sec-40.7 sec, Afterglow 1.46 sec- 2sec, safety 0 -12.6, adherence

0-4.89, No of match sticks in the box 44-46 sticks. Generated quality control limits prevailed within SLS requirements except the quality dimensions, the Length of Splint and the Burning time. They highlight that these boxes of matches which do not have SLS are unsafe due to the uncontrolled production process based on SLS. Thus, the Sri Lankan manufacturers should draw their attention to produce full quality productions with a high priority to safety.

Keywords: *Quality Control limits, boxes of matches, Quality Control charts.*

INTRODUCTION

Sri Lanka makes an attempt to remain and enhance the position in the world market while marching parallry with the changes in global economy factors. Therefore, to compete and to win the competitions in global market and local market, Sri Lankan industries are drawing attention towards for innovative and cost reduction strategies and making big efforts to overcome the difficulties of them. According to the annual report of Central Bank of Sri Lanka, highlights that the industry sector in Sri Lanka is achieving less presentation in G.D.P Around less than32% in 2015 and this mount as well as components in industry sector shows the positive trend in changes in GDP compared to previous years. Therefore, it is need of the time to draw attention towards the marketing procedures as well as a quality of the Sri Lankan industry products due to the Quality Of the product is considered as a primary indicator of organizational performance and key parameter in order to measure the performance of the product and services. Many researchers identified that Quality of the products resulted the in gaining sustainable competitive advantages (Gronroos 1998). The key of the quality can ability to exceed the expectations of the customers by providing them a required products or services which have low cost on time and very time. (Chinyemba 2008, Wachs 2011). There for its needed to consider about the quality of the products and the procedure of quality control in an organization to meet the customer expectation in developing industry sector in Sri Lanka.

Quality control and Quality Assurance Should be properly maintained in aim of having a proper production system stating from obtaining appropriate materials to deliver a quality product to the customers. Quality control procedures ensure the quality of the specific sample or batch which include the analysis of reference materials (ISO 8402 Quality Vocabulary). Statistical process Control methods are used in manufacturing system in aim of upgrading the system to improve on quality and cost effective. It emphasizes on early detection and prevention of a problem and bring distinct advantages over quality methods such as inspection of end product (Mason 2017). Key tools in Statistical Process control are control charts, continues improvement and design experiments (Franco-Santo et al 2017). Variations of the production process which lead to the poor quality can be detected and corrected. This provides real time analysis to make a controllable baseline and improve process capabilities and focus on the areas which should be needed in a manufacturing process (Tan 2002). Thus, this paper is focus on the determining Statistical Quality Control

for the non-Sri Lanka Standards certified matches in boxes manufacture in Sri Lankan to analyse the quality in the process in safety purpose.

LITERATURE REVIEW

Statistical Process Control is a procedure of statistical method applying for control and monitoring the manufacturing process in aim of producing the quality products through ensuring whether that the production process is out of control. The evaluation of quality control is begun with the inspection (Dooley 2000). Detection of unconformity products and causes arguments regarding how these methods fail to facilitate economical quality procedures, are considered as the basis of inspection mechanism in production. All these considered due to the detection of products defects and variation in production line being considered too late to be solved (Deming 1986). In aim of prevention of problems, a better tool which generate advantages over inspection should be needed.

The systematic mechanism of Statistical quality control is considered as Statistical Process Control. This systematic process control tools in Quality Control technique highlights the excellence in Business performance in different industry spheres (Mann et all 1999). There are seven Statistical Quality Control tools such as Check sheet, Histogram, Pareto Charts, Cause and effect Diagram, Scatter diagram, Control Charts. Among these Statistical Quality Control, Control Charts are the most common tools for determining whether a process is under control or not in manufacturing process. Therefore, in this study Control Charts under Statistical Quality Control are used to determine whether the process of manufacturing Sri Lanka Standards (SLS) uncertified matches in a box are under control or not.

Boxes of matches are usual consumption item in Sri Lankan lifestyle. Boxes of matches are consumption in Sri Lanka for various reasons such as fire for source of energy for cooking in rural areas, complements good for a cigarette etc. The significant contribution made by these boxes of matches are identified as important element in goods in calculating Sri Lankan Colombo Consumer Price Index. According to the Sri Lankan Socio-Economics Data 2016 highlights that 78.5% represented the Firewood as a source of energy for cooking. Gas represented 18.5 % and Kerosene represented 1.9 % from total source of energy. Uva province recorded 95.2% as majority of people use firewood as a source of energy for cooking. North Central Provinces recorded nearly 94.8% of firewood usage and North Western province recorded nearly 92.5% of firewood usage as a source of energy for cooking. It highlights without considering the provinces people consuming boxes of matches to fire the firewood rather than other energy sources. When we look at total expenditure of a household in year 2015 people expenditure nearly 6.8% for fuel and light from their monthly salary. Eastern Proving household recorded the highest rate of 12.3 for fuel and light from their monthly salary (Sri Lankan Socio- Economics Data 2016).

Thus, above central bank reports highlights that the consumption behaviour of the people regarding the energy sources and expenditure patterns of the Sri Lankans which recorded

significant value leads to the consumption of Boxes of matches as essential element in daily household products. This highlights that the quality of the boxes of matches should be drawn attention in order to ensure the safety of the consumers. When we look at the quality consideration of boxes of matches in India, Indian Government has revised their standard of Indian Standard Specification for safety matches in boxes as IS 2653:2004 replacing IS 2653: 1993. According to the Central Market Department 11 in India 2004 highlights that the requirements of quality control in boxes of matches should be in the form of Contents, match of boxes, envelopment, easy of opening, Match splints, Unserviceable sticks. In Sri Lanka, there is a standard introduced and issued by the Sri Lanka Standard Institute for the manufacture of boxes of matches under SLS (Sri Lanka Standard) 11, "Safety Matches in Boxes". It is imposed to follow in safety procedures under SLS 11 to manufacture, distribute, transport, store and sell or display for sale of safety matches in boxes under the consumer Affairs Authority Act No 09 of 2003. (Extraordinary Gazette 2012). But in Sri Lankan market we can find boxes of matches under company names which do not certified SLS for the safety matches of boxes. Therefore, this paper Address the quality control limits in control charts to ensure the process quality in SLS uncertified Boxes of matches in Sri Lankan market.

RESEARCH QUESTION AND OBJECTIVE

Main research question is "What are the Statistical quality control limits for the uncertified Sri Lanka Standards (SLS), boxes of matches in Sri Lankan market?". And sub research question is "Are SLS Uncertified Boxes of matches manufactured in Sri Lanka are Really safety to consume?" Based on research questions following research objectives are derived. Main research Objective of the study is "To determine the Statistical quality control limits for uncertified Sri Lanka Standards (SLS), boxes of matches in Sri Lankan market". Sub research objective is "To determine whether SLS Uncertified Box of matches are Really safety to consume."

METHODOLOGY

This is a quantitative research in nature. Primary data are collected for the study. Basically, sample is considered by number of match sticks. 1135 sample units of match sticks are used for the study. These sample units are drawn under 25 samples and each sample is consisted with 3 boxes of matches.1135 match sticks are taken from 75 boxes. For Analysis purpose number of box of matches also considered for quality dimension. Sample size is decided by 25% from an hourly production. Direct observations activities are carried out to get generated the quality characteristics under 08 quality dimensions. These dimensions are considered based on Sri Lanka Standards (SLS) and other quality standard related to manufacture of boxes of matches. The eight (08) quality dimensions considered for the study related to manufacturing process of boxes of matches are highlighted in this table no 02

Inclusive criteria of selecting samples are 1. Only wax boxes of matches are considered.2. Non-Sri Lanka Standards (SLS) certified boxes of matches are considered. Exclusive

criterias are non-wax manufacture boxes of matches are not considered. Statistical Quality control equations and process control charts for variables and attributes are used to analyses the data. X bar charts and Range charts, np charts are used for the analysis purpose.

ANALYSIS

To analyses the Quality dimension number 1,2,3,4,5,8 in table no 01, Statistical quality control charts such as x bar charts and Range charts are used under variable control charts. To analyses the Quality Dimension Number 6,7 Statistical quality control charts such as np charts are used. x bar charts are used to determine the variation between the samples and R charts used to determine the variation inside the sample. Control line figures calculations relevant to the x bar charts are shown in table no 03.and control lines figure calculations related to range charts are highlights in table no 04.

Table 1: Considered Quality dimensions

Quality dimension no	Quality Dimension	Feature
1	Length of Splint (the match stick) with head	Total length of the match stick
2	length of the head	Length of chemical head
3	Burning time	Burning up to the half of the match length and consider the time
4	Bending strength.	The time to bear 300g weight by each stick
5	After glow	After burning first quarter of the stick time taken to extinguish.
6	Safety	Each stick hope to strike the match against a suitable surface (sand paper)
7.	Adherence	Check whether the stick can be separable from the match stick
8	No of match sticks in the box.	Check the number of sticks in the box.

Table 2: Control level calculations for x bar charts

Quality dimension no	Upper control level	Central level	Lover control level
1	$\overline{\overline{x}} + A_2 \times \overline{R}$ 32.76+(1.023*2) = 34.8	$\overline{\overline{x}}$=32.76	$\overline{\overline{x}} - A_2 \times \overline{R}$ 32.76-(1.023*2)= 30.7

2	$\bar{\bar{x}} + A_2 \times \bar{R}$ 32.76+(1.023*2) =3.5	$\bar{\bar{x}}$ =3.4	$\bar{\bar{x}} - A_2 \times \bar{R}$ 32.76-(1.023*2)=3.3
3	$\bar{\bar{x}} + A_2 \times \bar{R}$ 15.8+(1.023*1.96) = 17.8	$\bar{\bar{x}}$ =15.8	$\bar{\bar{x}} - A_2 \times \bar{R}$ 15.8-(1.023*1.96)=13.8
4	$\bar{\bar{x}} + A_2 \times \bar{R}$ 37.9+(1.023*2.72) =40.7	$\bar{\bar{x}}$ = 37.9	$\bar{\bar{x}} - A_2 \times \bar{R}$ 37.9-(1.023*2.72)=35.1
5	$\bar{\bar{x}} + A_2 \times \bar{R}$ 1.68+(1.023*0.212)= 2	$\bar{\bar{x}}$ =1.68	$\bar{\bar{x}} - A_2 \times \bar{R}$ 1.68-(1.023*0.212)=1.46
6	$n\bar{p} + 3 \times \sqrt{n\bar{p}(1-\bar{p})}$ 12.6	$n\bar{p}$=5.7	$n\bar{p} - 3 \times \sqrt{n\bar{p}(1-\bar{p})}$ 0
7.	$n\bar{p} + 3 \times \sqrt{n\bar{p}(1-\bar{p})}$ 1.38+3.51=4.89	$n\bar{p}$=1.38	$n\bar{p} - 3 \times \sqrt{n\bar{p}(1-\bar{p})}$ 1.38-3.51=0
8	$\bar{\bar{x}} + A_2 \times \bar{R}$ 45.32+(1.023*1.08)=46.4	$\bar{\bar{x}}$ =45.32	$\bar{\bar{x}} - A_2 \times \bar{R}$ 45.32-(1.023*1.08)=44.2

Table 3: Control level calculations for Range charts

Quality dimension no (according to table 1)	Upper control level	Central level	Lover control level
1	$D_4\bar{R}$=2.574*2=5.1	$\bar{R}$=2	$D_3\bar{R}$=0*2=0
2	$D_4\bar{R}$= =(2.574*0.144)= 0.37	$\bar{R}$ =0.144	$D_3\bar{R}$ =0*0.144=0
3	$D_4\bar{R}$=2.574*1.96=5	$\bar{R}$=1.96	$D_3\bar{R}$=0*1.96=0
4	$D_4\bar{R}$= 2.574*2.72 =7	$\bar{R}$=2.7	$D_3\bar{R}$=0*2.72=0
5	$D_4\bar{R}$= 2.574*0.2=0.55	$\bar{R}$=0.2	$D_3\bar{R}$=0*0.2=0
8	$D_4\bar{R}$= 2.574*1.08	$\bar{R}$=1.08	$D_3\bar{R}$=0*1.08=0

Length of Splint (the match stick) with head

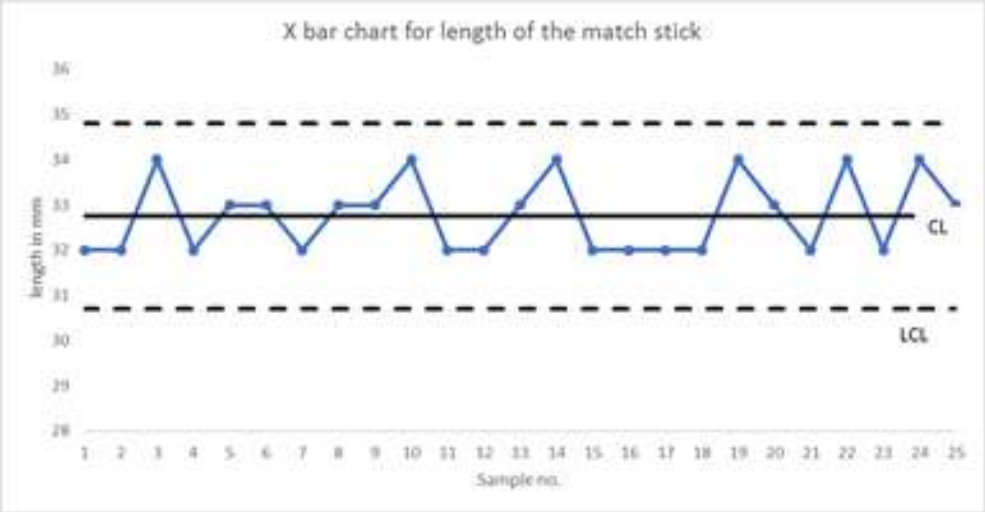


Figure 1: X bar chart for length of splint

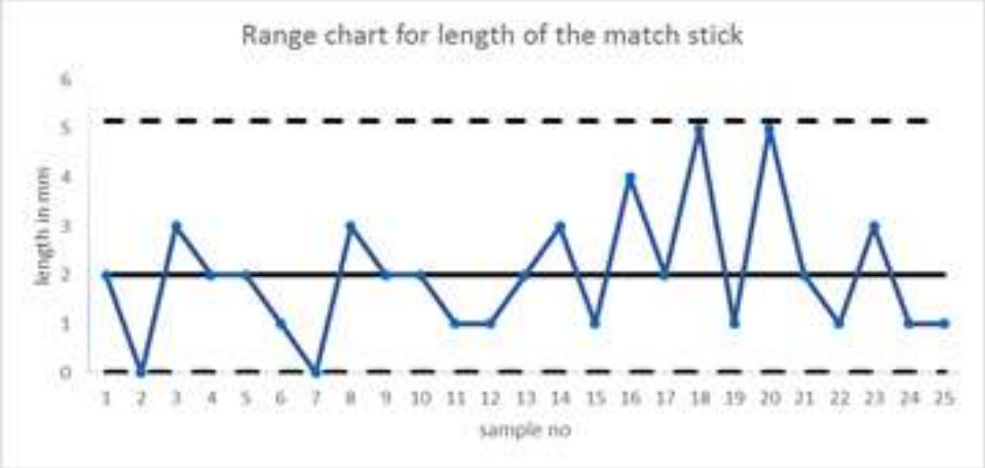


Figure 2: Range chart for length of splint

All sample points are prevailed between the control lines in both xbar chart and Range chart. Therefore, process of Length of Splint (the match stick) with head is under control.

Length of the head

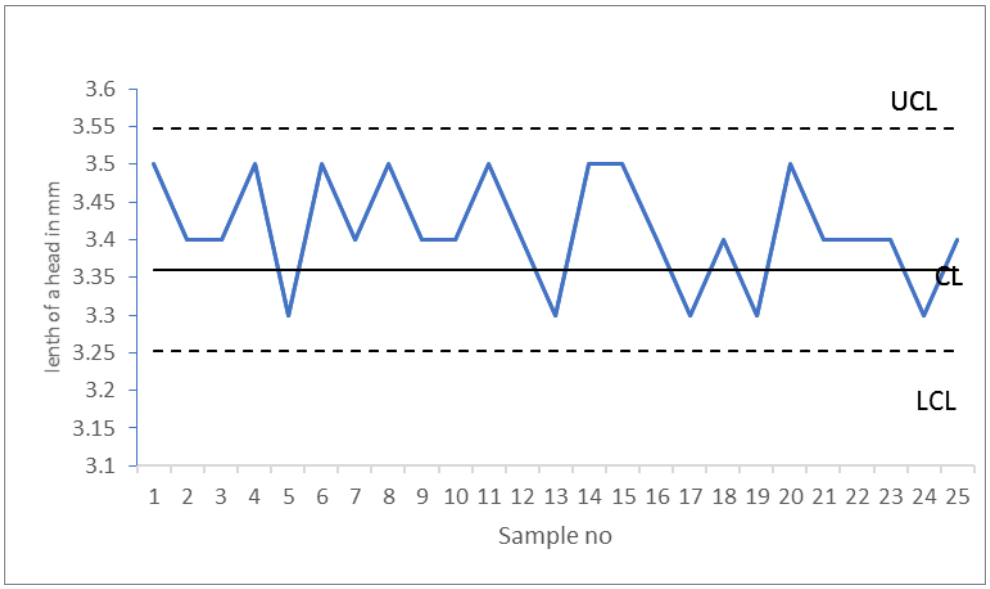


Figure 3: X bar chart for length of the head

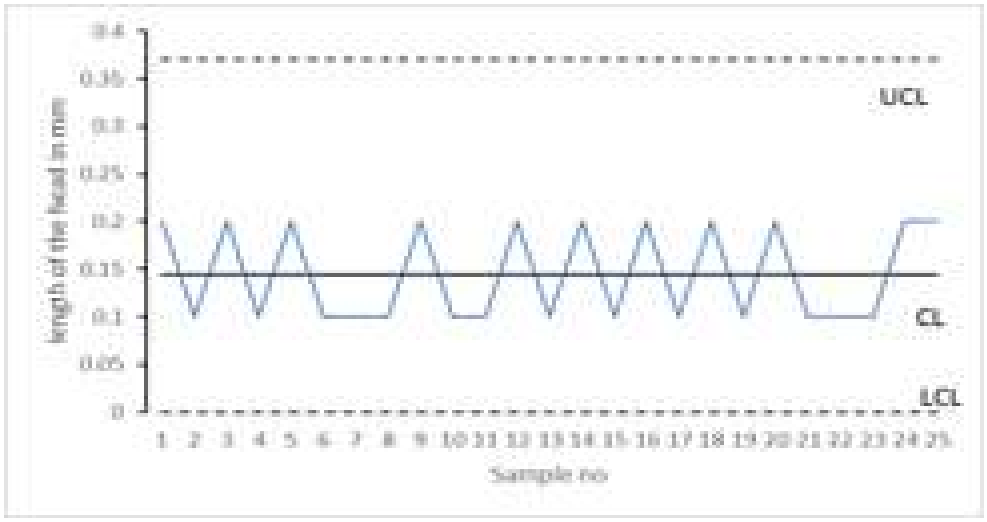


Figure 4: Range chart for length of the head

All sample points are prevailed between the control lines in both xbar chart and Range chart. Therefore, process of manufacturing length of the head is under control

Burning time

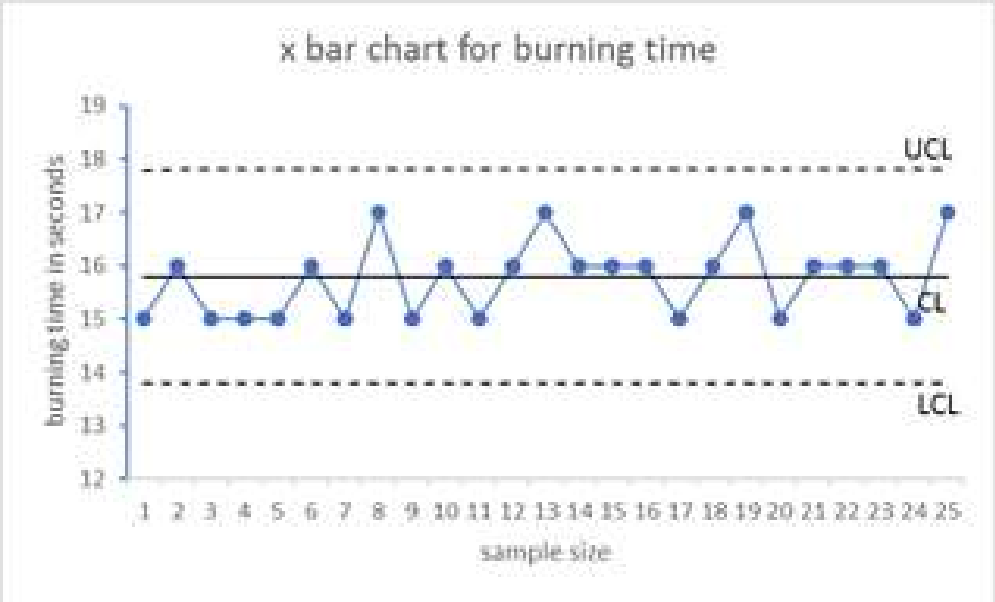


Figure 5: X bar chart for burning time

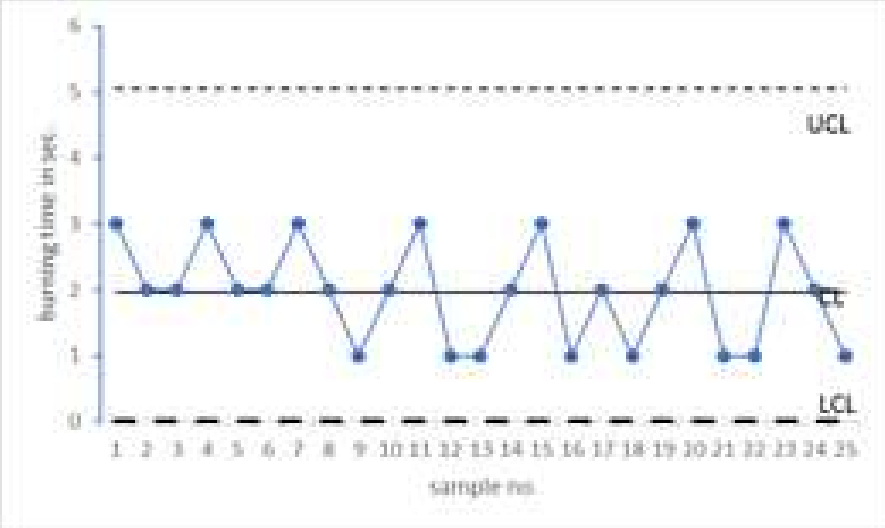


Figure 6: Range chart for burning time

All sample points are prevailed between the control lines in both xbar chart and Range chart. Therefore, process of manufacturing matches with good burning time is under control

Bending strength

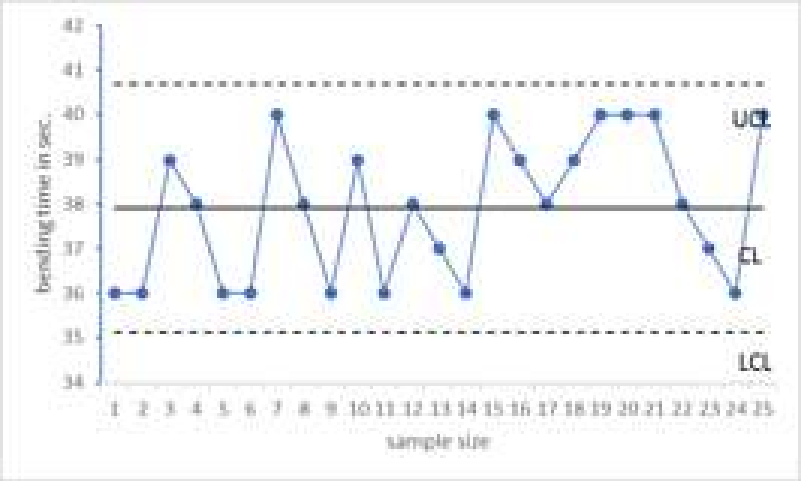


Figure 7: X bar chart for bending strength

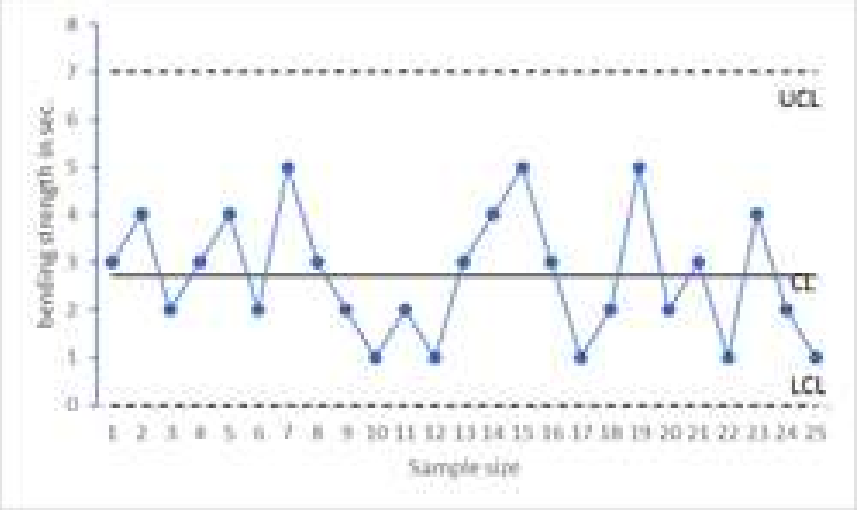
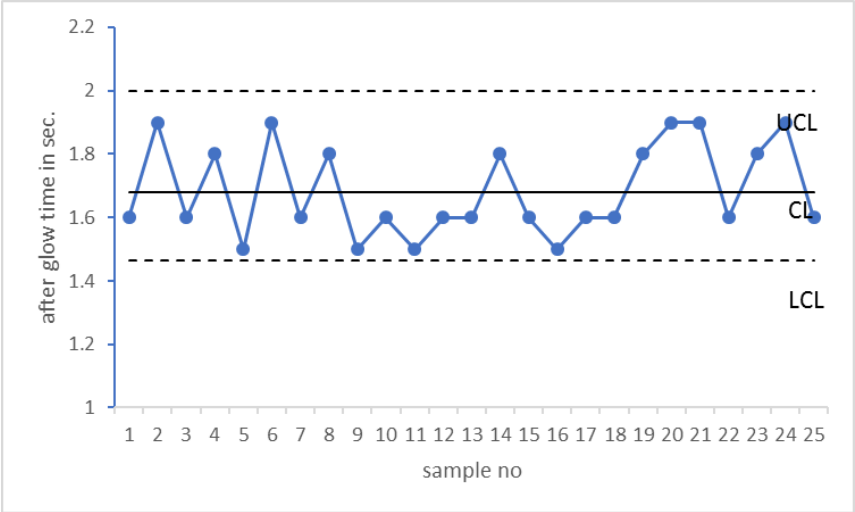


Figure 8: Range chart for bending strength

All sample points are prevailed between the control lines in both xbar chart and Range chart. Therefore, process of manufacturing matches with good bending strength is under control.

After glow



Ffigure 9: X bar chart for After glow

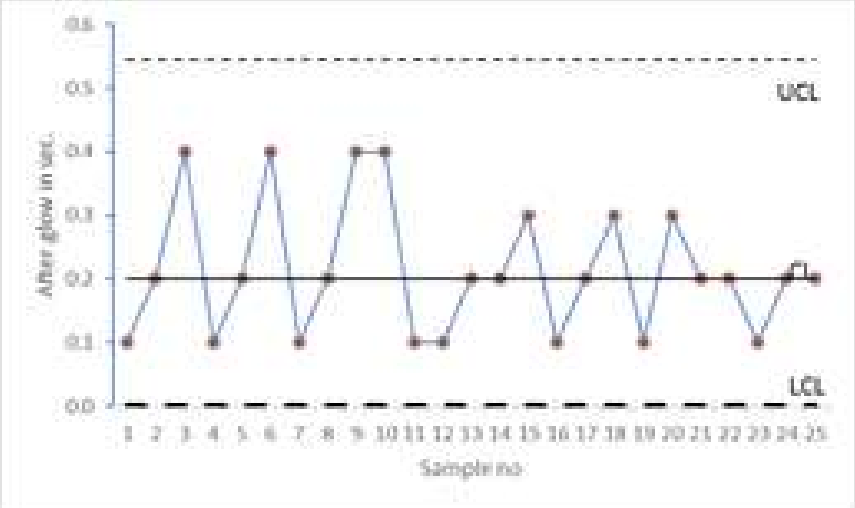


Figure 10: Range chart for after glow

All sample points are prevailed between the control lines in both xbar chart and Range chart. Therefore, process of manufacturing matches with good afterglow is under control

Safety

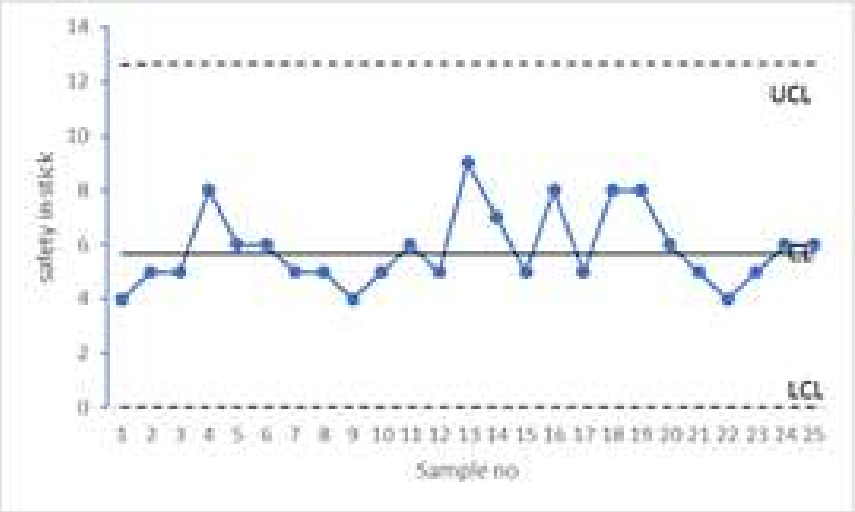


Figure 11: np chart for safety

All sample points are prevailed between the control lines in np chart. Therefore, process of manufacturing matches with good Ignite is under control.

Adherence

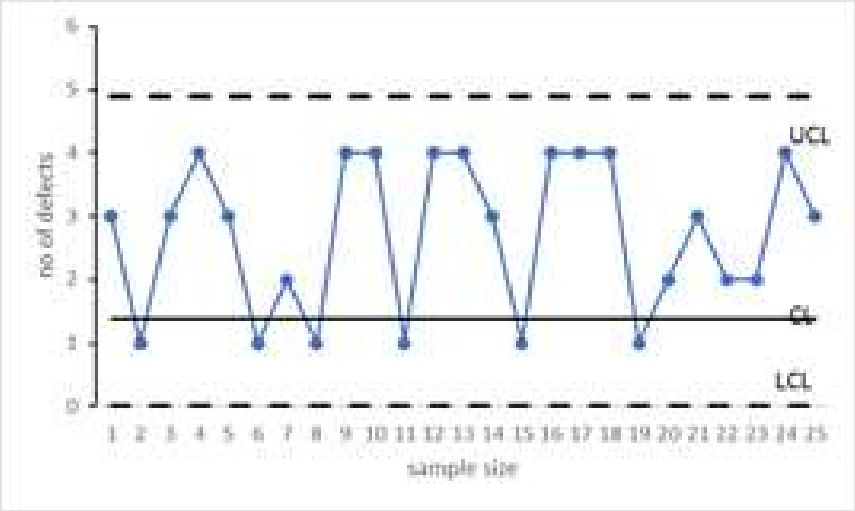


Figure 12: np chart for adherence

All sample points are prevailed between the control lines in np chart. Therefore, process of manufacturing matches with Adherence is under control.

No of match sticks in the box

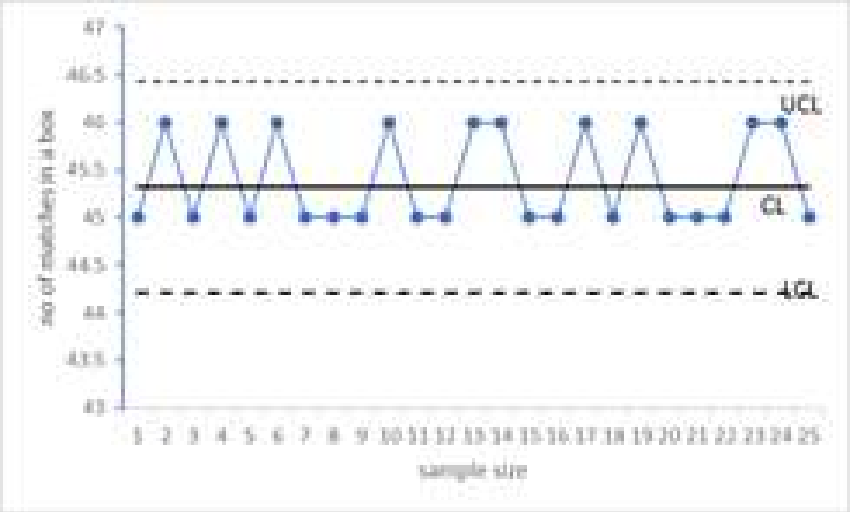


Figure 13: X bar for No of match sticks in the box

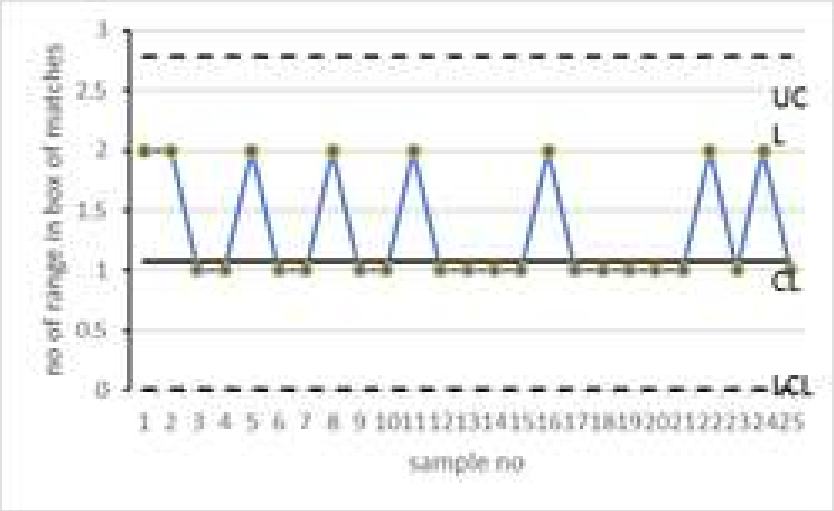


Figure 13: X bar for No of match sticks in the box

All sample points are prevailed between the control lines in both X bar chart and Range chart. Therefore, process of manufacturing matches with appropriate No of match sticks in the box under control

CONCLUSION

According to the analysis data quality control limits for the selected quality dimensions for the uncertified SLS boxes of matches are identified as an objective of the study in the Table 4.

Table 4: Quality control limits compared with SLS

Quality dimension	Quality control limits for SLS uncertified boxes of matches	SLS limit
Length of splint (the match stick) with head	30.7mm -34.8mm	32-35 mm
length of the head	3.3mm-3.5mm	$3.5mm >$
Burning time	13.8- 17.8	15s -18 s
Bending strength	35.1- 40.7 sec.	30s -40s
After glow	1.46s-2s	$3sc<$
Safety	$10>$	$10>$
Adherence	Unremovable	Unremovable
Number of match sticks in the box	Appropriate	Appropriate

According to the table no 10 it is revealed that generated quality control limits are prevail within SLS except the quality dimensions Length of Splint and Burning time. That highlights that these boxes of matches which do not have SLS are unsafety due to the uncontrol production process based on SLS.

RECOMMENDATIONS

The manufactures those who are not having SLS to produce boxes of matches should have ability to make changes and open a path to obtain the SLS to create win-win situation for both parties.

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