Application of Process Quality Control in Leather Industry

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ABSTRACT

Quality Control is the regulatory process measuring actual quality performance, comparing it with standards, and rectifying the difference. The objective of this study was to design control charts for raw and export goat skins to ensure that non-defective items are used, to customers. Ten random samples of raw goat and to ensure that defective items are not passed skins of different sizes (32 – 125pieces) were taken and inspected, and then a control chart was drawn. For outgoing wet blue goat skin, ten samples of the same size each of (125pieces) were taken and inspected then a control chart was drawn. The results were as follow; the process involved in delivery of raw skins was out of control, because the proportion defective (0.2080) in one of the samples was located above the upper action limit. The process of outgoing skin showed stability on control chart because all samples were within control limits.

Keywords: Control Chart ,Quality Control , Skin Inspection, Leather Industry.

INTRODUCTION

Concepts of Quality

Quality

Quality is a degree of excellence in the broader sense, it may be considered as specifications or set of specifications which are to be met within given tolerances or limits. Thus, the level, or the excellence of the product, may be considered as average, or mean level of quality required in the market place, and not necessarily the highest quality that is attainable regardless of cost. The uniformity of the product may be described in terms of minimum limits, or more commonly, a tolerance between the upper and lower control limits *(Krame. and Twing,* 1984).

Control

Control is the ability or need to observe or monitor a process, record the data observed, and take action on the process if not justified.

All processes can be monitored and brought ‘under control’ by collecting and using data. This refers to measurements of the performance of the process and the feedback required for corrective action, where necessary. (*Oakland ,* 2003)**.**

Quality Control

Quality control is the maintenance of quality of product at levels and tolerances acceptable to the buyer while minimizing the cost to the vender. Quality at a given level must also be controlled for raw materials and supplies, labor, machines, plus management functions such as budgeting, inventory, transportation, etc.*(Kramer A. and Twing B. A,* 1984). Also quality control is the regulatory process measuring actual quality performance, comparing it with standards, and acting on the difference **(***Wadsworth, et al,* 1986*).*

Quality Control in Leather Industry

One of the most important quality characteristics in the dyeing process is the relationship between color effluent and temperature which should be monitored over time. The profiles which model this relationship are similar under in-control situation. An example of a simple linear profile from the dyeing process of shoe leather in the leather industry was introduced and a step by step phase analysis was conducted to investigate that dyeing process was in statistical control.(*Amiri, et al,* 2011*).*

Control Charts

A control chart is a graphic representation of the variation in the computed statistics being produced by the process. It shows how the variation of a particular set of data representing process characteristic was produced. (*Oakland, 2003*)**.** The purpose of a control chart is to detect change in the performance of a process. The control chart has three zones and the action required depends on the zone in which the results fall, as shown in Fig.(1).

*Zone1: the process is under control, if its results fall in this zone.

*Zone2: it is a warning zone, and the process may be showing special causes of variation when the results fall in this zone, more information is needed.

*Zone3: it is an action zone. When the results fall in action zone, the process is unstable. Action must be taken or, where appropriate, the process is adjusted.

Control charts can be divided into two types:

Process Control by Variable Charts
Variable control charts are employed when it is necessary to examine a scale or measurement, characteristic. **(***Wadsworth, et al, 2004)*. Charts for variables are mean chart and range charts.
Mean Chart
chart is that chart which focuses attention on the constancy of average level. ¯Mean chart or an x If the process is stable, it is expected that most of the individual results lie within the range $X \pm 3$ σ. *Wiley and sons, (2010*).
The formulae for setting the action and warning lines on mean charts are:
Action control lines at
$\bar{x} \pm 3\sigma/\sqrt{n}$ …………………………………...………..………...Eq. (1)
Warning control lines at
$\bar{x} \pm 2\sigma/\sqrt{n}$ ……………………………...………...…………...Eq. (2)
Where:
$\bar{x}$ = process or grand mean of X_i items
σ = standard deviation
n = number of items.

Range Chart
An $\bar{R}$-chart (or range chart) is specifically designed for detecting changes in variability. Because an $\bar{x}$-chart is not sufficient alone, it needs to be supplemented with an $\bar{R}$-chart.
Range control chart is set up with:
Action limits:
Upper $= D'_{.001}\ \bar{R}$ ……………………...……………………..……..Eq.(3)
$Lower = D'_{.999}\bar{R}$ ……………………...……………….………………Eq.(4)
Warning lines:
$Upper = D'_{.025}\ \bar{R}$ ....Eq.(5)
Lower = $D'_{.975}\ \bar{R}$ ………………………………………………...Eq.(6)
(Oakland, 2003)
Process Control by Attributes
The quality of many products and services is dependent upon characteristics which cannot be measured as variables. These are called attributes and may be counted, having been judged simply as either present or absent, conforming or non-conforming, acceptable or unacceptable. There are two types of control by attribute:
Conformities or non-Conformities Units
This may be used to describe a product or service, e.g. number of defects, errors, faults, or positive values such as sales calls, truck deliveries. Hence, a defective is an item or 'unit' which contains one or more flaws, errors, faults or defects. A defect is an individual flaw, error or fault.
Number of Non-Conformities Defects
$\bar{c}$-chart is used for samples of same size every time, and it is used in the process control of attributes, where there are situations the number of events, defects, errors or non-conformities

can be counted, but there is no information about the number of events, defects, or errors which are not present.

Number of Non-Conformities Defects per Unit

The u¯-chart is for varying sample size, it measures the number of events defects, or non-conformities per unit or time period, and the 'sample' size can be allowed to vary. In the case of inspection of cloth or other surfaces, the area examined may be allowed to vary and the u¯-chart will show the number of defects per unit area, e.g. per square meter.

The control lines will vary for each sample size, but for practical purposes may be kept constant if sample sizes remain with 25% either side of the average sample size, n. *(Oakland, 2003).*

Non-Conforming Units

Each of which can be wholly described as failing or not failing, acceptable or unacceptable, present or not present, etc.

Number of Non-Conforming Defectives

This is used for constant sample size. Here the binomial distribution is used to set action and warning lines for the so-called 'np¯ - or process control chart'. Outer limits or action lines are set at three standard deviations i.e. 3σ either side of the average number defective and inner limits or warning lines at ± 2σ. The standard deviation (σ) for a binomial distribution is given by the formula:

$\sigma = \sqrt{np^{-}(1-p^{-})}$ … ……………………………………………………Eq. (7)

To calculate the control lines for the np¯-chart, the following formulae are applied:

Action lines (ACL) are set at

$np^{-} \pm 3\sqrt{np^{-}(1-p^{-})}$ …………………………..…………………….Eq. (8)

Warning lines (WCL) are set at

$np^{-} \pm 2\sqrt{np^{-}(1-p^{-})}$ ……………………………………………..Eq. (9)

……………………….…….. Eq. (10)..$p^{-} = np^{-} / n$ …………………………

Where:

p^{-}: average proportion defective.

np^{-}: average number of defective per sample.

Proportion of non-conforming units (defectives) (p^{-} - chart)

It is used for samples of varying size. The first step in the design of a p^{-}-chart is the calculation of the average proportion defective as explained by the following equations:

$p^{-} = \sum_{i=1}^{k} x_i / \sum_{i=1}^{k} n_i$ ……………………………………………Eq (11)

Where

k : the number of samples, and:

$\sum_{i=1}^{k} x_i$: the total number of defective items.

$\sum_{i=1}^{k} n_i$: the total number of items inspected.

If a constant 'sample' size is being inspected, the p^{-}-control chart limits would remain the same for each sample. When p^{-}-control is being used with samples of varying sizes, the standard deviation and control limits change with n and unique limits should be calculated for each sample size. However, for practical purposes, an average sample size (n^{-}) may be used to calculate action and warning lines. These have been found to be acceptable when the individual sample or lot sizes vary from n by no more than 25 % each way. For sample sizes outside this range, separate control limits must be calculated. The next stage in the calculation of control limits
for the p^{-}-chart is to determine the average sample size (n^{-}) and the range 25 % either side as explained in the following equations:

$n^{-} = (\sum_{i=1}^{k} n_i)/k$ ……………………………………..……………......…Eq. (12)

Range of sample sizes with constant control chart limits is calculated from the following equation:

$n^{-} \pm 0.25n^{-}$ …………………………………………………...….Eq. (13)

Action control lines (ACL) are set at:

$ACL = p^{-} \pm 3\sqrt{p^{-}(1-p^{-})}/\sqrt{n}$ ……………………….……....Eq. (14)

Warning control lines (WCL) are at:

$WCL = p^{-} \pm 2\sqrt{p^{-}(1-p^{-})}/\sqrt{n^{-}}$ ……………………….…..Eq. (15)

Cumulative Sum (Cusum) Chart

Cusum Charts are alternative control charts which consider more than one sample result. They are the most powerful management tools available for the detection of trends and slight change in data. *(Oakland., 2003).*

Cusum Charts are useful for the detection of short and long changes and trends, and they provide powerful monitors in the following areas:

Forecasting, absenteeism, production levels, and plant break down.

Calculation of the Cusum score (Sr) is very simple and could be represented by the following formula:

$S_r = \sum_{i=1}^{r}(x_i - t)$ ………………………………..….….…………Eq. (16)

Where:

Sr : the Cusum score of the rth sample.

x_i : The result from the individual sample.

t: the target value.

The choice of the value of t is dependent upon the application of the technique. The rules for interpretation of Cusum plots are:

When the Cusum slope is downwards, the observations are below target.

When the Cusum slope is upwards, the observations are above the target.

When the Cusum slope is horizontal, the observations are o target.

When the Cusum slope changes, the observations are changing level.

The procedure for quality control followed in tanneries is 100%inspection for hides and skins. But Sometimes the size of the lot is large and therefore inspection is costly, and chance of making inspection error is high, so using 100% inspection is impracticable. Also often, the supplier is very reliable in delivering skins and hides that are within the inspection criteria, so using 100% inspection takes a long time. The main objective of this study is to design control charts for raw and export skins to:
- Ensure that non-defective items are used.
to customers. - Ensure that defective items are not passed

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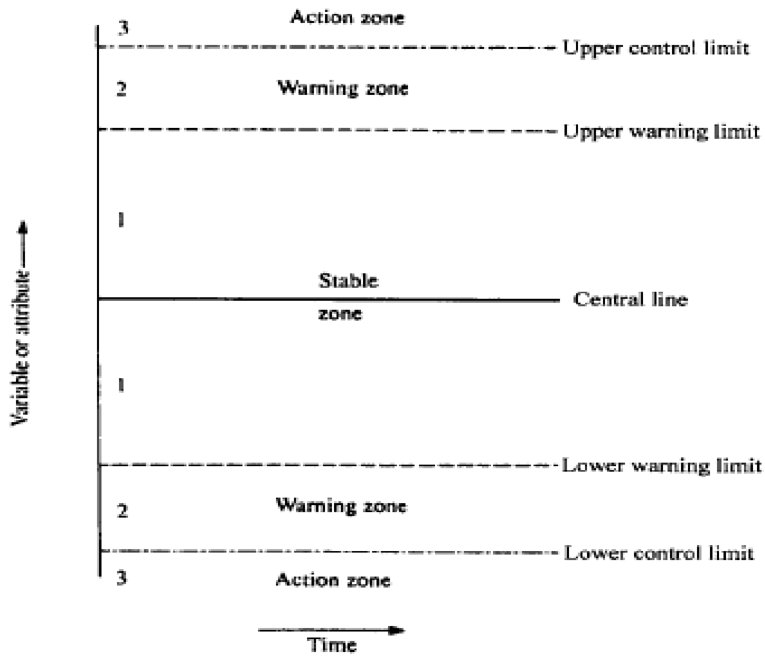

Fig (1) schematic control chart

MATERIALS AND METHODS

The following raw materials were used during the study:
Skins: raw goat skins were collected from Eastern, Western and Central Sudan as well as their wet blue skins .
The experimental works were carried out in Afrohide tannery, Omdurman. The methods used in sampling are presented below:

Raw Skin Inspection

Ten random samples of different sizes ranging from 32 to 125 pieces from different lots were taken and inspected using the Probability Simple Random Sampling Technique. (Kerlinder, 1986); the defects found were listed in Table.(1).

Sampling of Wet Blue Goat Skins

Systematic Sampling Technique (Kerlinder,1986) and Nordstrom Inspection Sampling Plan (NPG, 2006) were the method used to inspect wet blue skins. In that sampling one piece was selected after 14 pieces. Whereby 10 samples each sample contained 125 pieces were taken from the batches each of 1800 pieces. Then the defects were detected and the results were listed in Table (2).

RESULTS AND DISCUSSIONS

The results of sampling and inspection of the raw goat skins and wet blue goat skins sampling, are shown and discussed below.

Raw Goats Skins Inspection

Table (1) shows samples of different sizes ranging from32-125 pieces and the corresponding number of defects and proportion defectives, as result of sampling of goat skins in Afrohide tannery. Those lots of skins were collected mainly from Central, Eastern and Western Sudan. It was noticed that the skins from Central Sudan have fewer defects than the others that was due to an awareness of the people about keeping skins unreflective. The main defects taken into considerations in this sampling were putrefaction defective skins, skins with holes in main area, in addition to incorrect shape skin. As control charts are needed to check the variations of inspection process, referring to data in Table (1) where sample is of varying size, and because the data are of attribute type, it is possible to use $\bar{p}$-chart. The $\bar{p}$-chart control limits are as follow:

From equation (8): $\bar{n} = (\sum_{i=1}^{k} n_i\ )/k$

$\bar{n} = \sum_{1}^{10}(125 + 50 + 125 + 80 + 50 + 32 + 80 + 50 + 125 + 80)/10 = 79.7 = 80$

Range of sample sizes with constant control chart limits can be calculated from equation (9): $\bar{n} \pm 0.25\bar{n}$

$80 + 0.25 \times 80 = 80 + 20 = 100$

$80 - 0.25 \times 80 = 80 - 20 = 60$

Then the permitted range of the sample is 60 to 100

From equation (7): $\bar{p} = \sum_{i=1}^{k} x_i \ / \sum_{i=1}^{k} n_i$

$\bar{p} = 79 \div 797 = 0.0991$

For the sample sizes within the ranges 60 to 100, their control charts can be calculated from equations (10) and (11) as shown below:

Upper action limit (UAL)

$= 0.0991 + (3\sqrt{0.1(1 - 0.)}\ ) \div \sqrt{80} = 0.1993$

Lower action limit (LAL)

$= 0.1 - 3\sqrt{0.1(1 - 0.1)} / \sqrt{80} = -0.0011$

Upper warning limit (UWL)

= 0.1659

Lower warning limit (LWL)

= 0.0253

Samples (1, 2, 3, 5, 6, 8, and 9) in Table (1) fall outside the range 60 –100, there for their control lines must be calculated individually, as shown in Table (2).

Fig. (2) shows the p^{-}-chart plotted with the varying action and warning lines .the process involved in delivery of skins is out of control; since one sample is larger than upper action limit.

Sampling of Wet Blue Goat Skins

Table (3) shows ten samples of goat wet blue skins of the same size each is of 125pieces. These samples were taken from lots of the same size each is of 1800 pieces. It also shows the corresponding defects as result of sampling. Sampling was mainly concentrated on the putrefactive and skins which were damaged during manufacturing. Data in the table are of attributes type and of a constant sample size ,so np^{-}-chart is the most suitable for checking ongoing process of selection, so the calculation of limits of np^{-}-charts were as follow using equations (4, 5, 6).

$p^{-} = np^{-} / n$

Where:

p^{-} = the average proportion defective in the process.

np^{-}= average number of defective per sample. Therefore

$$np^{-} = \sum_{1}^{10}(13 + 19 + 11 + 6 + 13 + 9 + 15 + 10 + 12 + 5)/10$$

np^{-} =113/10 = 11.3

p^{-} =11.3/113 = 0.1

Action control lines (ACL)

$= np^{-} \pm\sqrt{np^{-}(1-p^{-})}$

Upper action limit (UAL)

$=11.3+3\sqrt{11.3(1-0.1)}$ =11.3+9.5 =20.87

Lower action limit (LAL)

= 11.3 – 3*3 = 11.3 -9.6 = 1.73

Warning lines (WCL)

$= np^{-} \pm 2\sqrt{np^{-}(1-p^{-})}$

Upper warning limit (UWL)

= 11.3+2*3.2 =17.68

Lower warning limit (LWL)

=11.3-2*3.2 = 4.92

Fig. (3) is np^{-}-chart on which the data concerning wet blue goat skin inspection from Table (3) are plotted using MATLAB10 software. The process is considered to be statistically controlled. It may be, therefore reasonably assumed that the process producing a constant level of 11.3 percent defective.

Table (1): The results from the raw goat skins in varying numbers

Sample number	Lot size(N) Pcs	Sample size(n) pcs	Number of defects(c) pcs	Proportion defective (c/n)	Type of defects
1	2600	125	26	0.2080	1-incorrect shape,
2	300	50	3	0.0600	2-Putrefactive damage
3	3025	125	7	0.0560	3-Damage from heat
4	1060	80	3	0.0375	4-cuts and gouges
5	377	50	4	0.0800	
6	248	32	4	0.1250	
7	1034	80	8	0.1000	
8	311	50	3	0.0600	
9	3106	125	9	0.0720	
10	1092	80	12	0.1500	

Table (2): Results from calculation of p‾-chart lines for sample size out the range 60 to 100

Sample number	Sample size pcs	σ	UAL	UWL	LWL	LAL
1	125	0.0267	0.1792	0.1525	0.0457	0.0190
2	50	0.0423	0.2260	0.1837	0.0145	Neg (i.e.0)
3	125	0.0267	0.1792	0.1525	0.0457	0.0190
5	50	0.0423	0.2260	0.1837	0.0145	Neg (i.e. 0)
6	32	0.0528	0.2575	0.2047	Neg(i.e.0)	Neg (i.e. 0)
8	50	0.0423	0.2260	0.1837	0.1450	Neg (i.e. 0)
9	125	0.0267	0.1792	0.1525	0.0457	0.0190

*P‾: proportion defective in sample.

* n‾: an average sample size

* UAL: upper action limit

* UWL: upper warning limit

* LWL: lower warning limit
* LAL: lower action limit
* $\frac{\sqrt{\bar{p}(1-\bar{p})}}{\sqrt{n}}$: Standard deviation (σ)

Table (3): Sampling of wet blue goat skins

Sample number	Lot size (pcs)	Sample size (pcs)	Number of defects (pcs)	Type of defects
1	1800	125	13	
2	1800	125	19	1. incorrect shape
3	1800	125	11	
4	1800	125	6	2.Putrefactive Damage
5	1800	125	13	
6	1800	125	9	3. damage caused by flashing machine
7	1800	125	15	
8	1800	125	10	4.damage caused by tanning operation
9	1800	125	12	
10	1800	125	5	

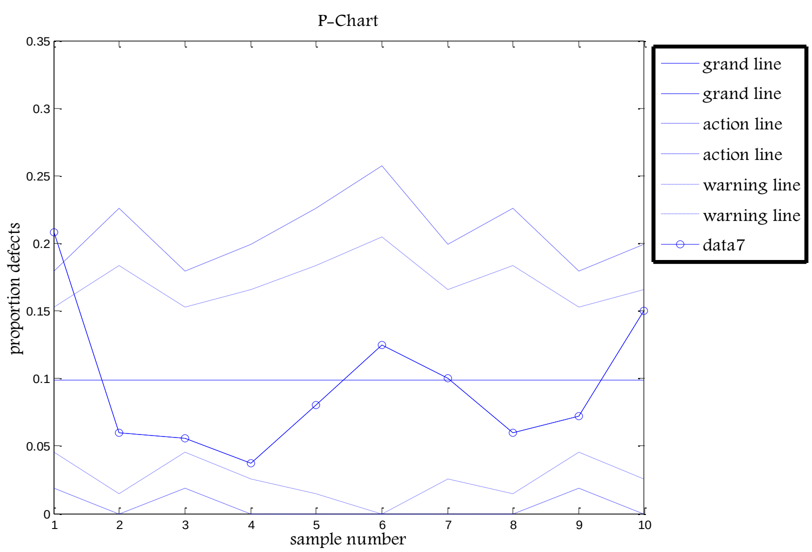

Fig. (1): p¯-chart for raw goat skins inspection
*The control lines are not straight because the samples are of different sizes
* MATLAB10 software was used to plot this figure.

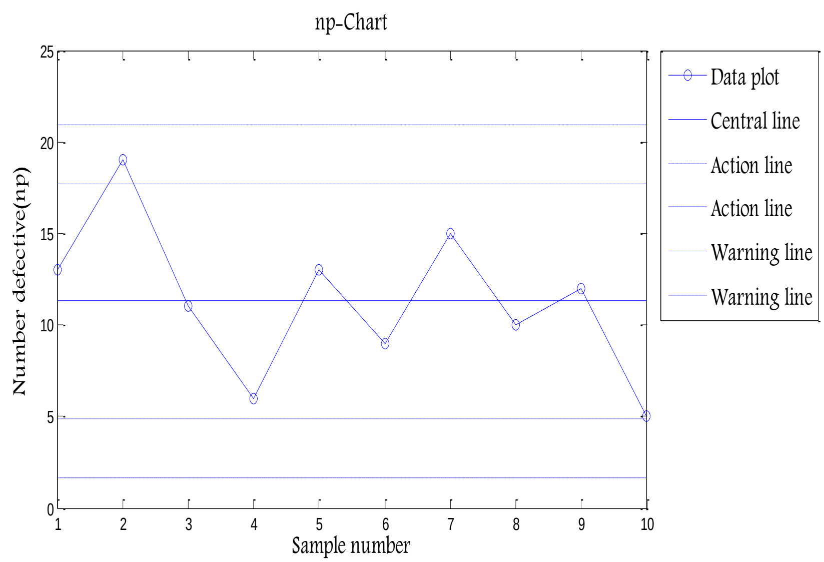

Fig. (2): np¯-Chart for wet blue goat skins inspection

CONCLUSION

This study was carried out to design control charts for raw and export wet blue goat skins in order to ensure that non-defective goat skins are used, and to ensure that defective skins to customers. are not passed

Goat skins were the core of the study. The raw goat skins were from Eastern, Western and Central Sudan, and they were tanned in Afrohide tannery, Omdurman, the industrial area.

Appropriately different sized random samples of raw and equal sized random samples of wet blue skins were sampled. It was found that the process involved in delivering raw skins was unstable due to the position of some proportion defective values outside upper action limit. For outgoing skins all the samples contained defectives that are within the controlled limits and only one out of 10 entered the warning zone and none of these samples were consecutive nor were trend or run. The process was considered to be statistically controlled. It was therefore reasonably assumed that the process was producing a constant level of percent defective.

RECOMMENDATION

(1) Construction of control charts for quality process control in leather processing should be applied in Sudanese tanneries.

(2) Normally in some Sudanese tanneries the processes are unstable and they are recommended to be systematically studied to detect the presence of special causes.

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ملخص البحث

ضبط الجودة عبارة عن عمليةُ تنظيميةُ تَقِيسُ أداءَ الجودة الفعليَة، ويُقارنُه بالمعاييرِ، و يقوم بمعالجة الاختلاف. أهداف هذه الدراسةِ هي تصميم مخططات التحكم لجلود الخامِ وجلودَ ماعز الصادر الزرقاء المدبوغة بالكروم لضمان عدم استخدام الجلود المعيبة. ولضمانْ أن الجلود المعيبة لَمْ تعبر إلى الزبائنِ. أخذت عشرة عينات عشوائية مختلفة الإحجام(32 –125) من الجلود الماعز الخام وتم فرزها ومن ثم رسم مخطط التحكم .أخذت عشرة عينات متساوية الحجم كل عينة تساوي 125 قطعة من جلود الصادر الزرقاء اللينة والمدبوغة بالكروم وتم فرزها ومن ثم رسم مخطط التحكم. وكانت النتائج على النحو التالي. عملية تسليم الجلود الخام قد خرجت عن نطاق التحكم لوجود نسبة مرفوضة واحدة خارج حد التصحيح الأعلى في مخطط التحكم. أظهرت نتائج فرز جلود الصادر الزرقاء اللينة والمدبوغة بالكروم بان هذه العملية مستقرة لوقوع جميع العينات في نطاق التحكم.