Evaluation of an Industrial Product Quality Level by Using Demerit Control Chart

Salman Hussein Omran
Mechanical Dept. Institute of Technology, Baghdad, Iraq.

Received Date: 25 / 4 / 2017
Accepted Date: 3 / 9 / 2017

الخلاصة

يعتبر هذا البحث محاولة لتحسين مستوى جودة منتج صناعي (مدفأة عشتار النفطية) في شركة الصناعات الخفيفة، باستخدام لوحة السيطرة النوعية لرقم القصور (لوحة-U) تم حساب رقم القصور للوحدة المعيبة (U) لغرض تحديد حدي السيطرة لثلاثين عينة مختارة. أظهرت النتائج ان عملية الانتاج منضبطة نوعيا استنادا على بيانات مسجلة إحصائيا. كما ان العيوب من الصنفين AوB ليس لها تأثير على أداء المنتج. إضافة الى ذلك، لقد وجد أن النسبة المئوية لمستوى جودة المنتج تتراوح بين (80-100 %) مما يدل على أن جودة المنتج جيدة جداً.

الكلمات المفتاحية

مستوى النوعية، لوحة رقم القصور، مستوى النوعية القياسي، مخططات السيطرة النوعية.

Abstract

This paper is an attempt to improve the quality level of an industrial product (Ishtar Kerosene Heater) in Light Industries Company by using Demerit Control Chart (U-chart). Demerit per defected unit (U) was calculated to determine the control limits for selected thirty samples. The results showed that the production process was under controlled according to the statistical recorded data. Also, the defects classes A and B have no influence of the product performance. Additionally, it was found that the percentage of the quality level of product was ranging between (80-100%), indicating that this level is quite good.

Keywords

Quality level, Demerits control chart, Standard Quality level, Quality Control charts.

1. Introduction:

Quality improvement means increasing the efficiency and completion of the company and expanding its ability to grow and develop, by producing a product that meets the desire of the consumer with good quality and the right price with efficiency in performance, and therefore reducing the likelihood of failures. It also helps in raising the morale of the employees and motivate them to produce products with higher quality and at lower cost. This will lead to increase the ability of local production to compete in foreign markets, with economic returns of quality is in its contribution to the national economy and national income.

There are several definitions of quality, which are given as follows:

Juran [1] defined it as " Fitness for purpose or use ", Feigenbaum [2] defined it as "Quality means best for certain customer conditions. Montgomery [3] define it as "Quality is inversely proportional to variability. the American National Standards Institute (ANSI) and the American Tociety for Quality (ASQ) [4] defined quality as " the totality of features and characteristics of a product or service that bears on its ability to satisfy given needs ". Wheeler and Chambers [5] define quality as being "on – target with minimum variance ". From the previous definitions, researcher has adopted Juran definition, since it focuses on the quality of product or service which is fitting to the specifications or using.

Quality control is a process employed by the company to provide and maintain the final product with the desired features, properties and characteristics of identity, uniformity, potency and stability within established

levels. is an effective system for integration the quality development, quality maintenance and quality improvement effects of the various groups in an organization so as to enable production and service at the most economical levels extending full customers satisfaction [6]. Fig. (1) shows the quality control system in a production system.

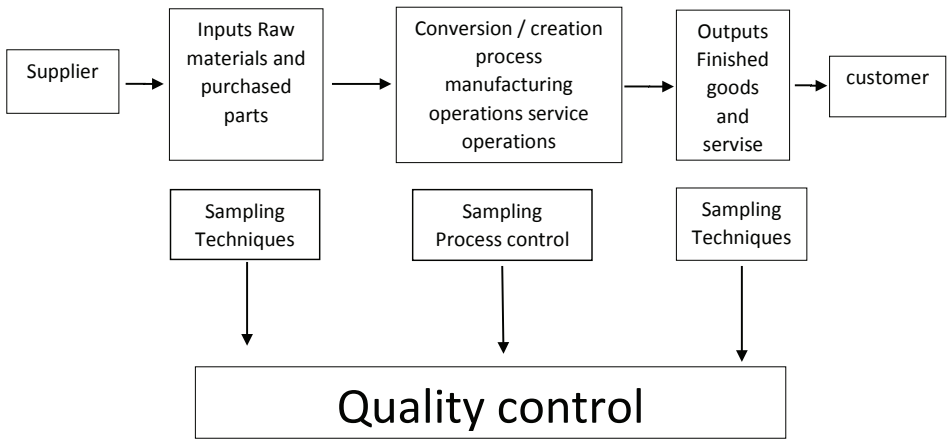

Fig. (1): Quality Control a production system [6]

1.2. Control charts:

Control charts are widely used for monitoring and examining a production process. The power of control charts lies in their ability to detect the process shifts and to identify the abnormal conditions in the process. This makes possible the diagnosis of many production problems and often reduces loses and brings substantial improvement in product quality. in 1924 (Walter She whart) designed the first control chart and proposed a general model for control charts [7, 8].

Control chart are the most important statistical process control (SPC) tools for monitoring the performance of products and services. They are classified in two parts according to their application, Variable and Attribute control charts [3]. Attribute control charts are often used to monitor services because they are based on quick diction of good or bad. C-Charts and U-charts are commonly used to render decisions on the statistical control status of products and services [9].

1.3. Demerit Control Chart:

A classical demerit control chart is used to monitor the counts of several different categories of defects simultaneously in a complex product. The traditional classical demerit control is used to plot the demerit statistic, a weighted sum of the number of defects in each category, on a control chart [10,11].

The demerit control chart was created by H. F. Dodge while working at Bell Laboratories as a means to chart product with more than one kind of possible defect. Some defects had very serious consequences on the performance of the product and some were not very serious [12]. The various types of defects were classified into four different categories, The different types of defects first need to be classified as either A, B, C or D. Once each defect is classified, a weight is given to each class depending on the impact of defect on performance or outward appearance , As well as the possibility of noting the defect or not noticed by the consumer [12] , as shown in Table (1) .

Table (1): Basic classification – definition of defects [13]

Defects class	Effect of defects on performance	Effect of defects on appearance	Effect of defects on complains	Numbers of demerits
A very important defects	Will certainly have a great influence on the function	Will certainly be noticed by customers and then cause complaints	Will certainly cause complaints	100
B Important defects	May have a great influence on the function	May be noticed by customers and will then cause complaints	Will possible cause complaints	50

C Less important defect	May to some extent have an influence on the function	May be noticed by customers but will then probably not cause complaints	Will probably not cause complaints	10
D Not important defects	Will not have influence on the function	Will not be noticed by customers	Will not cause complaints	1

1.4. Evaluation of the Degree of Product Quality:

The degree of product quality is to obtain information about the quality of the product extent of the acquisition and use of an appropriate degree of compliance with the specification as from the standpoint of the consumers, and use the audit result of a product quality in order to [14]:

provide production managers and officials with ongoing information about the levels of quality

know the defects, remove them, and continue to improve quality.

provide incentives for workers to do a good job and find an objective look at the quality of their output.

After the completion of the final inspection and packaging, then, the sample is randomly selected for examining and evaluating, depending on the characteristics and specifications, where the defect are recorded and classified according to the degree of importance, as was shown in Table (1) previously.

1.5. Used Methodology for Evaluating the Level of Product Quality by using Demirit:

This research aims to evaluate the final product quality by using Demerit Control Chart (U- chart) to determine the defects and its dangerous scope, in order to explain the Demerits from consumer point of view to improve the product quality.

The sample size is calculated every time by using the following equation [13, 14]

$$n = k\sqrt{2N} n = k\sqrt{2N} \quad \ldots\ldots (1)$$

where:

n: The sample size for ready product – examination

N: Total production volume – ready over a period of time (day, week, month)

k: A constant amount between (0.6 – 2.6) depending on the degree of complexity of product [13 ,14].

Examination of the sample. This is used most often in the same scales used in inspection during production stages.

Classification of four types of defect in relation to the degree of importance and the possibility of a complaint by the consumer which is given for each class demerit of points, which is shown in Table (1) previously.

Constructing a Demerit Control Chart.

Calculating the number of demerit per sample (U) through the following formula [15,16]:

$$U = \frac{d}{n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$d = (100d_A + 50d_B + 10d_D)$

U: Demerit per unit

n: The number of unit in the sample

where, d A is the no. of class A defects, dB is the no. of class B defects

dC is the no. of class C defects, dD is the no. of class D defects

ii-After calculating the number of demerit, it is compared with Table (2)

which shows the relationship between the level of quality and number of demerit.

Table (2): The relationship between the level of quality and number of demerit [16]

U(point of demerit)	Level of quality %
0 – 0.99	100 (Excellent)
1 – 1.99	90 (Excellent)
2 – 2.99	80 (very good)
3 – 3.99	70 (good)
4 – 4.99	60 (average)
5 – 5.99	50 (poor)
6 – 6.99	40 (very poor)
7 – 7.99	30 (very poor)
8 – 8.99	20 (very poor)
9 – 9.99	10 (very poor)

Table (2) shows when the value of level of the product quality is the range (60% -100%), this means that this level is acceptable by the company.

iii -Calculating the standard quality performance for the products (U) by following equation [10,15]:

$\bar{U} = 100\bar{U}_A + 50\bar{U}_B + 10\bar{U}_C + 1\bar{U}_D \dots\dots(3)$

$(\bar{U}_A, \bar{U}_B, \bar{U}_C, \bar{U}_D)$: The average number of each class of defect per unit (ex., $\bar{U}_A = \frac{\sum_{i=1}^{N} d_A}{\bar{n}}, \bar{U}_B = \frac{\sum_{i=1}^{N} d_B}{\bar{n}}, \bar{U}_C = \frac{\sum_{i=1}^{N} d_C}{\bar{n}}, \bar{U}_D = \frac{\sum_{i=1}^{N} d_D}{\bar{n}}$)

(dA, dB,dC , dD) = the total number of class (A,B,C,D)defects in the sample

$\bar{n}\bar{n}$: the total number of sample size.

Calculating the standard deviation through the following formula [13,16].

$$\sigma = \sqrt{\frac{(100)^2\bar{U}_A + 50^2\bar{U}_B + 10^2\bar{U}_C + 1^2\bar{U}_D}{\bar{n}}} \dots\dots\dots(4)$$

n- = Average Sample size

$$n^- = \frac{the\ total\ number\ of\ insfection\ unit}{sample\ number}$$

Calculate the control limits throw the following formulas [17]

Centre line =$\bar{U}\bar{U}$, as was shown in eq. (3) .

Upper control limit = $\bar{U} + 3\sigma \dots\dots\dots\dots(5)$

Lower control limit = $\bar{U} - 3\sigma \dots\dots\dots\dots(6)$

Plotting a demerit Control Chart (U-chart)

After drawing the center line and control limits, the values of(U) are pointed, if these values of (U) above the upper limit, this shows that the level of quality of the final product is less than the standard quality performance ($\bar{U}$ $\bar{U}$) . But, if it is near the centre line, this indicates the occurrence of a real improvement in the quality of the product. If the a value of (U) is between the upper and lower control limit, the quality of the product would be acceptable.

2. Practical Implementation:

In this section, a real application of industrial example, i. e, Ishtar Kerosene Heater product, Model (36) C, which is manufactured in the Light Industries Company, its geometry shape is described

in details in Fig. (2), and the manufacturing stages to produce the final product, are shown in Fig. (3).

Key No.	Part Name	Remarks	Key No.	Part Name	Remarks
1	CABINET COHPLETE				
1A	Top plate		4	PLNTE COVER	
1B	Screw for top plate	2 pcs.	4A	Plate cover	
1C	Grill		4B	Screw for plate cover	2 pcs.
1D	Cabinet				
1E	Carrying handle	2 pcs.	5	WICX ADJUSTER	
1F	Thumb screw for cabinet	3 pcs.	5A	Wick adjuster	
			5B	knob	3 pcs.
2	CHLMDEY COMPLETE		5C	wing nut	
2A	Heating coil		6	GLASS FIBER WICK	
2B	Chimney disc		7	RUSSER PACKING	
2C	Inner chimney		8	PUEL TANK	
2D	Middle chimney		8A	Main fuel tank	
2E	Outer chimney (glass)		8B	Fuel filler cap	
2F	Circular clip		8C	Fuel acceptance	
2G	Chimney supporter	2 pcs.	8D	Sub fuel tank	
2M	Cross pin	2 pcs.	9	DATSRY HOLDER	
3	LIGMING DEVICE		10	TRAY	4 pcs.
3A	Pilot heater		10A	Screw for tray	
3B	Lighting device				
3C	Screw for lighting device	2 pcs.			

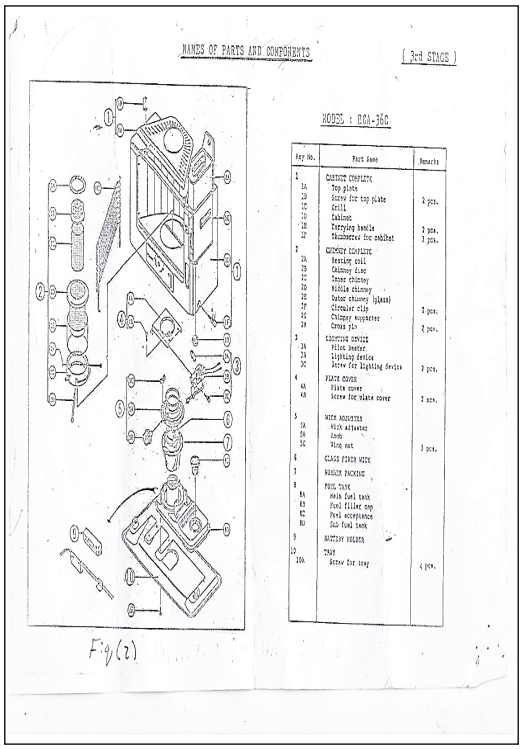

Fig. (2): Geometry Shape of Ishtar Heater

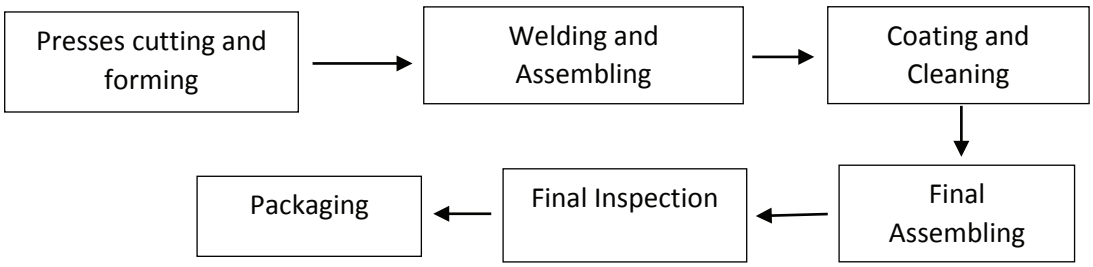

Fig (3): Manufacturing stages of Ishtar kerosene heater

To evaluate the quality of product, the following steps can be followed depending on the data given in Table (3):

(30) samples were selected randomly from the final products during (30) days.

The sample size was then calculated for each sample by eq. (1) taking the value of k=1 since the product is considered not a complex industrial one.

All the results of calculation are given in Table (3).

Table (3): Total production and sample size for Ishtar Heater product

No.	Date	Total production (N)	Sample size (n)	No.	Date	Total production (N)	Sample size (n)
1	12/1/ 2014	200	20	16	20/ 2	125	16
2	14/1	230	21	17	25/ 2	125	16
3	16/1	150	17	18	27 / 2	125	16
4	19 / 1	150	17	19	2 / 3	100	14
5	21 / 1	200	20	20	3 / 3	100	14
6	23 / 1	200	20	21	5 / 3	100	14
7	26 / 1	150	17	22	6 / 3	80	17
8	28 / 1	200	20	23	9 / 3	150	17
9	30 / 1	150	17	24	10 / 3	80	13
10	3 / 2	200	20	25	11 / 3	100	14
11	5 / 2	200	20	26	12 / 3	80	13
12	9/ 2	200	20	27	13 / 3	200	20
13	13 / 2	150	17	28	16 / 3	100	14
14	16 / 2	150	17	29	17 / 3	100	14
15	18 / 2	150	17	30	18 / 3	100	14
						∑ N=4345	∑ n=502

According to the form shown in Table (4) prepared by the researcher to find out the effective properties and classes of defects per property from the customer point of view regarding the product under the study, it was found that there are only effective properties. These are packaging, the performance

Of the product and appearance.

Table (4): The effective properties and classes of defects per property for the product under study.

Company		Batch size		Date	
Product name		Department		Issued	Issued date
No	Type of defect	Defect class			
		A	B	C	D
	Property (packaging)				
1	Install the product mark on the carton				X
2	Irregular striping found				X
	Property (The performance of the product)				
3	Main fuel tank	X			
4	Chimney completer	X			
5	Wick adjuster	X			
6	Knob	X			
7	Reflector		X		
8	Rubber packing	X			
9	Adjuster	X	X		
10	Tray	X			
	Property (Appearance)				
11	Top plate			X	X
12	Grill			X	X
13	Access			X	
14	Front panel			X	X
15	Decoration panel			X	
16	Cablnet			X	
17	Without the name of the product and model no.				X
18	Carrying handle			X	X

4- The results of classes of defects during the inspection period are given in Table (5).

5- The results of the calculated U for any day under study using eq. (2) are given below in Table (6).

Table (5): The numbers of classes defects (A, B. C. D)

No.	Date	Class of defects				No.	Date	Class of defects			
		A	B	C	D			A	B	C	D
1	12/ 1	-	-	-	3	16	20 / 2	-	-	1	-
2	14/ 1	-	-	2	-	17	25/ 2	-	-	1	1
3	16/ 1	-	-	-	1	18	27/ 2	-	-	-	1
4	19 / 1	-	-	-	1	19	2/ 3	-	-	-	2
5	21 / 1	-	-	-	-	20	3 / 3	-	-	-	1
6	23 / 1	-	-	1	-	21	5 / 3	-	-	4	-
7	26 / 1	-	-	-	-	22	6 / 3	-	-	1	-
8	28 / 1	-	-	1	2	23	9 / 3	-	-	-	-
9	30/ 1	-	-	2	-	24	10 / 3	-	-	1	-
10	3 / 2	-	-	-	-	25	11 / 3	-	-	1	-
11	5 / 2	-	-	-	5	26	12 / 3	-	-	-	-
12	9 / 2	-	-	4	-	27	13/ 3	-	-	-	2
13	13/ 2	-	-	-	2	28	16/ 3	-	-	1	1
14	16 / 2	-	-	-	3	29	17 / 3	-	-	-	3
15	19 / 2	-	-	3	-	30	18 / 3	-	-	-	1

$$\sum_{i=1}^{30} d_A = 0 \quad , \sum_{i=1}^{30} d_B = 0 \quad , \qquad \sum_{i=1}^{30} d_C = 23 \quad , \sum_{i=1}^{30} d_D = 29$$

Table (6): The number of demerit for (30) days

No	n	U	No	N	U	No	n	U
1	20	0.15	11	20	0.25	21	14	2.86
2	21	0.95	12	20	2	22	13	0.77
3	17	0.06	13	17	0.12	23	17	0
4	17	0.06	14	17	0.18	24	13	0.77
5	20	0	15	17	1.76	25	14	0.71
6	20	0.5	16	16	0.63	26	13	0
7	17	0	17	16	0.69	27	20	0.10
8	20	0.6	18	16	0.06	28	14	0.79
9	17	1.18	19	14	0.14	29	14	0.21
10	20	0	20	14	0.07	30	14	0.07

6- The percentage of quality level was in table (2) and values of U for 30 days, as computed depending on the data that given shown in Table (7).

Table (7): The percentage of quality and level number according to the no. of demerit (U) for product for 30 days

No	U(the number of demerit)	Level of quality	No	U(the number of demerit)	Level of quality
1	0.15	100	16	0.63	100
2	0.95	100	17	0.69	100
3	0.06	100	18	0.06	100
4	0.06	100	19	0.14	100
5	0	100	20	0.07	100
6	0.5	100	21	2.86	80
7	0	100	22	0.77	100
8	0.6	100	23	0	100
9	1.18	90	24	0.77	100
10	0	100	25	0.71	100
11	0.25	100	26	0	100
12	2	80	27	0.10	100
13	0.12	100	28	0.79	100
14	1.18	100	29	0.21	100
15	1.76	90	30	0.07	100

$$\sigma = \sqrt{\frac{(100)^2\bar{U}_A + 50^2\bar{U}_B + 10^2\bar{U}_C + 1^2\bar{U}_D}{\bar{n}}}$$

7-In order to construct the U- chart, one has to find the values of (U) according to eq. (3), standard deviation ( ) by eq .(4) ,and finally the upper and lower control limits . Therefore, the plot of demerit control chart (U- chart) is shown in Fig. (4).

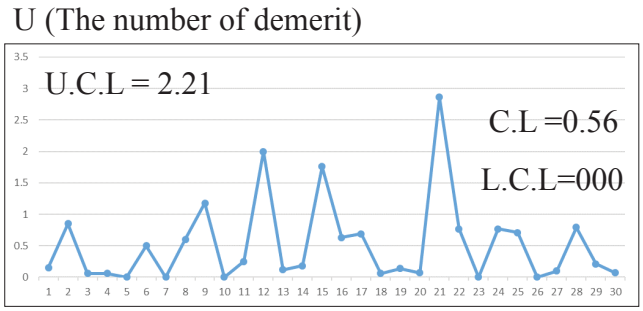

Fig. (4) Demerit Control Chart (U- Chart)

3. Results and Discussion:

The inspections of the selected sample (30 samples) showed that the sum of defects of class A and class B was Zero. Therefore, these types of defects had no effect on the product performance. But, the sum of defects of class C was (23) and class D (29), indicating that they had a slight influence on product function.

The percentage of quality level was found between (80 -100) Table (7), revealing that this quality was quite good, although that the (U) value for sample (21) is out the limit. And, this is attributed to insignificant assembling defects (class c defect), however these defects have no effect on the performance of product, there by no complaints have been not presented by any customer yet.

4.Conclusions:

From practical results, the following conclusions can be drawn:

The numbers of defect class (A, B) have zero percentage in comparison with the defects classes (C, D)

The defect class (D) has the larger (55.8 %) and these defects have no effect on the performance of a product which lead no complaints from the customers such as welding quality in grill less than the standard welding quality and the number of holes in top plate was less than the standard holes in holes.

The production process was statistically controlled because of the (U) value for samples is located between the upper and lower control limits.

The percentage quality for Ishtar Heaters in period (30) days was located

between (80%) and (100%.)

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