THE USE OF THE CONTROL CHARTS TO CONTROL THE DIMENSION OF THE CLAY BRICK UNITS

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ABSTRACT

Some manufactured material properties are expected to have unavoidable shifting in its average value for many reasons, however, they are still able to meet the established specifications. This case occurs when the standard deviation of the process at the various average values is very small compared to the difference between the upper and lower specification limits. On the other hand, any results out of these limits indicates that the efficiency of the process changes and the reasons have to be investigated and corrected .In this study, Al-Qadissiyah brick factory was adopted to examine the acceptance of the produced brick, in terms of its dimensions, according to Iraqi specifications. Control charts were plotted for this purpose. Two types of charts were used, the mean and the standard deviation charts. The upper and the lower limits (UCL andLCL) of each brick dimension were plotted and discussed. The results showed that the lower, the upper limits and the mean value for all dimensions are within the IQ specifications limits and the process is under control. However, the results of the length show that there is one point outside the LCL at the mean chart and one point outside the UCL at the standard deviation chart. This due to the chance causes, as it is only one point from thirteen patches .These charts can be adopted by the factory to show the production process and can be used in the future to investigate the mean of any measured patch.
Keywords: quality control, control charts, mean chart, standard deviation chart, brick dimensions.

استخدام لوحات السيطرة للسيطرة على إبعاد الطابوق الطيني

الخلاصة

من المتوقع ان تتغير خواص بعض المواد المصنعة وتتحول في متوسط قيمتها لأسباب كثيرة ,ومع ذلك فأنها ماتزال قادرة على تلبية المواصفات المعمول بها . تحدث هذه الحالة عندما يكون الانحراف المعياري للعملية عند المتوسط الحسابي لمختلف القيم صغير جدا مقارنه بالفرق بين حدود المواصفة العليا والدنيا . من ناحية أخرى فان أي نتيجة خارج هذه الحدود تعطي مؤشر بان كفاءة العملية تتغير ويجب البدا بالتحقق عن الأسباب وتصحيحها. في هذه الدراسة اعتمد معمل طابوق القادسية لفحص قبول إنتاجه من الطابوق من

حيث الإبعاد وفقا للمواصفة العراقية . وقد رسمت لهذا الغرض خرائط السيطرة وقد استخدمت نوعين من خرائط السيطرة ,خريطة المتوسط وخريطة الانحراف المعياري , الحدود العليا والدنيا لكل أبعاد الطابوق قد تم رسمها ومناقشتها .

مخططات السيطرة للمتوسط والانحراف المعياري لكل من الطول والعرض والسمك للطابوق قد رسمت وبينت ان الحدود العليا والدنيا والمتوسط الحسابي لكل الإبعاد ضمن المواصفات العراقية والعملية الإنتاجية تحت السيطرة .

لوحة المتوسط للطول بينت بان هناك نقطة واحدة خارج الحدود الدنيا للمخطط بينما بينت لوحة الانحراف المعياري بان هناك نقطة واحدة اعلى من الحدود العليا وبعد إجراء التحقق ألموقعي تبين ان هذه النتائج تعود لأسباب صدفية كونها نقطة واحدة من اصل 30 عينة .خرائط السيطرة على العرض قد رسمت والنتائج تشير بان النقاط كلها ضمن الحدود وتتوزع بشكل عشوائي حول الخط المركزي واتجاه النقاط هذا يعطي مؤشر بان العملية الإنتاجية ضمن السيطرة ونفس النتيجة قد تم تحصيلها لخرائط السيطرة على السمك . هذه الخرائط من الممكن اعتمادها في المعمل لتبين نتائج عمليات الإنتاج ويمكن ان تستخدم في المستقبل لتصحيح معدل نتائج أي وجبة مقاسه كما تساعد على مقارنة النتائج الجديدة للفحوصات بالحدود المرسومة في خرائط هذا البحث .

INTRODUCTION

The quality control is one of the main functions in all organizations as a tool that is responsible for the accomplished work in each stage of production process in order to make sure that the final results and the estimated results are identical. This will help to detect the deviation early so remedies can be deployed quickly. The quality of the product is a result of the quality of the process of production and the statistical quality control is necessary to detect changes in the behavior of these processes. The factories of different materials produce a large amount of products. This may causes shifting in their specifications. To control the quality of their products and testing the quality characteristics, many of laboratories are established inside the factory.

Since one of the basic tools in the control processes are the charts to monitor the quality of the products, as if the output acceptable, it allows for the manufacturing process to continue. However, if the output is unacceptable, it means that the process is out of control, which requires corrections. These charts are considered one of the important functions of the control in management of the structures in general and the construction industry factories in particular. The most widely used control charts are the Shewhart control charts[Gibra,1975],[Box,2011] that developed to distinguish between common and special-cause variation. The special cause variation was measured by a change in the mean of process. These Shewhart charts are known as the $\overline{X}$-chart (Average-chart or Mean–chart), the R-chart (Range–chart) and the σ-chart (Standard deviation chart) [Leavenworth,2000],[Montgomery,2007] . The brick unites produced in Iraqi factories are mostly varies in its dimensions and may not meet the standard specification. In this case, it is very helpful to apply the control charts in these factories to eliminate this problem.

To control the upper and the lower limits of the brick dimensions in a specific factory in Iraq (Al-Qadissiyah Factory), these charts were used in this study. The charts used are the mean ($\overline{X}$-chart) and standard deviation(σ-chart) charts. This will help to reduce or eliminate the variation outside the limits in the brick dimensions if it is caused by common causes not by chance causes[Heizer,2008] .

COLLECTING DATA

The collected data for quality control purposes is obtained directly from the factory. Thirteenth patches of brick units that produced during one month were taken from the factory. Each of them has twenty-four brick units as recommended by the Iraqi specifications No. 24. The dimensions of the units were measured according to method stated by Iraqi specifications [IQSNO.24 , 1988] .Tables 1-3show the length, width and the thickness of the selected brick units for these patches.

CONTROL CHARTS

The $\overline{X}$-chart plots the process averages of each patch from the production against three horizontal lines. The central line represents the average value of the mean of each patch. While the σ-chart plots the process standard deviation of each patch from the production against three horizontal lines. The central line represents the average value of the standard deviation of each patch. The other two lines are known as Upper and Lower Control Limits (UCL & LCL). The mean and the standard deviation are calculated as shown in Table 4.The Eqs.(1-3) and (4-6) represent the limits for the $\overline{X}$-chart and σ-chart respectively [Altaai,2008] .

$$UCL=\overline{\overline{X}}+A_1\overline{\sigma} \quad \ldots\ldots(1)$$

$$CL=\overline{\overline{X}} \quad \ldots\ldots(2)$$

$$LCL=\overline{\overline{X}}A_1\overline{\sigma} \quad \ldots\ldots(3)$$

$$UCL=B_1.\overline{\sigma} \quad \ldots\ldots(4)$$

$$CL=\overline{\sigma} \quad \ldots\ldots(5)$$

$$LCL=B_2.\overline{\sigma} \quad \ldots\ldots(6)$$

Where:
A1, B1, B2 is a constant and predetermined values [7] .
$\overline{\overline{X}}$is the average value of the mean
$\overline{\sigma}$is the average value of the standard deviation

RESULTS AND DISCUSSION

Figures (1 -3) show the control charts for the mean and the standard deviation of the length, width and the thickness respectively. It can be seen that the lower, the upper limits and the mean value for all dimensions are within the IQ specifications limits and the process is under control.

Figure (1a) shows the control chart for the mean of the length . It can be seen that there is one point outside the LCL. Figure (1b) shows the control chart of the standard deviation and there is one point outside the UCL. After the site investigation, these results can be attributed to the chance causes, as it is only one point from thirteen patches.

The control charts for the width, using the mean and the standard deviation charts, are shown in **Figure 2** (a and b) respectively. The results indicated that all points are within the limits and distributed randomly around the centerline. The trend of the points indicates that the production process is under control. The same results are obtained for the thickness as shown in **Fig. 3** (a and b).

These charts can be adopted by the factory to show the production process and can be used in the future to investigate the mean of any measured patch. This will help to compare the new results with the charts limits stated in this study.

If the results of the new patch are outside the limits, we have to study the cause and again we have to measure a second patch and compare it with the limits. If the results obtained from the second patches are similar to the previous one (the mean is outside the limits), then the production process is out of control and should be corrected. However, the number of the brick unites in the patch, specified by the IQ specifications, for measuring the dimensions of the brick unites (24 unites)is relatively high as shown in **Fig.4**(a and b). This increase the chance for the patch to pass the test successfully. As a result, it can be concluded that changing the specifications of the brick dimensions is urgent to give an accurate indication about the quality of the process of the production in the brick unites factories.

CONCLUSION

On the basis of the results obtained from the analysis of the real data of the brick dimensions, we can conclude that the mean value for all dimensions is within the IQ specifications limits and the process is under control.The control charts presented in this study can be used to help the factoryto investigate the mean of any measured patch in the future.

- It can be concluded that there is a need to change the IQ specifications regarding the number of the brick unites that have to be examined for its dimensions, as the current number is relatively high and give more realistic results.

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Table 1: The measured length of the selected unites

unit no batch no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	24.13	23.75	24.2	24.15	23.8	24.3	24.4	24.08	23.4	24.13	24.01	23.97	23.75	23.95	23.4	24.07	24.4	23.8	24.15	24.13	24.07	24	24.13	24.14
2	24.01	24.13	23.97	23.95	24.13	23.75	24.2	24.15	23.8	23.4	24.13	23.95	24.97	24.13	23.75	23.8	24.07	24.13	23.95	24.13	24.15	23.75	24.01	23.8
3	23.97	24.13	24.13	23.75	24.3	24.16	23.75	24.3	24.4	24.1	23.5	24.2	24.15	23.85	23.95	24.25	24.15	23.9	24.18	24.5	23.8	24.18	24.4	23.9
4	24.25	24.23	24.4	24.1	23.95	24.2	24.15	24.34	24.3	24.1	24.01	24.07	24.02	24.15	24.01	24.2	24.15	23.8	23.98	24.2	23.99	23.8	24.01	23.85
5	23.9	23.85	23.95	23.8	24.12	24.13	23.65	23.85	23.65	23.98	24.15	24.1	23.75	23.85	24	24.1	23.82	24.01	23.98	23.95	23.85	24.1	24.2	24.15
6	23.75	24.08	24.06	23.9	23.85	24.02	24.08	24.13	23.95	24.1	24.01	23.85	23.9	23.95	24.1	24.12	24.1	24.08	23.95	23.8	23.78	23.95	24.1	24.12
7	24.12	24.07	23.85	24	23.75	24.3	24.4	24	23.6	24.12	23.653	24.03	24.2	24.123	23.85	24.035	24.13	24.21	24.2	24.12	24.1	24.11	23.85	23.8
8	24.1	23.8	23.95	23.75	24.2	23.98	23.75	24.07	23.85	23.9	23.8	23.95	24.08	24.12	23.8	23.9	24.13	24.06	24.13	24.12	24.12	24.07	24.05	24.13
9	23.85	23.65	24.08	23.95	23.8	23.4	24.13	23.85	24.15	24.04	23.8	23.85	23.95	23.9	23.85	23.85	23.95	24.12	24.1	23.75	23.8	23.5	23.65	23.7
10	23.97	24.12	24.14	24.08	23.85	24.15	24.04	23.97	24.25	23.9	23.5	24.2	23.95	23.75	23.95	23.9	23.9	24.15	23.85	24.4	23.9	24.13	23.95	24.12
11	24.25	24.1	24.08	23.98	23.95	24.1	24.12	24.25	24.2	23.8	24.01	24.07	24.18	24.15	24.08	23.95	23.85	24.02	24.15	24.01	23.85	23.9	24.18	23.85
12	23.95	24.13	23.75	24.14	24.12	23.8	23.68	23.95	24.04	24.12	24.15	24.1	23.95	24.12	24.12	24.07	24.15	23.75	23.85	24.2	24.15	23.8	23.98	24.2
13	24.1	24.01	24.07	23.75	23.85	24.15	24.04	23.85	23.95	23.8	23.85	23.85	24.3	24.31	24	24.016	24.3	24.18	23.86	23.9	24.12	24.125	23.95	24.01

Table 2: The measured width of the selected unites

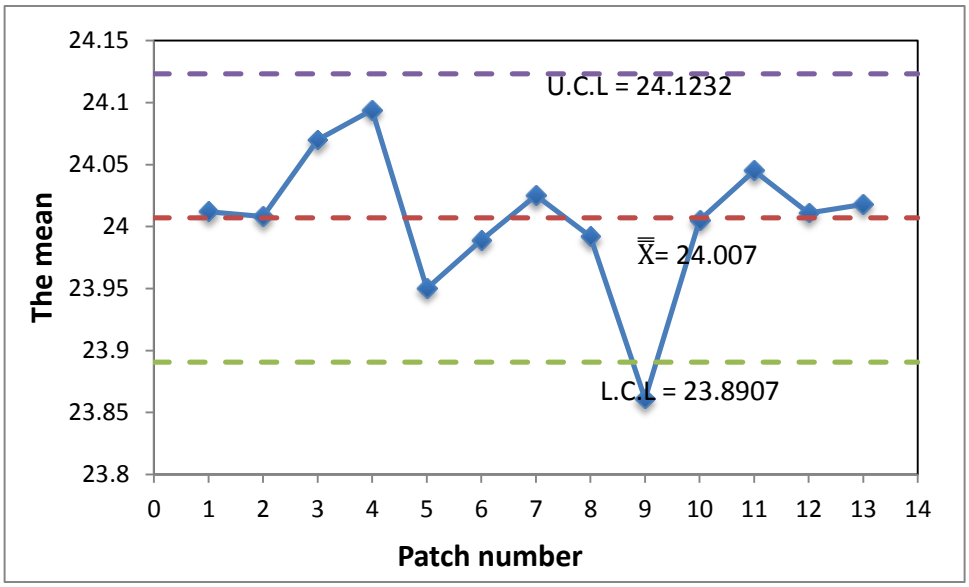
unit no batch no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	11.55	11.5	11.65	11.5	11.5	11.16	11.42	11.52	11.53	11.5	11.35	11.75	11.61	11.16	11.6	11.6	11.53	11.52	11.42	11.61	11.75	11.35	11.42	11.51
2	11.35	11.3	11.52	11.14	11.75	11.5	11.35	11.75	11.6	11.17	11.5	11.65	11.5	11.5	11.16	11.6	11.45	11.55	11.35	11.41	11.16	11.5	11.35	11.65
3	11.5	11.45	11.7	11.55	11.43	11.18	11.71	11.62	11.65	11.75	11.62	11.16	11.35	11.5	11.57	11.42	11.6	11.65	11.55	11.45	11.5	11.63	11.65	11.4
4	11.75	11.62	11.55	11.16	11.35	11.28	11.16	11.6	11.5	11.42	11.65	11.5	11.6	11.5	11.35	11.53	11.45	11.5	11.16	11.4	11.45	11.65	11.5	11.6
5	11.5	11.35	11.45	11.5	11.13	11.6	11.4	11.45	11.35	11.16	11.25	11.45	11.5	11.35	11.65	11.35	11.4	11.55	11.3	11.14	11.16	11.4	11.5	11.65
6	11.56	11.6	11.66	11.5	11.75	11.45	11.35	11.4	11.55	11.6	11.45	11.14	11.6	11.16	11.55	11.75	11.45	11.35	11.4	11.54	11.23	11.35	11.53	11.54
7	11.75	11.5	11.76	11.6	11.5	11.42	11.65	11.6	11.35	11.53	11.55	11.43	11.18	11.71	11.6	11.65	11.55	11.65	11.34	11.45	11.45	11.55	11.43	11.5
8	11.65	11.55	11.54	11.45	11.35	11.16	11.25	11.54	11.65	11.54	11.3	11.12	11.16	11.54	11.55	11.45	11.5	11.16	11.65	11.35	11.35	11.3	11.45	11.6
9	11.55	11.16	11.35	11.16	11.25	11.45	11.43	11.18	11.43	11.54	11.65	11.34	11.43	11.16	11.4	11.45	11.45	11.45	11.5	11.65	11.45	11.24	11.45	11.4
10	11.45	11.5	11.55	11.6	11.45	11.14	11.16	11.54	11.35	11.16	11.23	11.24	11.22	11.3	11.14	11.16	11.4	11.45	11.5	11.34	11.54	11.35	11.4	11.16
11	11.34	11.36	11.5	11.35	11.53	11.55	11.54	11.5	11.65	11.12	11.23	11.3	11.34	11.45	11.45	11.55	11.45	11.35	11.53	11.25	11.4	11.55	11.45	11.26
12	11.45	11.35	11.16	11.25	11.5	11.5	11.34	11.16	11.55	11.43	11.18	11.71	11.35	11.35	11.3	11.45	11.35	11.16	11.55	11.45	11.5	11.63	11.8	11.26
13	11.4	11.55	11.6	11.16	11.25	11.6	11.27	11.16	11.12	11.16	11.54	11.55	11.45	11.24	11.23	11.26	11.34	11.18	11.23	11.4	11.45	11.65	11.5	11.17

Table 3: The measured thickness of the selected unites

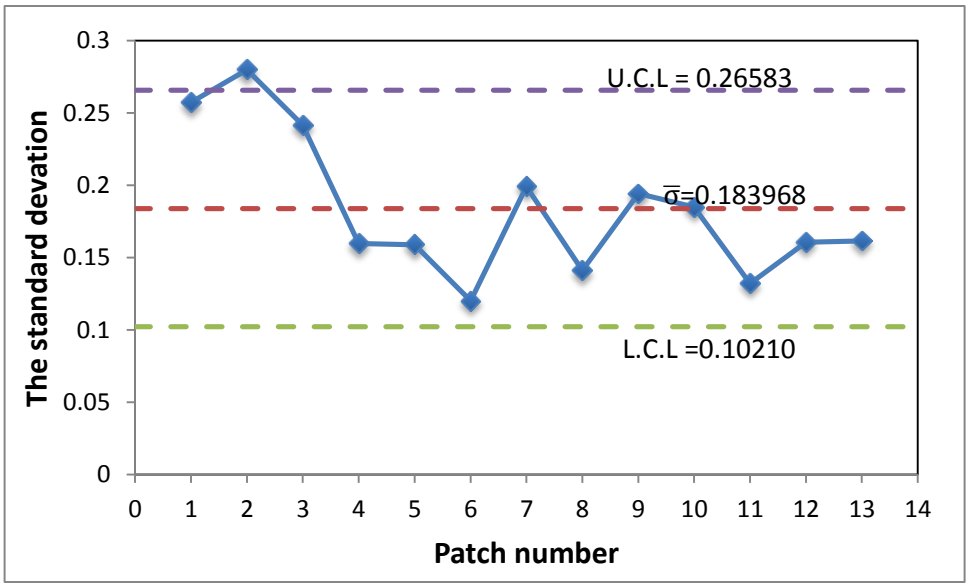
unit no batch no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	7.65	7.5	7.56	7.7	7.5	7.6	7.57	7.55	7.45	7.47	7.6	7.6	7.6	7.65	7.5	7.5	7.6	7.57	7.54	7.57	7.56	7.6	7.6	7.5
2	7.5	7.75	7.57	7.65	7.58	7.7	7.56	7.56	7.62	7.45	7.67	7.5	7.45	7.63	7.59	7.38	7.45	7.6	7.43	7.65	7.54	7.55	7.54	7.47
3	7.65	7.54	7.47	7.57	7.56	7.6	7.36	7.59	7.38	7.56	7.45	7.5	7.68	7.5	7.55	7.58	7.57	7.63	7.65	7.54	7.65	7.63	7.5	7.5
4	7.65	7.5	7.55	7.58	7.55	7.56	7.62	7.64	7.55	7.68	7.5	7.56	7.65	7.6	7.7	7.56	7.55	7.5	7.63	7.7	7.56	7.57	7.45	7.66
5	7.56	7.34	7.56	7.57	7.67	7.5	7.55	7.75	7.55	7.44	7.56	7.45	7.56	7.56	7.5	7.4	7.5	7.67	7.36	7.58	7.61	7.57	7.56	7.55
6	7.17	7.27	7.55	7.67	7.47	7.55	7.75	7.54	7.56	7.45	7.5	7.47	7.61	7.55	7.56	7.5	7.4	7.55	7.54	7.58	7.54	7.5	7.55	7.6
7	7.76	7.67	7.46	7.57	7.78	7.61	7.3	7.44	7.5	7.56	7.55	7.55	7.6	7.45	7.46	7.55	7.56	7.63	7.45	7.45	7.45	7.55	7.55	7.6
8	7.55	7.56	7.62	7.66	7.57	7.45	7.66	7.5	7.6	7.45	7.56	7.4	7.54	7.65	7.45	7.65	7.56	7.66	7.47	7.42	7.6	7.6	7.56	7.45
9	7.67	7.5	7.55	7.5	7.45	7.6	7.45	7.5	7.5	7.5	7.57	7.63	7.6	7.54	7.36	7.5	7.55	7.58	7.57	7.63	7.45	7.68	7.5	7.55
10	7.47	7.57	7.56	7.6	7.6	7.65	7.44	7.56	7.56	7.45	7.56	7.45	7.5	7.45	7.56	7.65	7.5	7.64	7.61	7.44	7.57	7.65	7.6	7.7
11	7.68	7.5	7.56	7.65	7.5	7.65	7.45	7.56	7.6	7.5	7.4	7.57	7.54	7.6	7.4	7.56	7.45	7.57	7.41	7.46	7.55	7.56	7.56	7.5
12	7.6	7.6	7.56	7.43	7.58	7.53	7.42	7.46	7.54	7.62	7.65	7.7	7.44	7.46	7.46	7.42	7.55	7.65	7.55	7.53	7.45	7.55	7.6	7.47
13	7.56	7.5	7.75	7.57	7.65	7.58	7.7	7.56	7.56	7.62	7.45	7.67	7.5	7.45	7.63	7.6	7.56	7.55	7.65	7.53	7.56	7.4	7.5	7.6

Table 4: The mean and the standard deviation for each dimension

Thickness		width		length	
Standard deviation	mean	Standard deviation	mean	Standard deviation	mean
0.0610	7.5642	0.1463	11.5004	24.0129	0.2573
0.0926	7.5579	0.1793	11.4483	24.0088	0.2803
0.0827	7.5504	0.1521	11.5246	24.0792	0.2416
0.0671	7.5863	0.1605	11.4679	24.0942	0.1597
0.0941	7.5383	0.1522	11.3975	23.9538	0.1589
0.1166	7.5179	0.1607	11.4775	23.9888	0.1201
0.1062	7.5438	0.1370	11.5292	24.0259	0.1992
0.0829	7.5496	0.1690	11.4233	23.9921	0.1411
0.0756	7.5388	0.1429	11.3967	23.8613	0.1942
0.0774	7.5558	0.1522	11.3471	24.0050	0.1850
0.0776	7.5325	0.1285	11.4167	24.0450	0.1322
0.0812	7.5342	0.1718	11.4054	24.0113	0.1606
0.0821	7.5708	0.1702	11.3525	24.0142	0.1615
Average =0.084396	Average =7.549263	Average =0.155592	Average =11.43747	Average =24.00709	Average =0.183968

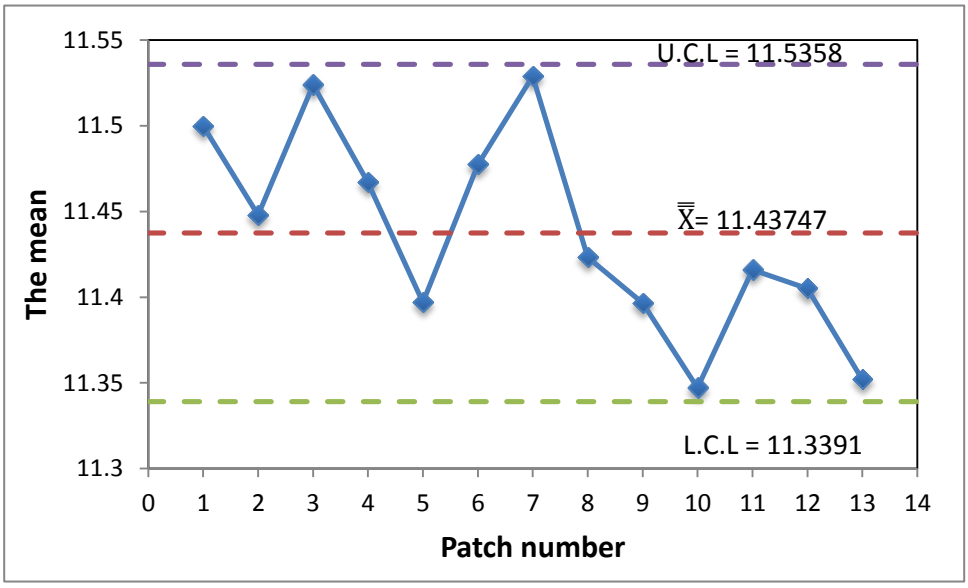


a: the mean chart

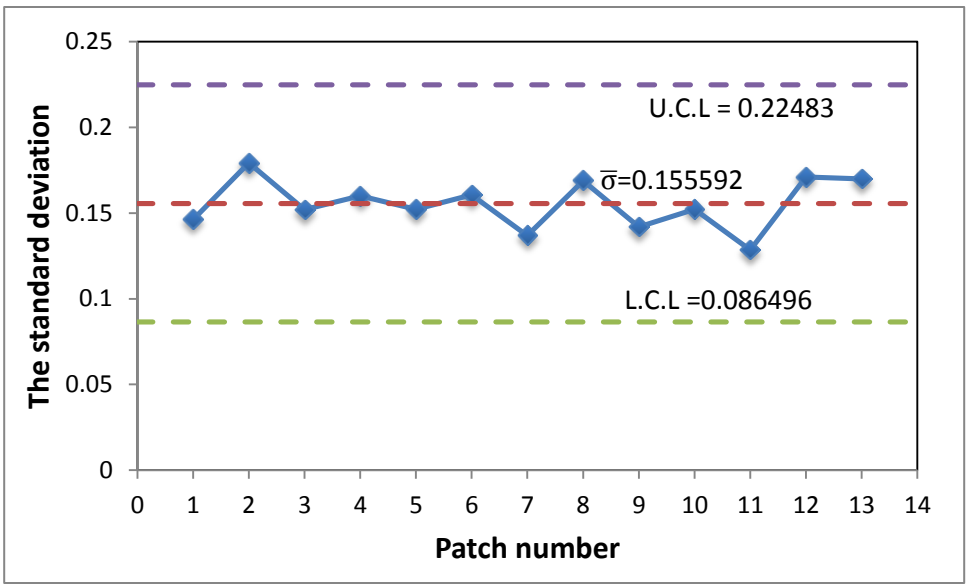


b: the standard deviation chart

Figure (1): Control chart for the brick length a: the mean chart b: the standard deviation chart

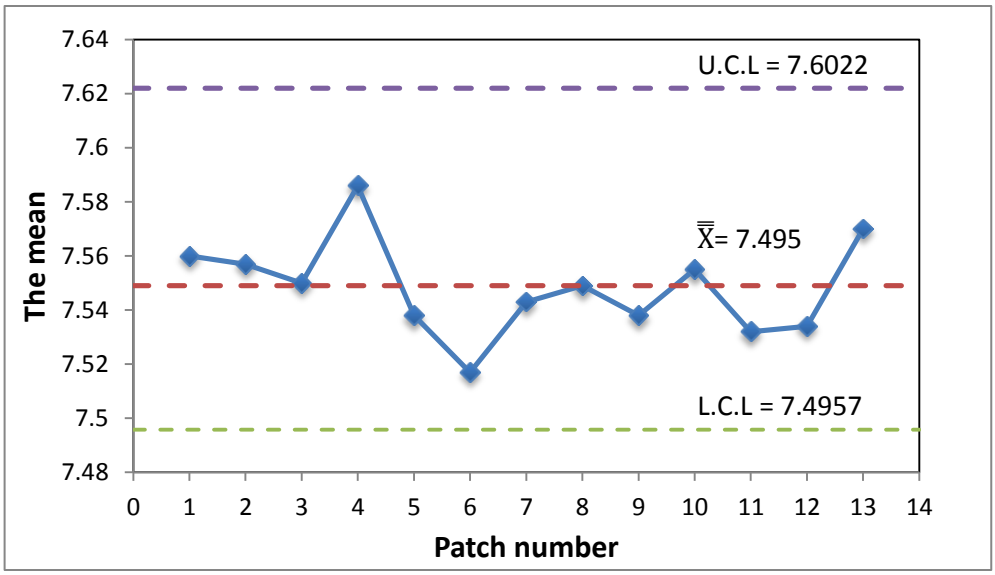


a: the mean chart

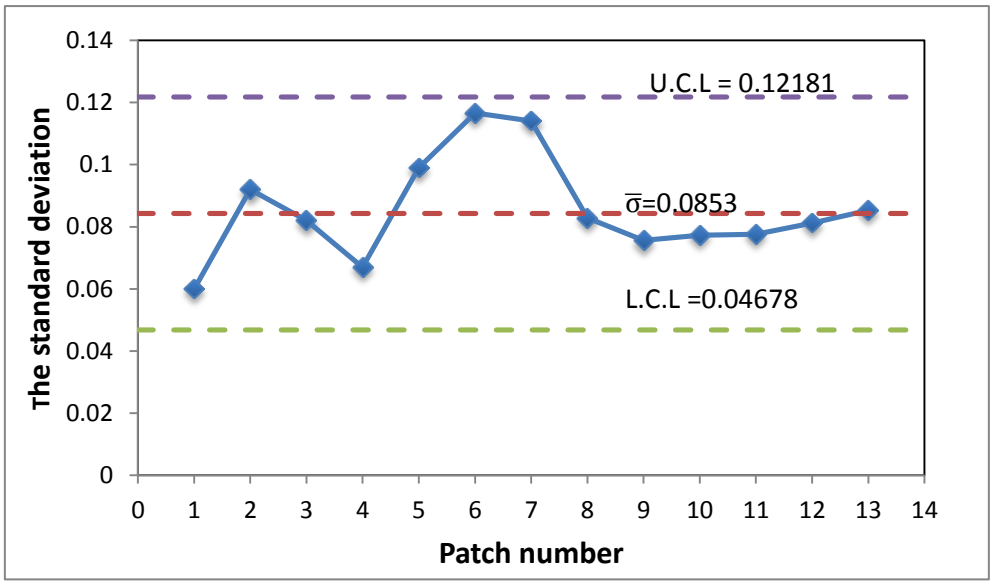


b: the standard deviation chart

Figure (2): Control chart for the brick width a: the mean chart b: the standard deviation chart



a: the mean chart



b: the standard deviation chart

Figure (3): Control chart for the brick thickness a: the mean chart b: the standard deviation chart

a- method of width test

b- method of thickness test

Figure (4): method of tests a- method of width test b- method of thickness test