The Scientific Journal of Cihan University – Sulaimaniya PP: 49-64
Volume (5), Issue (2), December 2021
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

Used Gamma Control Chart on L.O.I of Cement Factor

Kawa Mohammed Jamal [1], Shalaw Latif Khdir[2]

[1,2] Statistics and Informatics Department, College Administration and Economic, University of Sulaimani, Sulaimani, Iraq

Email: kawa.Rashid@univsul.edu.iq [1], shalaw.latif19@gmail.com [2]

Abstract:

Control charts are one of the scientific, statistical tools widely used to monitor the processes' stability and performance and detect abnormal changes and variations in the processes quickly by monitoring and controlling the processes. The purpose of a GAMMA control chart has been performed using the cement product factory in Sulaimani of interest supports variable the gamma distribution. The Wilson-Hilferty estimate is applied to change the gamma variable characteristic to a normal random variable. The Gamma control chart for data monitors the time until an event assumes that a particular event follows a homogeneous Poisson process. We display the GAMMA control chart's construction and determine the average run lengths for control and a shifted process. The out-of-control ARL is received after the procedure is shifted in intervals of the Gamma distribution scale parameter. Therefore, according process shift parameters, the ARLs are shown for many values of the shape parameter. Control charts have been evaluated to determine the effectiveness of the aimed chart. The implementation of the suggested map is shown using information on cement products. The GAMMA control chart is said to be more sensitive and reliable in identifying tiny changes since it gives a single explanation for several variables.

Ker word: GAMMA control chart, Wilson-Hilferty, Monitor, Scale and Shape parameter, ARL.

الملخص:

مراقبة الجودة أحد وسائل الاحصاء العلمي والذي يستخدم بشكل واسع في مجال متابعة قدرة الأسواق و مقدار ثبوتها و إضافة الى هذا يستخدم لكشف الإختلاف في الانتاج والتغييرات الغير طبيعية مع سرعة مراقبة الأسواق، في هذا البحث تحديداً نقصد بمراقبة جودة جاما متاعبة وإنتاج الاسمنت داخل أحد المعامل في مدينة السليمانية، وذلك لكي نصل الى جودة الانتاج والتغييرات الذي تحصل أثناء الانتاج، من خلال مراقبة جودة جاما إستفدنا من إقتراح (Wilson-Hilferty) لخصوصية تقسيم جاما وتغييره الى متغير عشوائي طبيعي.

مراقبة جودة جاما يقوم بمراقبة الانتاج لحين حدوث تغييرات غير طبيعية، فيقوم بتسجيله وإبلاغ المستثمر لكي يقدم إنتاجاً أفضل، ثم يقوم بعرض مراقبة جودة جاما للحصول على معدل طول العمل من خلال مراقبة عملية إنتقالية.

(ARL) يساعدنا على معرفة الى أي مدى يكون مقياس متغير إنتاجي تحت سيطرة مقياس جاما، إضافة الى أن (ARLs) يظهر قيم ومقاييس وفرضيات مختلفة والذي تشير الى مراقبة جاما، بإستخدام مراقبة الجودة المقترح بأرقام ومعلومات حول إنتاج الإسمنت، من خلال هذا التحليل تبينت لنا أن مراقبة جودة جاما حساس ومؤثر في الكشف عن التغييرات الصغيرة ويستفاد منه في مراقبة ومتابعة الانتاج في المعامل الصناعية.

الكلمات الرئيسية: التحكم الرسم البياني كاما، ويلسون هيلفرتي، المراقبة، مقياس و شكل المعلمة، ARL

DOI: http://dx.doi.org/10.25098/5.2.18

The Scientific Journal of Cihan University – Sulaimaniya **PP: 49-64**
Volume (5), Issue (2), December 2021
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

پوختە:

نەخشەی کۆنترۆڵی یەکێکە لەو ئامرازە ئامارە زانستیانەی کە بە شێوەیەکی فراوان بە کار دێت بۆ چاودێری کردنی جێگری و کارامەی بۆرسەکان وە هەروەها کەشف کردنی گۆڕانکاری نائاسایی و جیاوازییەکان لە بەرهەم هێناندا بە خێرایی لە ڕێگەی چاودێری کردن و کۆنترۆڵکردنی بۆرسەکانەوە. مەبەست لە نەخشەی کۆنترۆڵی گاما بۆ چاودێری کردن و بەرهەم هێنانی چیمەنتۆ لە کارگەیەکی سلێمانی بۆ ئەوەی بگەین بە باشترین بەرهەم دیاریکردنی گۆڕانکاری لە کاتی بەرهەم. لە نەخشەی کۆنترۆڵی گاما دا سود لە پێشنیاری (**Wilson-Hilferty)** وەرگیراوە کە تایبەت مەندی دابەشکردنی گاما بۆ گۆڕاوێکی هەڕەمەکی ئاسایی بگۆڕێت.

نەخشەی کۆنترۆڵی گاما چاودێری کاتی بەهەم هێنان دەکات تا ئەو کاتەی ڕوداو یان گۆڕانێکی نائاسایی ڕوو بدات تۆماری دەکات ئاگاداری بەرهەم هێن دەکات کە باشترین بەرهەم پێشکەش بکات. ئیمە نەخشەی کۆنترۆڵکردنی گاما نیشان دەدەین تێکڕای درێژای کارکردن لە ژێرچاودێری کۆنترۆڵ و پرۆسەیەکی گوازرا و دیاری دەکەین.

(ARL) یارمەتیمان دەدات بۆ ئەوەی بزانین تا چ ماوەیەک پێوەرێکی گۆڕاوی بەرهەم هێنان لە ژێرکۆنترۆڵی پێوەری گاما دەبێت. هەروەها **(ARLs)** پیشان دراوە بە بەها و پێوەری جیاواز گریمانەی بۆ کراوە و باس لە کارای نەخشەی کۆنترۆڵی گاما دەکات. بەکارهێنانی نەخشەی کۆنترۆڵی پێشبینرکراو بە داتا و زانیاری دەربارەی چاودێریکردنی بەرهەم هێنانی چیمەنتۆ. لە ئەنجامی ئەم شیکارییە دەرکەوت کە نەخشەی کۆنترۆڵی گاما هەستیار وکاریگەرە لە کەشف کردنی گۆڕانە بچوکەکان و سودی باشی هەیە بۆ چاودێری کردنی بەهەم هێنان لە کارگە پیشەسازییەکاندا.

کلیلە وشە: نەخشەی کۆنترۆڵی گاما، ویلسۆن- هێلفەرتی، چاودێری کردن، دیاریکردنی پێوەر و شێوە، **ARL**

Introduction:

Quality is described in a number of different ways, from "meeting the needs of consumers" to "fitness for purpose" to "conformance to specifications." Customers should be included in every concept of quality, as they must be the primary target of any company. Also, Quality has been shown to be important for marketing success and development in global markets over the last two decades [6].

The quality monitoring technique evaluates the factors that interact with the production process, deciding whether the manufacturing process or variables are under control. Are the variables in line with the requirements? If they are out of reach and do not meet the standards, it is critical to address the problem. Detecting defects in order to enhance quality [4].

One of the most important components in altering the commercial and marketing process of product creation, increasing output, and improving the efficiency of the manufacturing process is quality control. As a result, many industrial and commercial people depend on quality control systems to check their production quality and ensure consistent product quality [8].

In (1924) the statistician (Dr. Shewhart) presented a visual approach and used it for the first time based on the Quality Control Chart to notice vicissitudes in Non-randomness in the production progression. Also, Shewhart and many researchers have continued to interest in control panels and develop them through many studies and research [8].

Control charts are interactive methods for identifying some specific trigger in a process as a result of a shift in product quality. The centerline (CL) depicts the average value of the consistency characteristic, while the upper control limit (UCL) and lower control limit (LCL) are two level lines

DOI: http://dx.doi.org/10.25098/5.2.18

(LCL). It likewise aids in the monitoring of a production operation. After the produced goods have been prepared, they will be tested again to determine if they should be accepted or rejected. The acknowledgment sampling technique is a mathematical method used to make such assessments [3].

In addition, the gamma distribution is widely consumed in a number of disciplines. This distribution is regarded to be a good match with waiting time outcomes in live testing. The two-parameter gamma distribution may be useful for environmental checking and control. More particulars on the gamma control chart may be establish here. The average run length (ARL) of a gamma is calculated using random-shift generator software [5].

Later in these years, (Aslam, 2014) published the (EWMA) sign chart for repeated sample. The approximation is an easy, adequate, and unified method for resolving various gamma distribution issues, according to (Wilson-Hilferty). There is no exertion on generating the controller graph for the gamma variable using the (Wilson-Hilferty) guesstimate. Furthermore, we will generate a control chart utilizing cement data by supposing that the normal distribution of participation reflects the gamma variable. To convert the gamma variable to a normal flexible and define upper and lower control limits, the (Wilson-Hilferty) application will be employed. The suggested control chart's control steady is set for a specific in-control (ARL). After the mechanism is changed in relationships of the scale parameter, the out-of-control ARL begins [1].

In the case of a homogeneous Poisson process, the time before an incidence is monitored using a gamma control chart for outcomes. As a result, it cannot be utilized to track a specific gamma-distributed property. Create a switch graph aimed at the gamma distribution using a hypothesis estimator [9].

In life-testing applications, the lifespan of an element is amongst the most important quality aspects, and it must be monitored to verify that customer satisfaction fulfills the required standards. Assume that a supplier and a mean lifetime are in charge of producing a certain sort of electrical item. A decrease in the average lifetime level indicates a decrease in efficiency. To deactivate the attachable triggering and reset the process to a controlled state, the producer must conduct specific out-of-control procedures. An increase in the mean lifetime level, on the other hand, might signal that new approaches or process improvements are required to assess the output's relevance. By ignoring the censorship rate if the censoring rate is low, the classic Shewhart X control chart may be used to monitor the mean lifetime of objects using censored data [10].

DOI: http://dx.doi.org/10.25098/5.2.18

The Gamma Distribution

The gamma random variable's probability distribution well defined as shadows.

The function's gamma distribution is [7]

$$f\ (x) = \frac{\beta}{\Gamma(\alpha)}\ (\beta x)^{\alpha-1}\ e^{-\beta x} \qquad x \geq 0 \ldots\ldots. (1)$$

With scale parameter β>0 and shape parameter α>0. The mean and variance of the gamma circulation are [7]

Mean is $\mu = \frac{\alpha}{\beta}$ and variance $\sigma^2 = \frac{\alpha}{\beta^2}$

The gamma distribution is reduced to the exponential distribution with the parameter if α= 1. Depending on the values used for α and β , the gamma distribution will predict various shapes. The above equation can be used to model a broad range of continuous random variables.

Gamma control chart

The gamma circulation is a typical skewed data typical that is also used to describe the time among occurrences. We are attempting to create a gamma distribution control chart. Consequently, project a control chart to observer the gamma variable efficiency of assessment in an uncertain situation where the coherence of the value followed the gamma distribution [1].

Allow T to obtain a random variable from a gamma variable through scale parameter (β) besides shape parameter (α). The (CDF) of the gamma flexible is providing by

$$F(t) = P(T \leq t)$$

The (CDF) of gamma is [1]

$$P(T \leq t) = 1 - \sum_{j=1}^{\alpha-1} \frac{e^{-(\frac{t}{\beta})}\left(\frac{t}{\beta}\right)^j}{j!} \qquad \ldots\ldots\ldots\ldots (2)$$

Moment generating function of gamma is

$$M_y(t) = E(e^{tx}) = \int_{-\infty}^{\infty} e^{tx} f(x)dx \qquad \ldots\ldots\ldots\ldots (3)$$

Allowing to (WH), the change T* = $\sqrt[3]{T}$ is distributed nearly as a normal with mean [2].

The mean The mean is $\mu_{T^*} = \frac{\sqrt[3]{\beta}\,\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)}$ ………… (4)

and

The variance is $\sigma_{T^*} = \frac{B^{\frac{2}{3}}\Gamma(\alpha+\frac{2}{3})}{\Gamma(\alpha)} - \left(\frac{\sqrt[3]{\beta}\,\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)}\right)^2$ ………… (5)

DOI: http://dx.doi.org/10.25098/5.2.18

Or

$$\sigma_{T^*} = \frac{B^{\frac{2}{3}}\Gamma(\alpha+\frac{2}{3})}{\Gamma(\alpha)} - (\mu_{T^*})^2$$

T* has a symmetric distribution, which allows for the creation of a control chart with symmetric control limits. As a result, we used cement data to generate the control chart below for a gamma-distributed specific variable [5]:

Stage 1: Choose an item at random and assess its eminence property T. Then, estimate

$$T^* = \sqrt[3]{T} \qquad \text{……..…… (6)}$$

Stage 2: Indicate the procedure as out-of-control if $T^* \leq UCL1$ or $T^* \leq LCL1$. Assert the procedure as in-control if $LCL_2 \leq T^* \leq UCL_2$. Contrarily, continue to Stage 1 and recurrence the procedure.

The upper and lower controller limits are the two sets of control limits that make up the aimed control chart. The switch graph is a combination of multiple control charts. When α = 1 (an Exponential case), the offered map becomes the chart. When α = 1 and $L_1 = L_2$, the aimed graph becomes the chart. The control limits are discovered to have the succeeding methods and are generated after the data once the machine is under control [9].

Let β_0 is the scale parameter after the procedure is in regulator. Then, the outside regulator limits are given, and the moments above can now nonstop the regulator limits of an around normally dispersed procedure in closed form [5].

Lower Control Limit $LCL_N = \mu_{T^*}\text{-}L_N\ \sigma_{T^*}$

$$= \frac{\sqrt[3]{\beta}\,\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)} - L_N\left(\frac{\beta^{\frac{2}{3}}\Gamma(\alpha+\frac{2}{3})}{\Gamma(\alpha)} - \left(\frac{\sqrt[3]{\beta}\ \Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)}\right)^2\right)^{1/2} \qquad \text{……… (7)}$$

Upper Control Limit $UCL_N = \mu_{T^*}+L_N\ \sigma_{T^*}$

$$= \frac{\sqrt[3]{\beta}\,\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)} + L_N\left(\frac{\beta^{\frac{2}{3}}\Gamma(\alpha+\frac{2}{3})}{\Gamma(\alpha)} - \left(\frac{\sqrt[3]{\beta}\ \Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)}\right)^2\right)^{1/2} \qquad \text{……….(8)}$$

LCL: Lower control limit

UCL: Upper control limit

μ_{T^*}: Mean of the GAMMA control chart

σ_{T^*}: standard deviation of the GAMMA control chart

L_i: Control coefficients of the GAMMA control chart

α : Alpha parameter (Shape parameter)

β: Beta parameter (Scale parameter)

DOI: http://dx.doi.org/10.25098/5.2.18

The Scientific Journal of Cihan University – Sulaimaniya **PP: 49-64**
Volume (5), Issue (2), December 2021
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

The limiting worth for the standard deviation of the GAMMA statistic is used to assess these constraints. It should be noted that using these predefined control limits is more convenient. It also makes the control chart vulnerable at first. We'll utilize this approximation throughout the rest of the article because it's commonly utilized in industrial applications. However, if a quality practitioner decides to utilize the precise number for the GAMMA statistic's confidence interval, the control limits become [2].

Since calculation (9) and (10), the First control limits of the GAMMA are set by [2]

$$LCL_1 = \mu_{T^*} - L_1\, \sigma_{T^*}$$

$$= \frac{\sqrt[3]{\beta}\,\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)} - L_1\left(\frac{\beta^{\frac{2}{3}}\Gamma(\alpha+\frac{2}{3})}{\Gamma(\alpha)} - \left(\frac{\sqrt[3]{\beta}\;\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)}\right)^2\right)^{1/2} \qquad \ldots\ldots\ldots\ldots (9)$$

$$UCL_1 = \mu_{T^*} + L_1\, \sigma_{T^*}$$

$$= \frac{\sqrt[3]{\beta}\,\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)} + L_1\left(\frac{\beta^{\frac{2}{3}}\Gamma(\alpha+\frac{2}{3})}{\Gamma(\alpha)} - \left(\frac{\sqrt[3]{\beta}\;\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)}\right)^2\right)^{1/2} \qquad \ldots\ldots\ldots\ldots (10)$$

Since calculation (11) and (12), the second control limits of the GAMMA are set by [2]

$$LCL_2 = \mu_{T^*} - L_2\, \sigma_{T^*}$$

$$= \frac{\sqrt[3]{\beta}\,\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)} - L_2\left(\frac{\beta^{\frac{2}{3}}\Gamma(\alpha+\frac{2}{3})}{\Gamma(\alpha)} - \left(\frac{\sqrt[3]{\beta}\;\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)}\right)^2\right)^{1/2} \qquad \ldots\ldots\ldots\ldots (11)$$

$$UCL_2 = \mu_{T^*} + L_2\, \sigma_{T^*}$$

$$= \frac{B^{\frac{1}{3}}\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)} + L_2\left(\frac{\beta^{\frac{2}{3}}\Gamma(\alpha+\frac{2}{3})}{\Gamma(\alpha)} - \left(\frac{\sqrt[3]{\beta}\;\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)}\right)^2\right)^{1/2} \qquad \ldots\ldots\ldots\ldots (12)$$

Control coefficients L_1 and L_2 are to be calculated through taking into account the given in-control ARL. In above, L_1 and L_2 are control coefficient to be resolute by bearing in mind the in-control ARLs while β_0 is the scale parameter when the development is in control. The suggested approach simplifies the Shewhart control chart when the control coefficients $L_1 = L_2$ and i = 1 [2].

The control limits can also be written as follows

$$LL_1 = \left(\frac{\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)} - L_1\left(\frac{\Gamma\left(\alpha+\frac{2}{3}\right)}{\Gamma(\alpha)} - \left(\frac{\Gamma\left(\alpha+\frac{1}{3}\right)}{\Gamma(\alpha)}\right)^2\right)^{1/2}\right) \qquad \ldots\ldots\ldots\ldots (13)$$

DOI: http://dx.doi.org/10.25098/5.2.18

The Scientific Journal of Cihan University – Sulaimaniya **PP: 49-64**
Volume (5), Issue (2), December 2021
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

$$\text{UL}_1 = \left(\frac{\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)} + L_1 \left(\frac{\Gamma\left(\alpha+\frac{2}{3}\right)}{\Gamma(\alpha)} - \left(\frac{\Gamma\left(\alpha+\frac{1}{3}\right)}{\Gamma(\alpha)} \right)^2 \right)^{1/2} \right) \quad \ldots\ldots\ldots\ldots (14)$$

$$\text{LL}_2 = \left(\frac{\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)} - L_2 \left(\frac{\Gamma\left(\alpha+\frac{2}{3}\right)}{\Gamma(\alpha)} - \left(\frac{\Gamma\left(\alpha+\frac{1}{3}\right)}{\Gamma(\alpha)} \right)^2 \right)^{1/2} \right) \quad \ldots\ldots\ldots\ldots (15)$$

and

$$\text{UL}_2 = \left(\frac{\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)} + L_2 \left(\frac{\Gamma\left(\alpha+\frac{2}{3}\right)}{\Gamma(\alpha)} - \left(\frac{\Gamma\left(\alpha+\frac{1}{3}\right)}{\Gamma(\alpha)} \right)^2 \right)^{1/2} \right) \quad \ldots\ldots\ldots\ldots (16)$$

Then, the control limits between Eqs (9) then (16) are condensed to

$\text{LCL}_1 = \sqrt[3]{\beta_0}\ \text{LL}_1$

$\text{UCL}_1 = \sqrt[3]{\beta_0}\ \text{UL}_1$

$\text{LCL}_2 = \sqrt[3]{\beta_0}\ \ \text{LL}_2$

$\text{UCL}_2 = \sqrt[3]{\beta_0}\ \ \text{UL}_2$

Only the gamma distribution scale is thought to be able to alter as the mechanism evolves. As the machine is moved, the form parameter, on the other hand, remains constant. The shape parameter is usually set in a variety of ways depending on the application type, similar to how the Weibull parameter is set. Let β_0 be the scale parameter while the procedure is in control and let $\beta_1$be the scale parameter after it is shifted. Additional, the scale parameter for the shifted process has β_1 = c β_0 for a constant c [1].

When the process is regulated, the likelihood that it will be considered out of control for a lone example is provided underneath according to the based control chart.

$$P^0_{out,1} = P(T^* < LCL_1|\beta = \beta_0) + P(T^* > UCL_1|\beta = \beta_0) \quad \ldots\ldots\ldots\ldots (17)$$

$$P^0_{rep} = P(UCL_2 < T^* < LCL_1|\beta = \beta_0) + P(LCL_2 < T^* < UCL_1|\beta = \beta_0) \quad \ldots\ldots\ldots\ldots (18)$$

$$P^0_{out} = \frac{P^0_{out,1}}{1-P^0_{rep}} \quad \ldots\ldots\ldots\ldots (19)$$

The (ARL) for the in-control, practice is assumed as monitors:

$$\text{ARL}_0 = \frac{1}{P^0_{out}} \quad \ldots\ldots\ldots\ldots (20)$$

DOI: http://dx.doi.org/10.25098/5.2.18

The Scientific Journal of Cihan University – Sulaimaniya PP: 49-64
Volume (5), Issue (2), December 2021
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

Now, we assume that the gamma distribution scale is transformed since $\beta_0$to β_1 = c β_0, for a constant c. The probability of stating as out-of-control for the shifted procedure founded on a single sample is assumed as follows.

$$P^1_{out,1} = P(T^* < LCL|\beta = \beta_1) + P(T^* > UCL|\beta = \beta_1) \quad \ldots\ldots\ldots\ldots \text{(21)}$$

$$P^1_{rep} = P(UCL_2 < T^* < UCL_1|\beta = \beta_0) + P(LCL_1 < T^* < UCL_2|\beta = \beta_0) \quad \ldots\ldots\ldots\ldots \text{(22)}$$

Therefore, the probability of declaring as out-of-control for the shifted process is given as

$$P^1_{out} = \frac{P^1_{out,1}}{1-P^1_{rep}} \quad \ldots\ldots\ldots\ldots\text{(23)}$$

$$\text{ARL}_1 = \frac{1}{P^1_{out}} \quad \ldots\ldots\ldots \text{(24)}$$

We first determine L_1 and L_2 for each of the gamma distribution's various shape parameters so that ARL_0 is close to the specified in-control ARL. The out-of-control ARL (ARL_1) will then be obtained according to multiple shifts in the scale parameter. The control chart coefficient was as estimated L_1 and L_2 [1].

Case study

When we utilized a Gamma control chart to scientifically monitor production during production at the Tasluja cement mill, we collected data for a month of creating cement. Gamma Control Chart was used to track the entire procedure. For the Loss On Ignition (L.O.I) We'll talk about using the proposed Gamma control chart for cement product at Sulaimani's variable factory. (L.O.I) is a test in use in quantitative analytical chemistry and environmental research to determine material and soil chemical structure. It involves rapidly heating (or "igniting") a part of the sample to a preset temperature, enabling volatile chemicals to escape before the sample's mass stops changing. This can be done in the open air or in a reactive or inert environment. A basic test usually involves putting a few grams of the substance in a tared. The Gamma variable of 30 observations is shadowed by the (Loss On Ignition) data. Thesis of collecting data, the production is daily for one line product. Assuming that process has shifted to β_1 = 1.4 β_0 where (c=1.4) for this in-control (L.O.I) data α =5.6554 and β= 0.4749. Let ARL_0= 200, and observations are generated from the gamma distribution. Although proposed (Wilson and Hilferty) that the change of $T^* = \sqrt[3]{T}$ .Is distributed roughly as normal with mean. The data of thirty observations are described in Table 1.

DOI: http://dx.doi.org/10.25098/5.2.18

The Scientific Journal of Cihan University – Sulaimaniya **PP: 49-64**
Volume (5), Issue (2), December 2021
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

Table (1): Shows data from a Gamma distribution with 30 observations applying the transformation **$T^* = \sqrt[3]{T}$**

Design Gamma control chart for Cement data

#No.	T	#No.	T^*
1	1.23	1	1.07144127
2	2.21	2	1.302559062
3	2.8	3	1.409459746
4	3.5	4	1.518294486
5	3.5	5	1.518294486
.	.	.	.
.	.	.	.
.	.	.	.
27	1	27	1
28	1.9	28	1.23856233
29	1.82	29	1.22092915
30	2.2	30	1.300591447

When seeing the Gamma Control Chart, two control charts will appear at the same time. When we look at cement production, we can see that all of the production values are under control. However, several of the numbers in the second chart, particularly UCL_2 and LCL_2, are ready to be. Notify the producer that one of the production's parties will no longer be under their control. It will result in poor output, which will no longer be deemed under control, and poor output will be provided, which is neither the customer's nor the producer's requirement. In addition, the four limits are found by UCL_1= 1.530531, LCL_1= 1.194966, UCL_2= 1.506034 and LCL_2= 1.219462. We planned the changed data $T^* = \sqrt[3]{T}$ on the control chart in Fig (1).

DOI: http://dx.doi.org/10.25098/5.2.18

The Scientific Journal of Cihan University – Sulaimaniya **PP: 49-64**
Volume (5), Issue (2), December 2021
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

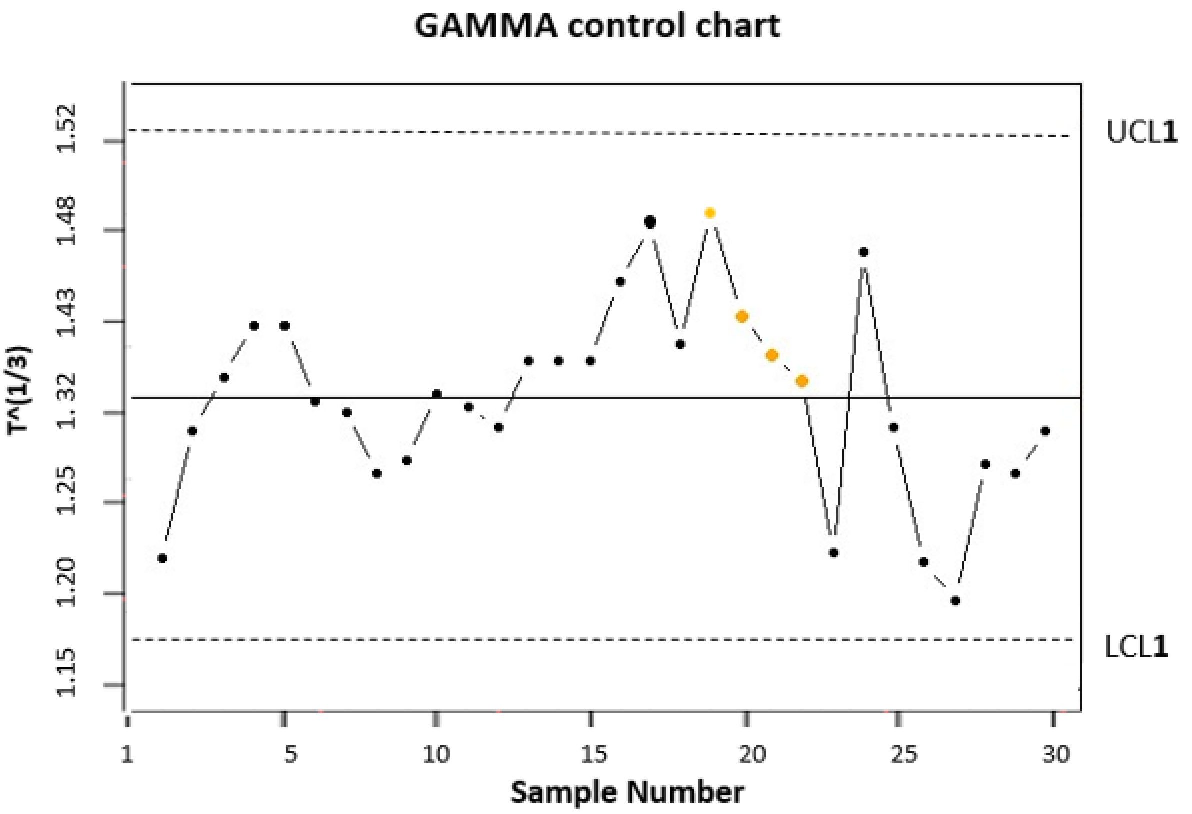

Figure (1): The planned close to the first control chart for cement data

Fig (1) shows the statistic T* designed on the GAMMA control chart. Some beliefs of T* are close to UCL1 and LCL1, and four points are in the boring region. The source of distinction in the procedure would be identified, as shown in fig (1). As shown, the graph of the GAMMA control chart shows that the process is in the public of statistical controller because all the points of the data fall on the upper control limit (UCL_1=1.530) and lower control limit (LCL_1=1.194). When (Mean= 1.363 and variance= 0.0379). This figure shows that all the values of production are under control by the first GAMMA Control chart. However, some points are closed nearly UCL, so we should build a second control chart. The result shows that the progression in the national of statistical control because all the points of the data falls between the upper and lower control limit.

DOI: http://dx.doi.org/10.25098/5.2.18

The Scientific Journal of Cihan University – Sulaimaniya **PP: 49-64**
Volume (5), Issue (2), December 2021
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

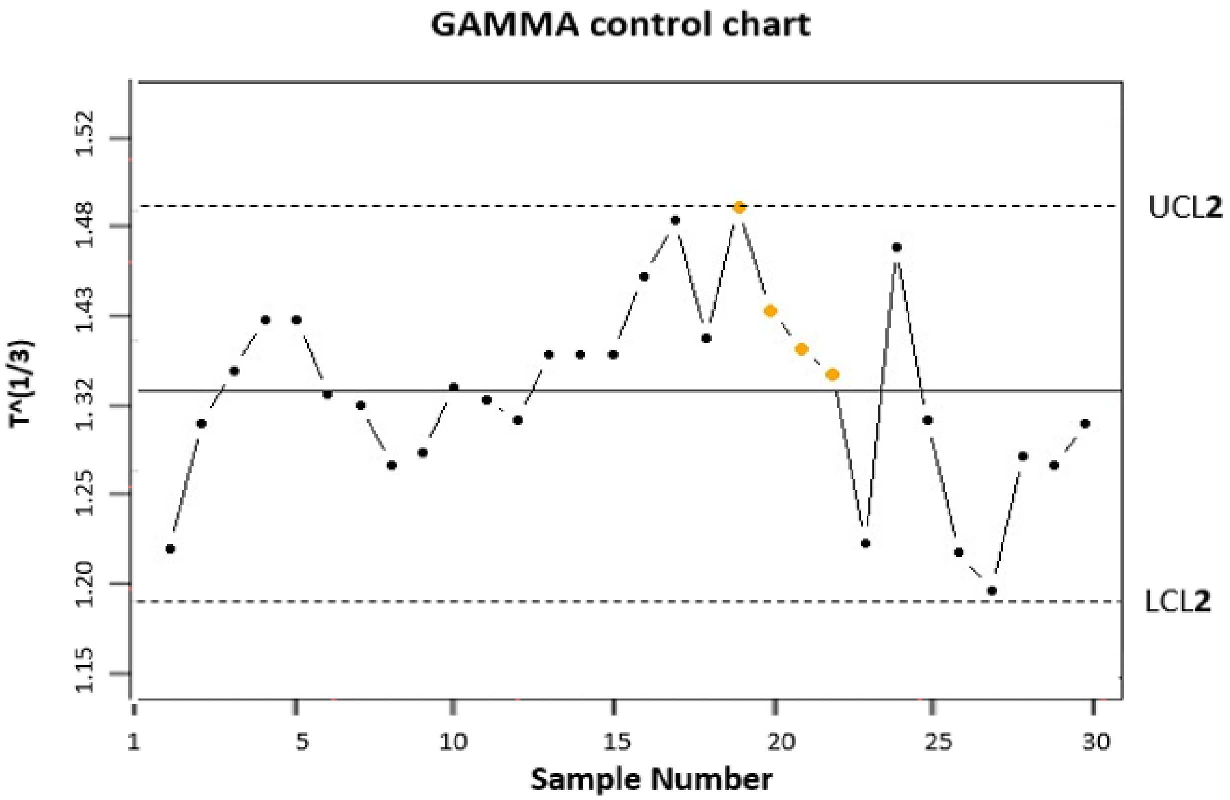

Figure (2): The proposed close to the second control chart for cement data

The statistic T* may be seen shown on the GAMMA control chart in Fig (2), with numerous values around UCL_2 and LCL_2 and three numbers in the repeating area. Fig (2) shows that all values are within control.Nevertheless, some of the points are close to $UCL_{2,}$ especially the 17th, 19th, and 27th, near out of control. As can be seen, the graph of the GAMMA control chart shows that the procedure is under statistical control. because all the points of the data fall on the (UCL_2=1.506) and (LCL_2=1.219). When (Mean= 1.363 and variance= 0.0379). The first GAMMA Control chart is shown to be in control of all output values in this diagram. However, some points are nearly UCL closed. Finally, since all of the data numbers reduction between the upper and lower control limits, the result designates that the procedure is statistically regulated (UCL and LCL).

DOI: http://dx.doi.org/10.25098/5.2.18

The Scientific Journal of Cihan University – Sulaimaniya **PP: 49-64**
Volume (5), Issue (2), December 2021
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

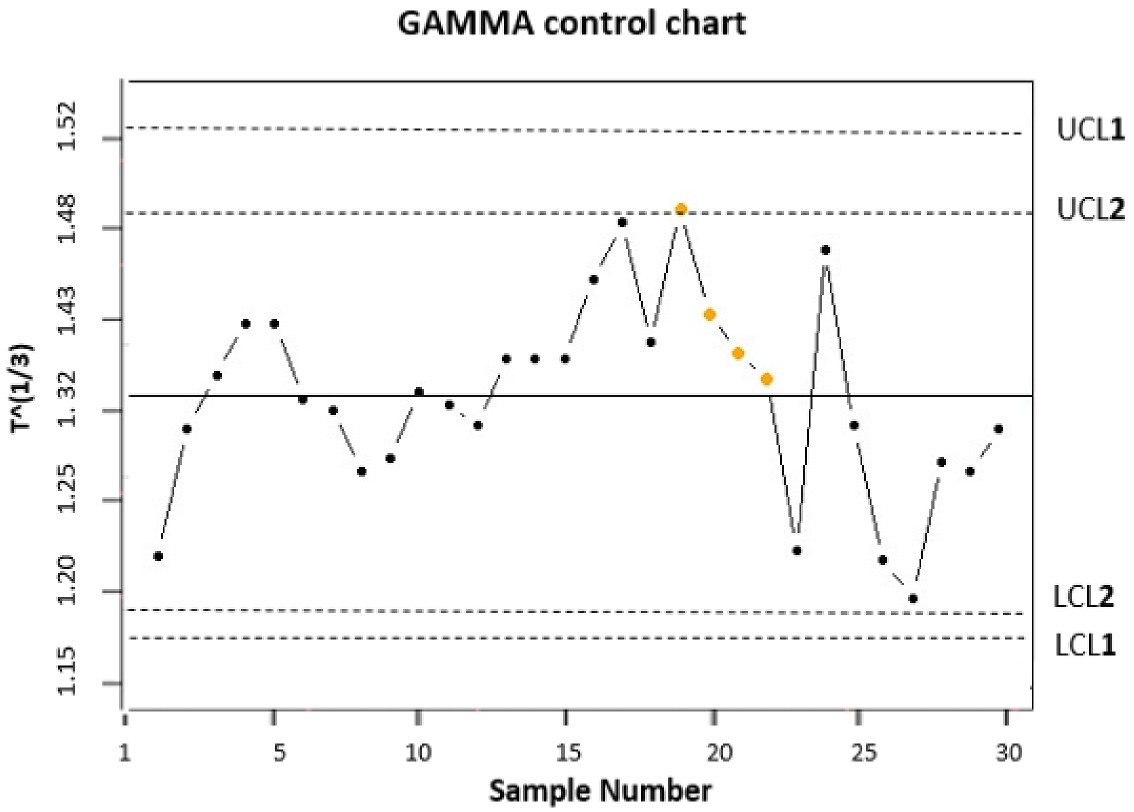

Figure (3): The planned two control chart for cement data

As may be shown in the fig (3),the graph of the GAMMA control chart shows that the procedure is under statistical control. because all the points of the data fall on the upper control limit (UCL) and lower control limit (LCL) in chart two upper control limit and two lower control limit. Also, From fig (3) for cement, the chart is constructed under the normality assumption with upper control limit (UCL_1=1.530) and lower control limit (LCL_1=1.194). Also, The graph for the (GAMMA) chart shows that refer to that all values under control (UCL_2= 1.506) and (LCL_2= 1.219). Nevertheless, some of the points are close to (UCL_2), Specially the point of 17^{th}, 19^{th}, and 27th, somewhat out of control. These parameters were estimated from the data. Of the 30 non-excluded points shown on the charts, three are beyond the control limits on the first chart, while three are beyond the limits on the second chart. As we see, the GAMMA control chart consists of four limit controls in this way LCL_1 and UCL_1. This is the first chart control that is an important part of determining the monitoring limit. The second part of controlling the proximity of values in this border, in addition to LCL_2 and UCL_2, requires the manufacturer to ensure that the entire production process is close to exiting control, requiring it to be more accurate and better need of some production.

Two control charts will appear at the same time when the Gamma Control Chart is shown. When it comes to cement quality, we can observe that all of the manufacturing processes are regulated. However, several of the values for UCL2 and LCL2 are quite comparable to those in the second table.

DOI: http://dx.doi.org/10.25098/5.2.18

Volume (5), Issue (2), December 2021
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

The GAMMA control plan would guarantee that the cement factory's completely manufacturing process is under control, resulting in a satisfactory product that fulfills client needs.

Table 2: The values of ARL_1 for cement data when difference ARL_0

c	$\alpha = 5$	ARL_0=150	$\alpha = 5$	ARL_0=300	$\alpha = 5$	ARL_0=370
	ARL_1		ARL_1		ARL_1	
1.00	150.660		300.93		370.96	
1.01	145.191		265.39		328.76	
1.02	138.570		234.61		292.05	
1.03	126.502		207.89		260.03	
1.04	121.002		184.63		232.03	
1.05	115.824		164.35		207.49	
1.10	94.048		94.78		122.29	
1.15	77.616		57.37		75.47	
1.20	65.004		36.26		48.53	
1.30	47.397		16.27		22.35	
1.40	36.090		8.39		11.67	
1.50	28.470		4.91		6.80	
1.60	23.123		3.22		4.38	
1.70	19.239		2.34		3.09	
1.80	16.334		1.85		2.35	
1.90	14.107		1.56		1.91	
2.00	12.362		1.39		1.63	
2.50	7.481		1.09		1.15	
3.00	5.351		1.03		1.05	

From Tables (2), for almost the same values of c, we see the well and ARL_1 drops as c increases. The suggested control chart under ARL compares favorably to the control chart under addition to performing linear classification. We will use the identical values for the supplied values in both performance measures for a cement compare. The proposed GAMMA chart also considers the parameters of the chart (α and B). The control chart coefficients were L_1 and L_2 as predicted. Calculating correct ARL levels is, once again, a difficult task. As a result, we calculated the ARL values using the R code program. The particular instance of the suggested chart was performed with

DOI: http://dx.doi.org/10.25098/5.2.18

losing generality, and the ARL values of the in-control and out-of-control were computed and summarized.

Again, the in-control ARL values were kept close to (370, 300, and 150), demonstrating the R-code program's precision and legitimacy. As previously stated, the ARL values are used to assess the comparative performance of any chart. The better the chart, the lower the value of the ARL for the shifted process is. Likening these graphs can also be adjudged same quickly that the proposed chart scheme has smaller ARL_1 values for different shifts. For instance the presented graph depicts the out-of-control application's signal for detecting a movement of (1.40), (c=1.40) for (α = 5) in (ARL_1= 11.67). Simultaneously, the same shift is detected with (8.39) samples on the average for the existing chart (ARL_0 =300). For many of the factors in the suggested chart, this very same tendency of decreased ARL_1 numbers can be seen. As a result, the prospective chart can be labeled more critical than the existent chart again here.

Conclusion

In this paper, when we see at the production process, we see that the whole process is under control. However, some values are close to the second monitoring limit. Exceptional Gamma control charts with known parameters shape parameter and scale parameter are proposed founded on the finest self-assurance intermission. When the data or parameters are indefinite values instead of exact or definite values, the design control chart can be used. The actual data is used to explain the capacity of the suggested control chart. We demonstrate that the suggested control chart works better in an unpredictable environment after condensing it with the present control chart. Additionally, our results all point to the control chart, some point near to out-of-control UCL_2 and $LCL_{2,}$ and it is concluded that the GAMMA control chart is more sensitive and effective in detecting. In addition, we can say that the total production of cement in this factory is excellent, and by monitoring the statistical program, they can produce better products. We advise industrial engineers and healthcare providers to use the suggested control chart to monitor data gathering information from a sample or a community with partial data. Finally, future study might use the provided control chart for lifetime data and time between events.

DOI: http://dx.doi.org/10.25098/5.2.18

The Scientific Journal of Cihan University – Sulaimaniya **PP: 49-64**
Volume (5), Issue (2), December 2021
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

Reference

1. Aslam, M., Bantan, R. A., & Khan, N. (2019). Design of a control chart for gamma distributed variables under the indeterminate environment. IEEE Access, 7, 8858-8864.
2. Aslam, M., Khan, N., & Jun, C. H. (2016). A control chart using belief information for a gamma distribution. Operations Research and Decisions, 26(4), 5-19.
3. Demirkol, S. (2008). Comparison of control charts for autocorrelated data (Doctoral dissertation, DEU Fen Bilimleri Enstittist1).
4. John S. Oakland (2008) (Statistical Process Control) PhD, CChem, MRSC, FCQI, FSS, MASQ, FloD Sixth edition , Printed and bound in Great Britain
5. Khan, N., Aslam, M., Ahmad, L., & Jun, C. H. (2017). A control chart for gamma distributed variables using repetitive sampling scheme. Pakistan Journal of Statistics and Operation Research, 47-61.
6. M. Jeya Chandra, (2001) ,(Statistical Quality Control) Library of Congress Cataloging-in-Publication Data, No claim to original U.S. Government works International Standard Book Number 0-8493-2347-9 Printed in the United States of America , Printed on acid-free paper
7. Peihua Qiu, (2014) , (Introduction to Statistical Process Control) ,by Taylor & Francis Group, LLC CRC Press is an imprint of Taylor & Francis Group, an Informa business, International Standard Book Number-13: 978-1-4822-2041-4 (eBook - PDF).
8. Rashid, K. M. J. (2011). Statistical optimization of quality improvement by using TAGUCHI methods with application. P.H.D, dissertation, college of administration and economics, university of SULAIMANI
9. Saghir, A., Ahmad, L., & Aslam, M. (2019). Modified EWMA control chart for transformed gamma data. Communications in Statistics-Simulation and Computation, 1-14.
10. Yang ,K, Basem ,S. El-Haik (2009) (Design for Six Sigma) Second Edition, by McGraw-Hill Companies.

DOI: http://dx.doi.org/10.25098/5.2.18

Appendix

Find Mean and Variance, Upper and lower control limit for the GAMMA control chart.

$\alpha = 5.6554 \qquad \beta = 0.4749$

L_1= 4.427538 $\quad$ L_2= 3.781105

$$\mu_{T^*} = \frac{B^{\frac{1}{3}}\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)} = \frac{(0.4749)^{\frac{1}{3}}\Gamma(5.6554+\frac{1}{3})}{\Gamma(56554)} = 1.362748$$

$$\sigma_{T^*} = \sqrt{\frac{B^{\frac{2}{3}}\Gamma(\alpha+\frac{2}{3})}{\Gamma(\alpha)} - \left(\frac{B^{\frac{1}{3}}\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)}\right)^2} = \left(\frac{(0.4749)^{\frac{2}{3}}\Gamma(5.6554+\frac{2}{3})}{\Gamma(56554)} - \left(\frac{(0.4749)^{\frac{1}{3}}\Gamma(5.6554+\frac{1}{3})}{\Gamma(56554)}\right)^2\right)^{1/2} = 0.03789$$

$$LCL_1 = \mu_{T^*} - L_1\,\sigma_{T^*} = \frac{B^{\frac{1}{3}}\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)} - L_1\sqrt{\frac{B^{\frac{2}{3}}\Gamma(\alpha+\frac{2}{3})}{\Gamma(\alpha)} - \left(\frac{B^{\frac{1}{3}}\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)}\right)^2}$$

= (1.362748) - (4.427538) * (0.03789526) = 1.194966

$$UCL_1 = \mu_{T^*} + L_1\,\sigma_{T^*} = \frac{B^{\frac{1}{3}}\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)} + L_1\sqrt{\frac{B^{\frac{2}{3}}\Gamma(\alpha+\frac{2}{3})}{\Gamma(\alpha)} - \left(\frac{B^{\frac{1}{3}}\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)}\right)^2}$$

= (1.362748) + (4.427538) * (0.03789526) = 1.530531

$$LCL_2 = \mu_{T^*} - L_2\,\sigma_{T^*} = \frac{B^{\frac{1}{3}}\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)} - L_2\sqrt{\frac{B^{\frac{2}{3}}\Gamma(\alpha+\frac{2}{3})}{\Gamma(\alpha)} - \left(\frac{B^{\frac{1}{3}}\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)}\right)^2}$$

= (1.362748) - (3.781105) * (0.03789526) = 1.219462

$$UCL_2 = \mu_{T^*} + L_2\,\sigma_{T^*} = \frac{B^{\frac{1}{3}}\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)} + L_2\sqrt{\frac{B^{\frac{2}{3}}\Gamma(\alpha+\frac{2}{3})}{\Gamma(\alpha)} - \left(\frac{B^{\frac{1}{3}}\Gamma(\alpha+\frac{1}{3})}{\Gamma(\alpha)}\right)^2}$$

= (1.362748) + (3.781105) * (0.03789526) = 1.506034

DOI: http://dx.doi.org/10.25098/5.2.18