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Engineering Quality and Knowledge Systems: An Appraisal for Improving the Spinning Stage

Mohammed A. Ahmed Al-Dujaili

School of Mechanical, Aerospace and Civil Engineering, University of Manchester, Sackville Street, Manchester M13 9PL, UK

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Abstract: The industrial organisations have a vested interest in quality and its practices in making a quantum leap, thereby requiring proper refocusing and rethinking. This is targeted seriously towards firms acquiring Knowledge Systems (KS) in order to nurture the employees' capabilities. Therefore, to enhance performances and their highly creative direction takes consideration of QE (quality engineering) and KS and disciplines complementary to each other. Additionally, the flow of operations and activities of the KS through the application of quality engineering (QE) principles is according to the view of Japanese engineer Taguchi. This aims to achieve good quality in the product design and processes, and also to anticipate problems that may occur before the shipping of the products. In this study, the use of quality control engineering and Taguchi's function methods in determining these properties and the loss caused by the company will be examined. However, the adopted approach of study scope to the society will aid KS. Also, efforts in this direction motivate the employment of a statistical method by Taguchi which relied on the principle of target-oriented quality, representing the value characterising the product quality.

Key words: Quality on statistical control, knowledge systems, control charts, process production capability, Taguchi's function.

1. Introduction

Quality has become a much broader concept. The concept no longer just refers to the high quality of products; it also encompasses quality in terms of service delivery, timeliness, after-sale services, and the production process itself [1]. Deming said that the consumer is the most important part in the production line, and it must be the goal of quality of the consumers' needs of present and future [2].

Generally speaking, this is a new way of thinking: Look at the organisation and how to deal with and to work within it. Quality has come to be seen as a strategic issue [2], which will enable the organisation to meet the manufacturing specifications of global "world-class manufacturing", and to address current and future differentiation in the market. Accordingly, it is very important to continue to learn and develop skills that can enable organisations to grow.

Consequently, workers should be provided with the personal and professional development required in order to raise product quality. Every decision must consider quality in order to enhance growth and ensure the survival of the organisation [3].

In this paper, we analyze the characteristics of the product by using a new programme with the Taguchi loss function. This requires the adoption manner of standard deviation to all of the processes. Additionally, use of the process capability (CP) to form the rate of the spread among the process specifications (the specification width) to the spread of process values equal to 6, as was pointed out in the literature review previously. This is depending on Taguchi's function manners in column formation of multi-levels for the factors affecting the quality of the product. This method is used to measure the financial impact (process deviation) from target value via exhibit,

Corresponding author: Mohammed A. Ahmed Al-Dujaili, assistant professor, Ph.D. student, research fields: quality control, and knowledge systems. E-mail: Mohammed.Al-Dujaili@postgrad.manchester.ac.uk, mhammed aldujaili@yahoo.co.uk.

examining how each non-perfect part is produced leading to the loss of the company. However, the experimental results prove that the Taguchi's function looks at maintenance engineering from a positive standpoint, and clarifies its elevated status as a highly technical, scientific, and complex field, but doesn't use only failure maintenance or lack condition-based maintenance programs. This requires monitoring of indicators of failure continually, such as vibration, temperature, or some other factors before the cessation of machinery from the work, especially if the machines are old and extinct. Machines will have a reduced reliability over time. The paper is organized as follows: Section 2 discusses the statistical quality control; section 3 introduces the KMS implementation and practice with benefiting from QCS application; section 4 is process production capability estimation; section 5 introduces Taguch's method tracking; section 6 methods of Taguch's function calculating; section 7 talks about research methodology; section 8 presents results and discussions; section 9 makes conclusions; section 10 presents the future work.

2. Statistical Quality Control

Statistical quality control defined as concept is used to explain the set of statistical tools which is used by quality professionals, in line with engineers' aspirations that focus on reducing the proportion of defective units and the volume of complaints [4]. In view of that, statistical quality control can be divided into three broad categories [5]:

- Descriptive statistics are used to describe quality characteristics and relationships. Included are statistics such as the mean, standard deviation, the range, and a measure of the distribution of data;
- Statistical Process Control (SPC) involves inspecting a random sample of the output from a process and deciding whether the process is producing products with characteristics that fall within a predetermined range. SPC answers the question of whether the process is functioning properly or not;
- Acceptance sampling is the process of randomly inspecting a sample of goods and deciding whether to accept the entire lot based on the results. Acceptance sampling determines whether a batch of goods should be accepted or rejected.

Subsequently, the tools in each of these categories provide different types of information for use in analysing quality for fault detection in operations of the manufacturing through statistical monitoring and process-controlling charts [6] are as follows:

(1) Control charts for variables: This method collects measurements on large numbers of process variables; multivariate statistical methods for the analysis, monitoring and diagnosis of process-operating performance have received increasing attention. It is an extension to a traditional Shewhart method [7] where, according to Buffa, E. he has said that the process been acceptable at the following limits [8]:

- In the degree of confidence its value (68.3%) becomes the accepted limit (σ + M);
- In the degree of confidence its value (95.45%) becomes the accepted limit (2σ + M);
- In the degree of confidence its value (99.33%) becomes the accepted limit (3σ + M).

Most studies have adopted the degree of confidence (99%) to become the acceptable limit because the chance factors are equal to three standard deviations (3σ).

On this side, there are set from control charts in this scope including [9]:

- Mean chart ($\overline{X}$) and Range chart;
- (δ-chart) Standard deviation chart;
- Standard deviation chart by using of factor (Aσ) and its symbol (δ-chart-A).

Accordingly, the study will use the standard deviation chart (δ-chart). This is because most of the engineering industries are using this chart due to the changes being small in proportion, to limit its disproportion, as well as to a range chart. The steps to both charts are as follows [10]:

Account of an average chart to standard deviation

As seen from the above explaining, the key equation signals can be written as $(j = 1, 2, 3, \ldots, n)$, Eq. (1):

$$\overline{X} = \sum_{i-1}^{n} Xij \ /N \tag{1}$$

where: (N) = the number of readings or observations in each subgroup; (R) = Largest Value; (X) = Smallest Value.

Or: $R = Li - Si$

$$\overline{\overline{X}} = \sum_{i-1}^{n} \overline{X}\, i/K \tag{2}$$

where: $\overline{Xi}$ —the arithmetic average of the observations; $\overline{\overline{X}}$ —average of computational averages; K —the number of sub-groups.

$$U.C.L = \overline{\overline{X}} + 3\alpha/\sqrt{n} \tag{3}$$

where $(U.C.L.)$ represents upper control limit, which is calculated as Eq. (3) above.

$$\alpha = \overline{R}/d_2 \tag{4}$$

where (D_2) represent the size of the impurities, and depends on the basis of the test hours in the day.

$$\overline{R} = \sum_{i-1}^{n} R_i \ /IK \tag{5}$$

$$L.C.L = \overline{\overline{X}} - 3\alpha/\sqrt{n} \tag{6}$$

where: (R_i) is represents the difference between the largest and the lowest value in each sub-group; $(\overline{R})$ the arithmetic average of the range; (K) the number of sub-groups in test.

Accordingly, it can be accounted of a range chart to standard deviation. Eq. (7):

$$UCL = D_4\overline{R}$$
$$CL = \overline{R}$$
$$LCL = D_3\overline{R} \tag{7}$$

where (CL) represents center line for a average chart and range chart; (D_4, D_3) represents Values are fixed in the values table derived according to the number of observations.

(2) Control charts for attributes: Control charts can be used in attribute inspection, where the unit of measurement is a distinct value. Therefore, control charts are concerned with two types of attributes—the percentage defective (P-chart) or the defects per unit (C-chart) [11].

3. KMS Implementation and Practices with Benefiting from QCS Application

In the hunt for inventing administrative processes KMS organisational practices have aimed at acquiring and disseminating knowledge within companies. This is because those practices could be the way to enhance the processes continuously in order to be more active and efficient. For this reason KMS must be formatted in the organisation structure. Moreover, this structure, as in TQM, is quite necessary to be flexible and adaptive rather than rigid, to encourage sharing and cross-pollination of the ideas among all of the employees and divisions of the organisation [12].

Accordingly, V.M. Ribiere, et al., (2004) recommend that TQM practices have to be used during KMS application and practices within organisations for the following reasons [13]:

(1) Both TQM and KMS require a sound training program. That’s particularly relevant when a company wants to become a learning organization;

(2) They are now considered as everyone’s job even if it was not the case when they started (e.g., Quality Control Dept.);

(3) TQM and KMS both may require organizational changes/restructuring;

(4) Both had some Japanese Gurus (Quality: Kaoru Ishikawa, Genichi Taguchi—KMS: Ikujiro Nonaka, Hirotaka Takeuchi). That means must be their focus, transferred to the knowledge for the creating of innovation via learning.

In conclusion, knowledge systems hold opposing views from the traditional systems in a master way.

This is because they have the capability to construe and implement knowledge systems by identifying substantive procedures related to engineering qualities and the extrinsic procedures related to assignment productivity. That means, this both insures enhanced measurement techniques, and ways to convince through knowledge engineering costs and performance parameters, whereas evaluated knowledge systems have to aid in explaining the technical relationships found in the engineering of the knowledge and the engineering of data [14].

By and large, the quality assurance (QA) in the process of KMS development has a big resemblance to the QCS model in programs project management. This is because QCS is considering one of the basic programs which undertakes the efficient program implementation to KMS, aiding accomplishing of the required aim. Additionally, KMS is helping to reduce the programs' development cost, maintenance, and programs' development risk. This could explain how to build the QCS quality and the quality characteristic index of KMS, and documentation specification. This has much potential to guide the development of knowledge system projects to meet specific performance targets over time to the companies [15].

On the other hand, mining data in the QCS is mining knowledge. This is because the data mining utilises search algorithms (patterns, similarities, correlations or text matching). For this reason, data results are visually presented to the user, which is creating better understanding and improved judgments about the manufacturing processes [16].

Therefore, the life cycle of programs' development involves the core standards; feasibility analysis specification (FS), requirements analysis specification (RS), functional specification standard (FSS), user interface specification (UIS), general design specification (GDS), detail design specification (DDS), coding specification (CS), testing specification (TS), database design specification (DBS), user guide specification (UGS), development report specification (DRS) and other specifications towards the knowledge management with knowledge requirements specification (KRS), knowledge modelling specification (KMS), and knowledge base specification (KBS) [15]. The QCS of KMS based on benchmark is explained in Fig. 1.

Fig. 2 explains the relationship model between KMS and TQM. On this premise, it could be inferred that management support processes are accumulated with TQM activities and the companies' lifecycle procedures are composed with the KMS activities. As a result, both companies and support processes exploit techniques of KMS to manoeuvre according to the specification. Tests, checks and management revisions are supporting processes that implement improvement actions to correct or prevent non-conformities as contained in the techniques of KMS. The technique of KMS helps to solve problems with such as brainstorming, communities of practice, face-to-face interaction and training. However many non-conforming products are corrected during the previous stages, the level of the customers' satisfaction has changed the TQM obligations through the system of improvement [17]. Fig. 2 gives structure Model of integrating between KS and TQM.

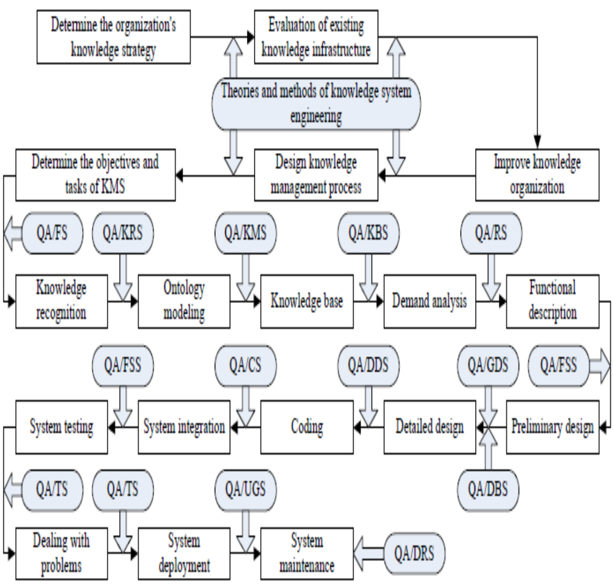


Fig. 1 The QCS of KMS based on benchmark. Source: Ref. [16].

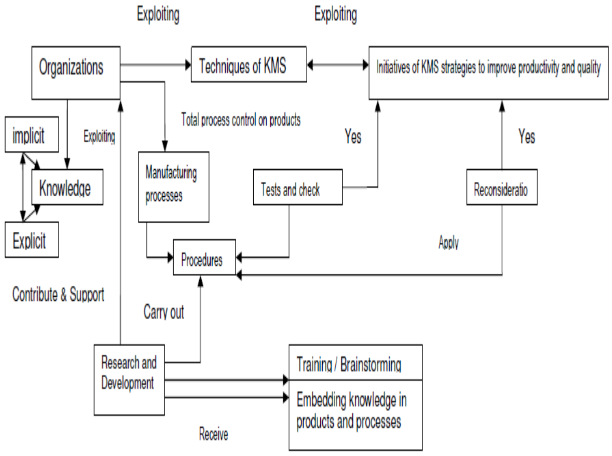


Fig. 2 Structure model of integrating between KS & TQM. Source: Ref. [17].

On this premise, KMS has become an effective tool, and many companies aim to gain competitive advantage via the efficient and effective management of their knowledge assets. Therefore, the companies can create links between two systems, to enable KMS to benefit so much from TQM experiences because of the importance of their common attributes. This is because the individuals encouraged to brainstorm can support the transfer of individual knowledge to organisational knowledge, meet specific performance targets (such as increasing productivity, improving quality) and increase employee satisfaction, development and personal growth [18].

4. Process Production Capability

Process capability compares the output of an in-control process to the specification limits by using capability indices. The comparison is made by forming the ratio of the spread between the process specifications (the specification "width") to the spread of the process values, as measured by six process standard deviation units (the process "width") [19-20].

Accordingly, the process capability index uses both the process variability and the process specifications to determine whether the process is capable. Comparing the output of a stable process with the process specifications enables us to make a statement about how well the process meets those specifications. However, the capable process is one where almost all measurements fall inside the specification limits [21]. Fig. 3 gives process specification limits to the production methods.

However, the capability of the process calculates by using the following Eq. (8) [19, 21].

$$\alpha = \frac{\sqrt{\sum (Xi - \overline{X})^2}}{n - 1} \quad (8)$$

$$\alpha = \frac{\overline{R}}{d_2} \quad (9)$$

where (α) is standard deviation, is extracted from either the mathematical mean or range.

The process capability index (CP) is calculated by Eq. (10):

$$CP_K = \min\left[\frac{\overline{X} - Ls}{3\sigma}, \frac{US - \overline{X}}{3\sigma}\right] \Rightarrow CP = \frac{T}{6\sigma} \quad (10)$$

where: (CP) is process capability ratio; (US) is upper specification; and (LS) is lower specification.

Meanwhile, tolerance (T) can be calculated using Eq. (11).

Tolerance (T)

= upper specification – lower specification (11)

However, if the CP is greater than 1, the process is capable. If the tolerance limits of the process are greater than the actual extent of the outputs, and if CP is less than 1, the process will produce products outside the control limits. An increase in this ratio represents an increase in process capability. Table 1 shows the relationship between the indicator of the process capability and the number of defects per million items.

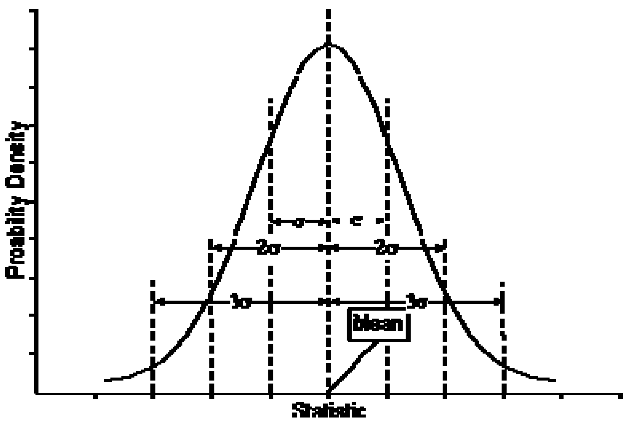


Fig. 3 Process specification limits to the production methods [5].

Table 1 The relationship between the process capability indicator and the number of defects per million [22].

Expansion of tolerance area	Process capability indicator (Expansion of the area of tolerance/ *6ó)*	Number of defects per million items
4	0.67	46000
5	0.83	12000
6	1	3000
7	1.17	500
8	1.33	60
9	1.50	7

Note that the best indicator for production process capability is achieved when the disparity is equal to 8 in standard deviation. This means that the number 1.33 is the best indicator of process capability (CP), because any change or removal in mean will not affect the dispersion of production, which will remain within the limits allowed [22].

5. Taguchi'S Method

Taguchi's function made a start and is increasingly popular as one of the possible methods for developing engineered products. Additionally, there is capacity to deliver products on time, as well as ability to improve the quality of an engineered product via simple changes in the manner by which engineers perform traditional design tasks in harmony with the possibilities of manufacturing in the firms [23].

In accordance with this, Taguchi's method has been defining quality; is it the losses or costs that are carried to society through the product after delivery to the customer [24]? These costs represent the loss of quality, which Taguchi has defined as the loss imposed by the products on society as a result of a deviation of quality characteristics from the target value.

This is represented by the target value of characteristics that specify product quality, when properties achieved are farther from the limited target value which has led to increasing and unwelcome costs. Due to the inability of the production to accomplish the precision requirements for the customer, which represents the loss of quality [25]. Therefore, there are two features to Taguchi's method [26-28].

Quality design: Design patterns encapsulate valuable knowledge to resolve design problems, and more importantly to improve design quality. As this work continues to increase in popularity, a systematic and objective approach to verify the design of a pattern is increasingly important. Because design is taking care of all aspects of the customer's requirements, including cost, production, safe and easy use, and maintainability of products and services, design must take place in all aspects of:

- Identifying the need (including need for change);
- Developing that which satisfies the need;
- Checking the conformance to the need;
- Ensuring that the need is satisfied.

Quality Loss Function: The Quality Loss Function means a financial value of clients' displeasure increasingly from the product performance. This is when products fall below the desired target performance. The Quality Loss Function is a quantitative measure for the success or failure in quality control, and reflects the quality costs for the customer and the society. Where these costs are very low the product becomes of high quality relatively, and increasing by a quadratic function of the deviations from the targets in the case of lower quality products. Fig. 4 explains that.

6. Methods of Taguchi's Function Calculating

Through what has been observed from ideas arising from Taguchi's method of enhancing quality, the quality loss function can be measured, according to an equation of simplified quadratic format, which is as follow [29]:

$$L = D^2 C \quad (12)$$

where ($L = loss$), (D^2) = deviation squared from the largest value, and (C) represents the cost to avoid deviation.

Taguchi's function can also be calculated by the use of Eq. (13) [30]:

$$L(Y) = K(Y - M)^2 \quad (13)$$

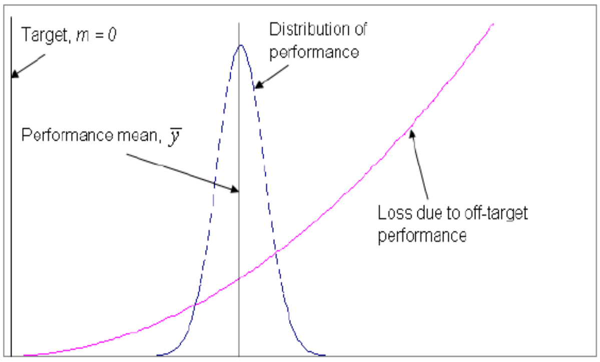


Fig. 4 Quality loss function. Source: Ref. [25].

where: (M) = target value; (Y) = the value of the functional characteristics; and (K) = constant of proportionality and extracts may be found through Eq. (14):

$$K = C / D_2 \qquad (14)$$

where, C represents the loss that associated with the unit one, which was produced at the limits of the specification and assuming that the loss per unit when the target value is equal to zero (the cost of replacement or maintenance), while D_2 represents the distance from the target value for the limits of the specification (dispersion). This means we have calculated the loss for one unit from the product. But if we want what needs to be a comprehensive view of the process, it requires of us to establish a comprehensive evaluation of the outputs of the process, or to look at all of the variance or deviation, the target value, and the formula that can be used in this case is

$$L = K[(\overline{Y} - M)^2 + Q^2] \qquad (15)$$

Where M represents the target value, Y the output average of production process, and Q the standard deviation of the output. K represents the coefficient of the financial fixed, M-Y represents the impact of the process that is not to be according to target-value. Q^2 refers to a variation or difference of the process.

7. Research Methodology

There are two general approaches to research. These approaches are known as inductive research and deductive research. Inductive research is a theory-building process, starting with observations of specific instances and seeking to establish generalisations about the phenomenon under investigation. Deductive research is a theory-testing process that commences with an established theory or generalisation, and seeks to discover whether the theory applies to specific instances [31]. In view of that, this study has used mixed methods to conduct the research [32]. A research model has been developed based on comprehensive literature review. A scheme of this research model is presented in Fig. 5.

The researcher has selected one of the Textile Industries companies in Iraq to be a scope of his study, while in the stages of the spinning. This is because the section considered key stages in which working is harder and operations must be more precise. This includes the demobilisation process for the tape lumbar, draft of the product tape, determination of thread count, and twisting of the thread for the purpose of run in subsequent stages. These processes also involve the addition of a Carboxy of Cellulose Matheal item (CMC) and the starch for the purpose of strengthening the thread before the process of fabric, with a winding process of pirns for use in the fabric in some types of machinery.

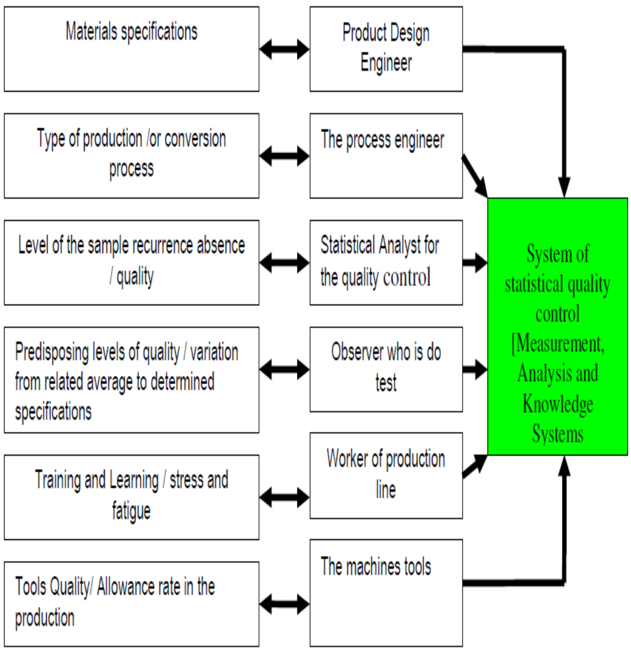


Fig. 5 The basic elements of the suggested QCS.

Most of the engineers have confirmed that most of the production deviations (Evaluator is 90%) are due to defects of the manufacturing in this section. Accordingly, the researcher adopted the method of data collection in this section. The samples were selected from sub-groups randomly and with use of a random numbers method, at regular times through a full month, and by three samples per day in the process of the card and four samples per day for the primary draw, secondary and ten samples per day for the spinning. This means, results constitute a ratio of 19% for the card and 25% for the initial draw and the secondary, and 63% of the yarn. And after drawing the subsamples and identifying them, there were procedures to measure the dimensions and determine the limits of the control for the specification.

Subsequently, the study has used some of the non-parametric methods. These methods rely on a significant fact, and whether the distribution used is normal distribution, whether it was the sample distribution of natural, or if the sample size is large, the approximate distribution will be normal distribution. To ensure the homogeneity of sample, it is drawn from production in the practical side. And do those samples represent a community of the phenomenon under study or not? It was used by the following two tests:

(1) Bartlett's test: It is used to check the homogeneity of variances of the drawn samples, and the standard test of the hypothesis is [33]

$$X^2 = \frac{C_1}{C_2} = X^2{}_{(K-1)} \tag{16}$$

Where $H_0 \Rightarrow$ means that the subsamples drawn of community is variance it σ^2, $H_1 \Rightarrow$ means that the subsamples drawn from communities are different from the variance.

Accordingly, the formula for the test, as in Eqs. (17)-(18):

$$C_1 = \sum_{1-1}^{k}(n_i - 1)Log_e \frac{S_2}{S_i^2}, S_2 = \frac{\sum_{i-1}^{k}(n_i - 1)S_i^2}{\sum_{i-1}^{k}(n_i - 1)} \tag{17}$$

$$C_2 = 1 + \frac{1}{3(K-1)}\left[\sum_{i=1}^{k}\frac{1}{n_i - 1} - \frac{1}{\sum_{i=1}^{k}(n_i - 1)}\right] \tag{18}$$

The study is an accepted hypothesis (H_0) when the value of X^2 is extracted < tabular value when the level of moral is (α).

In this case, consider if variance are the homogeneous samples.

Otherwise reject the null hypothesis (H_0). In this case, the data is not homogeneous.

(2) Goodness of fit test: This test can calculate the cumulative distribution function to data that is binned. However, the value of the chi-square test statistic is dependent on how the data is binned. Another disadvantage of the chi-square test is that it requires a sufficient sample size in order for the chi-square approximation to be valid. And the steps to this test are as follows [34]:

(1) The hypothesis determines what is required of test (H_0) and the alternative hypothesis as follows:

- The variable under study has a limited distribution (H_0);
- The variable under study has no specific distribution (H_1).

(2) Determine the level of moral (α) and then calculate the test, symbolised by the symbol according to the Eq. (19):

$$X^2 = \sum \frac{(O_i - E_i)^2}{E_i} \tag{19}$$

where E_i and O_i represent the frequency of the scenes in the sample, and the frequency distribution expected under the hypothesis specified in H_0, respectively. The Ei-npi depending on *n* represents the size of the sample (pi), which represents the relative frequency (probability) that we get it by using the specific distribution of the hypothesis (H_0) required in testing.

(3) Determine the rejection region on the basis of value (ά), and the use of the Chi-square distribution with degrees of freedom equal to K-1, where K represents variable values under the study.

(4) Decision-making with respect to the hypothesis where accepting H_0 when giving values of X^2 extracted < its tabular value at the amoral level ά.

8. Results and Discussion

The researcher has tabulated data for a sample study, according to the sequence of samples from the first day and until the thirtieth of the month, and with the number of 3 samples per day to be 90, and 4 samples for some tests in order to be 120 samples, and 10 samples to be 100 samples for testing the latter. This was in spinning, and the results were as follows:

8.1 Count of Card Ribbon Magnitude

The class consists 20% polyester and is added to 80% cotton and the magnitude required is 30 Tex, (one of the metric systems of numbering of threads, yarns and ribbons) and magnitude of thread is based on system (text). It has a weight (in grams) for the fixed length of 1000 M. At this stage, the process of demobilisation, hairs of cotton fibre textile are arranged parallel to each other as much as possible so that eventually they lie in the form of card ribbon via a carding machine. Table 2 shows the readings.

Prior to the account of these readings, there was testing of the homogeneity of the samples' variances and using the Bartlett test in Eq. (16). This found that the value (X^2) was elicited equal to 30.6300, less than the tabular value that is equal (X^2 0.05, 29 = 52.3356). That means the acceptance of the hypothesis H_0. In other words, the 30 samples have been drawn of the community variances (σ^2), i.e., the variations were homogeneous, giving S^2. It is a good estimate of the variation of this community (σ^2).

As for the Goodness of Fit Test in Eq. (19), it has found that the value of a standard test with degree of freedom (K-1 = 29) and with moral level (0.05) it was 2.964, less than the tabular value ($X^2_{0.05,\,29}$ = 42.556). This means acceptance of the hypothesis (H_0). In other words, the sample was selected of the phenomenon community under study.

Table 2 The readings to the card ribbon magnitude.

Sample	X1	X2	X3	$\overline{X}$	Ri
1	3.63	3.61	3.42	3.46	0.27
2	3.37	3.48	3.29	3.38	0.19
2	3.40	3.32	3.49	3.40	0.17
4	3.32	3.38	3.43	3.37	0.11
5	3.51	3.31	3.47	3.43	0.20
6	3.49	3.33	3.52	3.44	0.19
7	3.25	3.32	3.39	3.32	0.14
8	3.42	3.37	3.39	3.39	0.05
9	3.49	3.37	3.28	3.38	0.21
10	3.38	3.22	3.41	3.33	0.19
11	3.31	3.20	3.47	3.35	0.18
12	3.49	3.52	3.30	3.43	0.22
13	3.32	3.27	3.39	3.32	0.12
14	3.37	3.50	3.32	3.43	0.18
15	3.32	3.29	3.41	3.34	0.12
16	3.48	3.51	3.49	3.49	0.30
17	3.35	3.60	3.51	3.48	0.25
18	3.82	3.80	3.61	3.44	0.21
19	3.28	3.49	3.41	3.39	0.21
20	3.38	3.39	3.30	3.35	0.09
21	3.32	3.47	3.50	3.43	0.18
22	3.63	3.68	3.41	3.51	0.27
23	3.52	3.31	3.39	3.40	0.21
24	3.38	3.41	3.38	3.39	0.04
25	3.62	3.52	3.22	3.45	0.34
26	3.59	3.66	3.49	3.51	0.07
27	3.52	3.60	3.61	3.51	0.09
28	3.38	3.34	3.40	3.37	0.06
29	3.28	3.27	3.48	3.34	0.21
30	3.41	3.32	3.70	3.47	0.34
∑				102.73	5.56

According to Table 2 for readings of the card ribbon magnitude, this allows for two charts: δ-chart and R-chart as follows:

$$R = 0.19, \quad d_2 = 1.69, \quad \sigma = 0.11, \quad \overline{\overline{X}} = 3.42$$

$$U.C.L = 3.61 \qquad L.C.L = 3.23$$

$$D_4 = 2.57, \quad D_3 = 0, \quad \overline{R} = 0.19$$

$$U.C.L = 0.49 \qquad L.C.L = 0$$

Fig. 6a explains the standard deviation chart, and Fig. 6b the Range-chart. It demonstrates that all the points

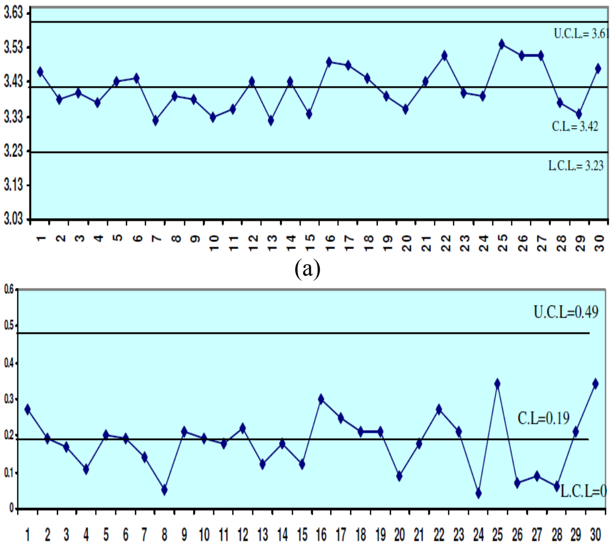


Fig. 6 (a) Chart of average for the card ribbon magnitude; (b) Chart of range for the card ribbon magnitude.

Table 3 Results from improved acquisition.

Class table	Frequency	Center class
3.20-	6	3.24
3.28-	21	3.33
3.37-	26	3.42
3.46-	23	3.51
3.55-	9	3.60
3.64	3	3.69
3.73-3.82	2	3.78
∑	90	

fall within the limits of control and this means that the process is under the influence of factors of sudden, unexpected and uncontrollable. Therefore, we will account process capability in terms of range and with informatics.

$$D_2 = 1.69$$
$$CP = T / 66 = 3.55$$
$$CP = 0.74$$

This reinforces the above analysis, where CP < 1. Hence, this is requiring action to improve the situation of the machine or production line within the division as well as product inspection fully (100%). It will be helpful to use the histogram, as of Table 3, where explains this in centres classes, and frequencies.

Fig. 7 explains that the average and the range in the process is acceptable, but the production process average has deflected to the left. This confirms that the

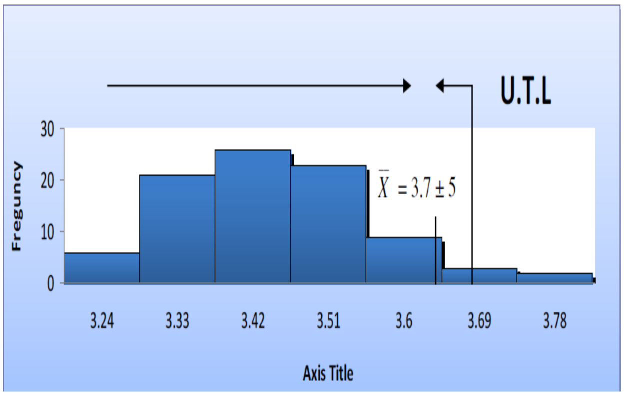


Fig. 7 Histogram of card ribbon magnitude.

process will be outside the limits of statistical control in the future. This also requires the examination of the final product to be comprehensive. The reason is that the process is undergoing sudden factors at this stage, yet there are many factors that have little effect on production.

Accordingly, there will be account of loss of function at this stage, an account of cost deviation, according to the following formula:

$$L = D^2 C = 36.3DI \quad (20)$$

This means that quality loss per unit has cost the organisation 36.3 dinars.

The loss function can be calculated according to Eq. (21):

$$L(Y) = K(Y - M)^2 \quad (21)$$

With informatics (K = 1079.4) amounting to a process loss of 61.7 dinars per unit.

Then we can calculate the loss function after taking into consideration the target value and the variance (deviation) according to Eq. (22):

$$L = [(Y - M)^2 + Q^2] \quad (22)$$

where the loss amounting for the process in this stage is 55.5 dinars per unit, which is displayed in Fig. 8.

This means that the company's loss per unit is 61.7 dinars, and there is also a loss to the society by moving away from the target value and amounting to 155.5 dinars. This requires the reduction of deviation as explained in Fig. 4 according to Taguchi's function. To

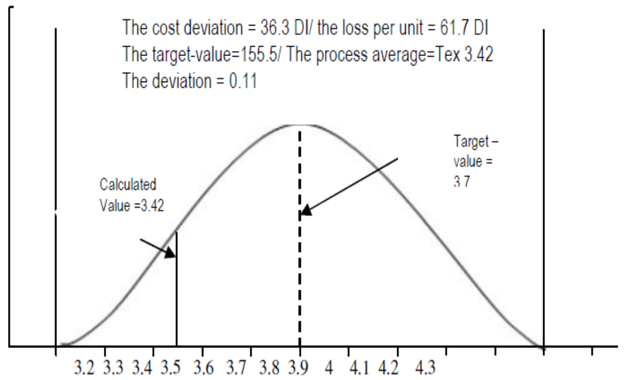


Fig. 8 Quality loss function to card ribbon by magnitude (Tex 30).

be within the target value requires that the manufacturing process average is equal to 3.70, or the value is according to Eq. (22):

$$L = 1079.4(3.70 - 3.70)^2 = 0$$

This means that the average of process ($\overline{\overline{X}}$) must be equal to the target value; this is because it leads to the process loss being equal to zero. Fig. 9 explains that.

8.2 Account of the Draw Ribbon Magnitude

The class produced within this stage includes 20% Viscose Fibres, added to 80% Cotton and the magnitude required is 30 Tex, the standard required 3.7, and the ratio permitted: T = ± 0.5. At this stage a draw process makes the product ribbon. For the purpose, fibres are parallel to each other in order to set up conduct with stages of the other yarn, cascading via the machines of drawing. Where is called this process with the drafting system and ligament of stomping in fabric. Table 4 explains the results of examination of samples.

Prior to the accounting of these readings there was testing of homogeneity of the samples' variances using the Bartlett test in Eq. (16). Where has found that the value (X^2) is elicited equal to 41.3888, it is less than the tabular value ($X^2_{0.05}$, 29 = 52.3356). That means the acceptance of the hypothesis H_0. In other words, the 30 samples have been drawn from the community of variances (σ^2).

As for the Goodness of Fit Test in Eq. (19), it found that the calculated value was 3.04029, and of less than the tabular value (X20.05, 29 = 42.556). This means

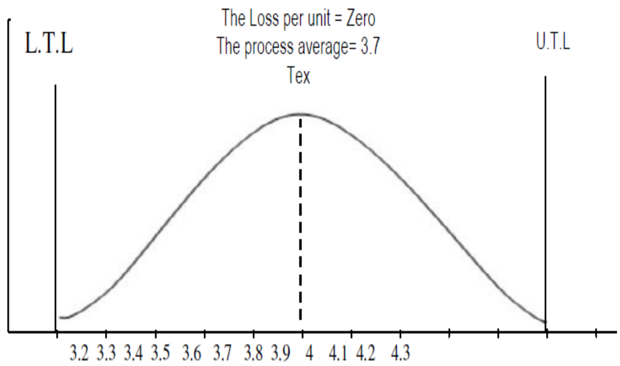


Fig. 9 The target value to the card magnitude.

Table 4 Readings of the drawing ribbon magnitude.

Sample	X1	X2	X3	X4	$\overline{Xi}$	Ri
1	3.70	3.72	3.65	3.67	3.68	0.07
2	3.72	3.71	3.68	3.68	3.69	0.04
2	3.68	3.66	3.60	3.63	3.65	0.05
4	3.63	3.65	3.62	3.67	3.64	0.03
5	3.70	3.69	3.72	3.71	3.70	0.03
6	3.68	3.66	3.64	3.69	3.66	0.05
7	3.68	3.70	3.67	3.70	3.69	0.03
8	3.68	3.70	3.61	3.63	3.64	0.07
9	3.68	3.65	3.71	3.11	3.71	0.1
10	3.71	3.68	3.66	3.69	3.68	0.05
11	3.72	3.70	3.69	3.67	3.69	0.05
12	3.68	3.69	3.70	3.68	3.68	0.02
13	3.70	3.75	3.69	3.74	3.70	0.05
14	3.72	3.65	3.62	3.64	3.66	0.1
15	3.67	3.69	3.65	3.69	3.67	0.04
16	3.60	3.61	3.70	3.65	3.62	0.05
17	3.72	3.71	3.69	3.69	3.70	0.03
18	3.60	3.78	3.71	3.64	3.69	0.17
19	3.71	3.72	3.16	3.63	3.61	0.17
20	3.65	3.62	3.23	3.72	3.65	0.17
21	3.62	3.61	3.66	3.65	3.61	0.05
22	3.69	3.69	3.75	3.65	3.70	0.1
23	3.60	3.62	3.64	3.62	3.62	0.04
24	3.63	3.61	3.67	3.62	3.63	0.06
25	3.77	3.74	3.60	3.61	3.68	0.17
26	3.67	3.63	3.74	3.71	3.68	0.11
27	3.64	3.69	3.69	3.68	3.67	0.15
28	3.60	3.61	3.63	3.66	3.62	0.01
29	3.61	3.68	3.64	3.60	3.63	0.08
30	3.79	3.78	3.70	3.71	3.70	0.08
∑					109.93	2.89

that the samples that were used in assessing the production of this station have been withdrawn from the society under study.

According to Table 4 for readings of the draw ribbon magnitude, two charts (δ-chart and R-chart) were calculated as follows:

Calculation of Standard Deviation chart

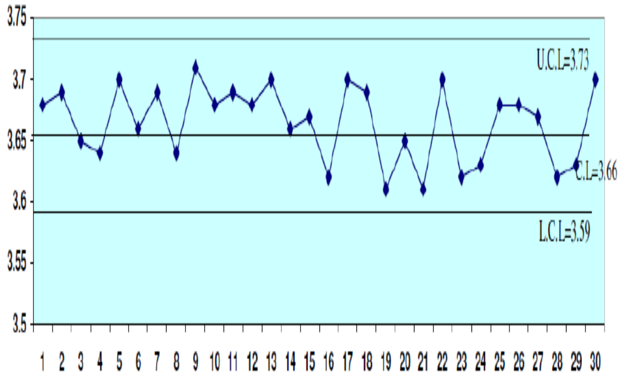
$R = 0.096$, $D_2 = 2.06$, $\alpha = 0.047$, $\overline{\overline{X}} = 3.66$, $UCL = 3.73$, $CL = 3.66$, $LCL = 3.59$, while the calculation of range chart $CL = (\overline{R}) = 0.96$, $D_4 = 2.283$, $D_3 = 0$, $UCL = 0.22, LCL = 0$

Fig. 10a explains the average of the manufacturing process, and Fig. 10b the Range chart, which explains dispersion in the manufacturing process. We can observe that the all of points fall within the limits of control. But there is big dispersion in the process, where we can see that most of the points in the range chart are far away from the central line. This means that the process is under the influence of sudden, unexpected, and uncontrollable factors. Therefore, we will account process capability in terms of range and with informatics (R = 0.096, D_2 = 2.06, and CP = 1.79).

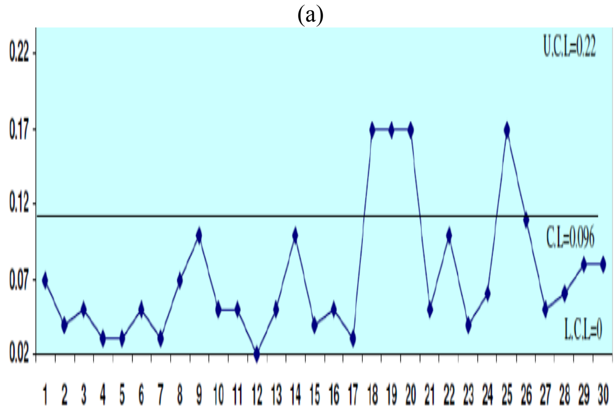
This requires of the plant the test within the limits of the specification or production process or both to reduce production costs. There is not a need for such high accuracy because 1.33 < CP. Where 1.33 it represents the best indicator of the ability of the process that can be achieved, when the disparity is equal to 8 deviations. This is because any change or displacement, on average, will not affect the dispersion as that production will remain within the limits of disparity to the determined standard (CP = 8σ/6σ = 1.33). For more information on the behaviour of the manufacturing process and to confirm its situation accurately, it will be helpful to use the histogram, as of Table 5.

Table 5 above explains this in classes, centres, and frequencies, and we can draw a histogram of the variation in the average displacement process and the dispersion, shown by Fig. 11.

Fig. 11 explains the average chart and the extent of the manufacturing process to be acceptable to some extent. But we can observe that the average of the production process has displaced towards the left. This shows at Table 5 that 96 sample from origin (120), or proportion (85%) is lower than that of specification. This is caused by the large dispersion in the production process, specifically in the extent chart, but this dispersion will not affect the production process where the process remains within the standardised specification limits and its value (1.33).



(a)



(b)

Fig. 10 (a) Chart of averages to the drawn ribbon; (b) Chart of averages to the drawn ribbon.

Table 5 The details of the drawn ribbon magnitude.

Class table	frequency	Center class
3.16 -	1	3.20
3.23-	1	3.27
3.31-	zero	3.35
3.39-	zero	3.43
3.47-	9	3.51
3.55-	3	3.59
3.63	69	3.67
3.71-3.79	28	3.75
$\sum$	120	

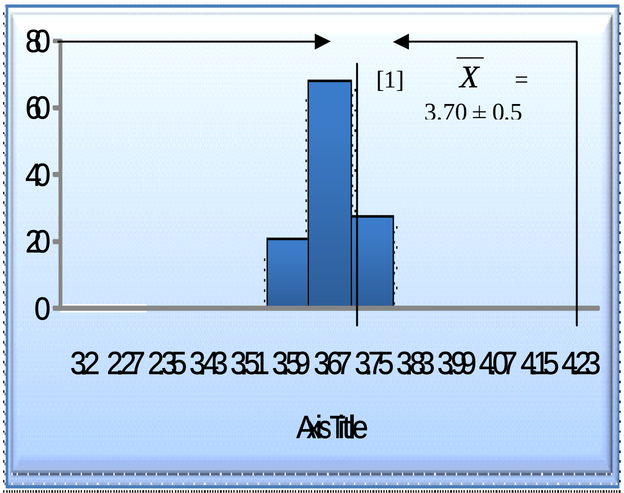


Fig. 11 The histogram of the drawn ribbon magnitude.

Based on the analysis above there can be calculation of function of loss in this stage if there has been deviation in cost (6.4 DI), according to Eq. (20).

This means that the quality loss per unit is causing loss to the organisation amounting to 6.4 dinars. In this situation, the costs have been less than compared to the previous phase, and when was calculated the loss function according to Eq. (21).

With informatics (K = 1404.9) this amounted to a process loss of 0.14. This confirms our previous analysis, when CP was calculated. It emphasises the need to check the limits of the specification or production process, or both together, for the purpose of reducing the costs of production, which is not required to be of very high precision, and this was confirmed by loss of function of the process, amounted to 0.14 dinars.

Based on this there will be an account of loss of function after taking into consideration the target value, and variation according to Eq. (21).

This gives a process loss of 5.35 dinars. This shows the costs being very low, and this is another proof of the quality of the process and production inside the station. The loss function can be illustrated in Fig. 12.

This indicates that the organisation's loss per unit is equal to 0.14 dinars, i.e., the process is very good and the loss to community is 5.35 dinars, a low value as well. Therefore, the organisation is done for the purpose of reducing the deviation, which is displayed

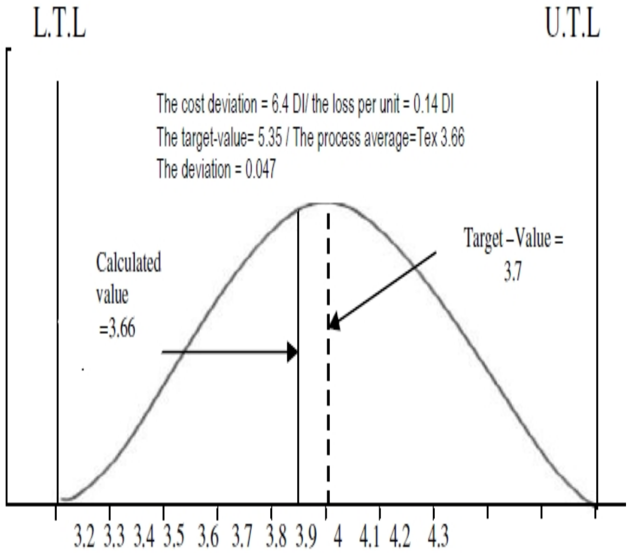


Fig. 12 Quality loss function to drawn ribbon by magnitude (Tex 30).

in Fig. 11, according to a Taguchi loss function, so as to become within the limits of the target value and make the manufacturing process average 3.7, whereby the value is shown according to Eq. (22).

$$L = 1404.9(3.70 - 3.70)^2 = 0$$

This means that the process average (X) must be equal to the target value because it makes the process loss equal to zero. Fig. 13 illustrates this.

8.3 Account of the Magnitude to the Machine Thread/Open Engine

The product is blended with 20% Viscose Fibres and added to 80% Cotton and the magnitude required is 30 Tex, the standard required 30 Tex, and with a permissible ratio of T= ± 0.5. The goal of this process is to convert the filaments and textile fibres into threads suitable for the various textile processes. The thread count is a system that reflects the longitudinal density of thread (thread length *x* weight unit or weight of thread in the unit of length). Where is producing of thread on one of the types of textile machinery, it is called open-end yarn. In this stage, the threads rotating on a beam for the use of certain textile machinery are Jpeixaria. Table 6 explains the results of the examination of samples.

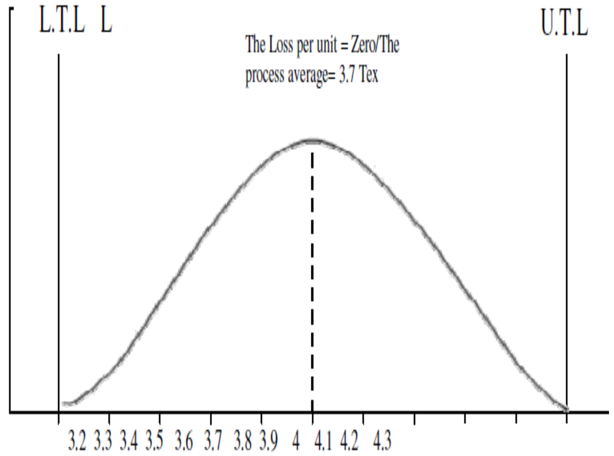


Fig. 13 The Target value for the drawn ribbon magnitude.

Table 6 Readings to the thread count for the machinery/open engine.

Sample	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	Xi	Ri
1	30.4	29.4	29.8	31.0	30.2	30.6	29.9	29.4	30.5	29.8	30.1	1.6
2	29.9	30.2	29.0	30.3	26.7	29.8	30.5	30.9	30.1	29.9	29.6	4.2
3	30.6	28.8	29.9	29.4	29.8	25.3	30.6	30.3	29.4	29.9	29.4	5.3
4	28.9	27.4	29.3	29.9	30.4	30.2	31.2	29.4	30.5	31.0	29.8	4.3
5	29.0	29.9	29.3	30.3	30.3	31.0	32.0	29.9	29.5	30.6	30.2	3.1
6	30.6	31.1	30.3	29.4	29.9	29.5	30.0	30.3	32.0	30.1	30.2	2.6
7	29.9	29.1	30.5	31.0	30.3	29.9	29.5	29.5	29.5	30.6	30.0	1.5
8	30.3	31.1	31.5	29.9	29.8	32.0	31.6	30.7	29.7	29.8	30.6	2.3
9	29.9	29.9	28.7	29.1	30.4	31.0	31.2	31.4	29.7	29.5	29.9	2.7
10	29.4	30.6	29.2	30.2	29.0	30.0	29.5	29.4	30.6	30.7	30.1	2.0
Σ											299.9	30.5

A Bartlett test in Eq. (16) measured the samples homogeneity finding the value (X^2) to be equal to 11.1639, less than the tabular value ($X^2_{0.05,\ 9}$ = 23.5893). That means acceptance of the hypothesis H_0. In other words, the 30 samples have been drawn from community variance (σ^2).

The Goodness of Fit Test depends on the distribution of Chi Square. It has found that the calculated value was 5.989 according to Eq. (19), and is less than the tabular value ($X^2_{0.05,\ 9} = 16.919$).

These are based on the physicist's lab results for the samples specified by test results of the thread count, according to Table 6, where *xi* = 299.9 and *Ri* = 30.8. Therefore, we can calculate two charts (δ-chart and R-chart) as follows:

(ς -chart) $X = 29.99$ Tex, $\alpha = 1.01$, $D^2 = 3.08$, $R = 3.1$, $UCL = 31.0$ Tex, $CL = 29.99$, $LCL = 29.0$ Tex.

$(R - chart)$, $D_4 = 1.777$, $D_3 = 0.223$, $R = 3.1$, $UCL = 5.5$, $LCL = 0.7$.

The standard deviation average in Fig. 14a has highlighted that the average of the process for the calculated standard was 29.99 Tex to the machinery thread for the type of open engine. Where the points centred around the average line of the manufacturing process, and the extent in Fig. 14b confirms this point.

Also note that the process dispersion is very large. This confirms the previous analysis that the manufacturing operations within the plant are largely experiencing sudden factors, and a large number of action factors, which are, for each of them, of little effect in the production process. Subsequently, this is where the factors occur out of the limits of the possibility of control by the company, but the company is trying to reduce the impact of these factors through strict quality control measures.

And so we can calculate the capability of the process (CP) with informatics: R = 3.1, D_2 = 3.08 and it was found that CP = 0.1. In this case, necessary measures must be taken to improve the situation of the machines in the plant or production line with a full inspection and by a rate of 100% to the production batch. This is because it contains large amounts of the damaged products.

To be sure of the safety of production in a batch, precisely and more broadly, we will calculate the average centre of the specification of the production process and the magnitude of its dispersion through the use of a histogram, as in Table 7.

Table 7 has clarified to us the specification centre and the frequencies, which are the basis for the drawing of the histogram diagram for the purpose of displaying the amount of the displacement in the production process, by average and the dispersion, as shown in Fig. 13.

Fig. 15 highlights to us that the dispersion of the process and its average have been little dislodged around the upper limit of variation, but there was no proportion from the products falling outside the control

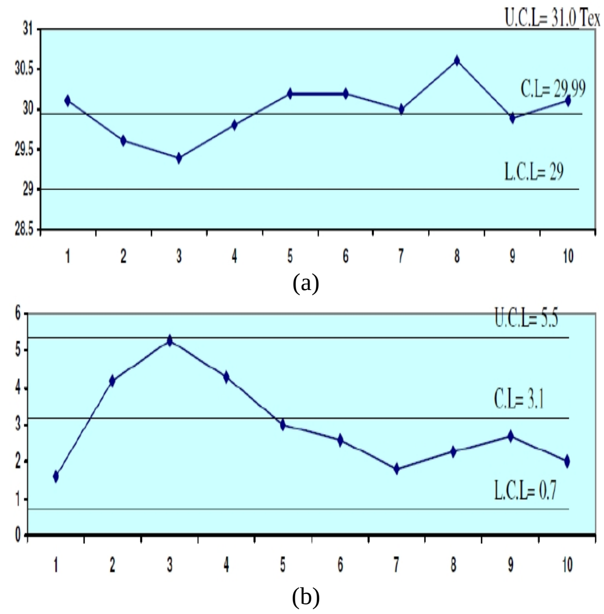


Fig. 14 (a) The average for the machine thread count/open-engine; (b) The range for the machine thread count/open-engine.

Table 7 The frequency distributions for the machinery thread count/open-engine.

Class table	Frequency	Center class
-25.3-	1	25.8
-6.3-	2	26.8
-7.3	1	27.8
28.3-	9	28.8
29.3-	47	29.8
30.3	34	30.8
31.3-32.3	6	31.8
∑	100	

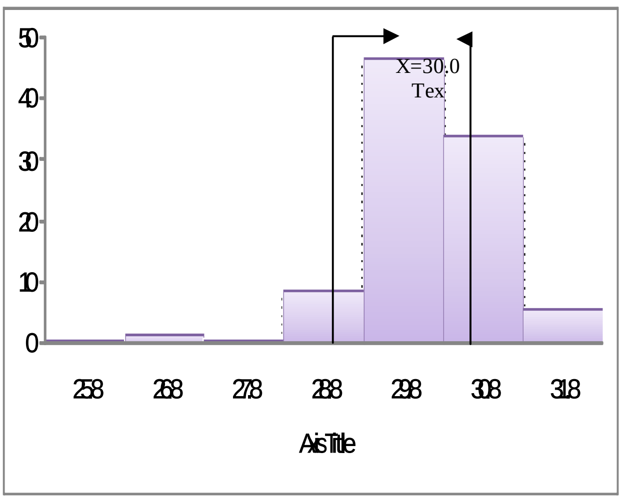


Fig. 15 The histogram to the machine thread count/ open engine.

limits. However, the continuation of the process average with displacement towards the right side of the histogram will lead a proportion of the products outside the upper limit to be allowed variation in the future. This is required to stop the displacement and try to control or reduce the random factors that affect the manufacturing process to ensure production according to what is targeted in the specification.

Therefore, in order to identify the extent of the losses incurred by the organisation and the community with informatics of C = 2894 dinars. We can identify the cost deflection is equal (2952.169 DI) in accordance with Eq. (20).

This means that the quality loss per unit incurred by the organization is 2952.169 dinars, and the loss function of the process can be calculated according to Eq. (21), and with informatics of K = 940DI where the loss amounted was 958.988 dinars per unit and can be illustrated in Fig. 16.

In Fig. 16, it is seen that mean the process is not within the specifications, this is because it is far of the median value (30 Tex).

The calculations above and Fig. 14 show to us that the organisation of the study subject would be in high loss in this station, which is amounting to deflection cost (2952.169 DI). The loss of the operation was very low, amounting to 0.094 dinars per unit. Additionally,

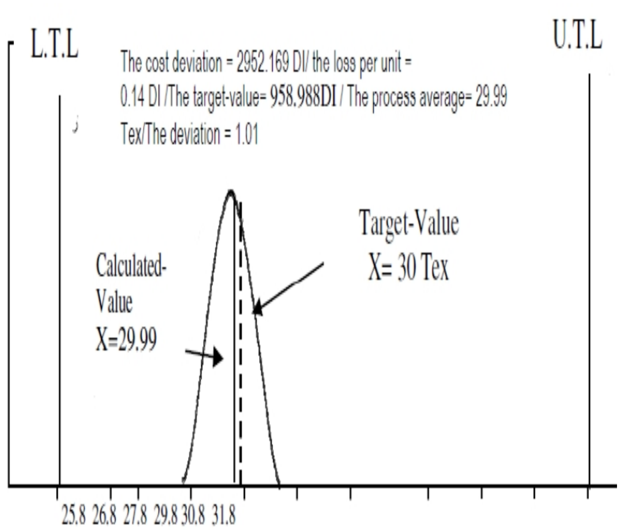


Fig. 16 The quality loss function for the machinery thread count/open engine.

the long-term loss for the manufacturing process due to a move away from the target value (which amounted to 953.988 dinars) will affect the reputation of the company and its customers as well as the community finally. Therefore, this requires the company to approach the determined specification, from the study subject, which is 30 Tex. This can be illustrated in Fig. 15 according to Taguchi's equation so that results stand within the target value according to Eq. (22). The target value is equal (0).

This means that the process average (X) is equal to target value, making the company avoid the loss incurred by society and itself. Fig. 17 illustrates the process.

9. Conclusions

The big development in mechanical-design software during the past decade has permanently changed the manufacturing industry. One of these developments is design engineering that has taken a new programme with the Taguchi loss function. This invites us to focus on the quality of the product-manufacturing operations that lead to the integration of check processes for enhancing productivity during research and development so that high-quality products can be developed and produced quickly and at low cost. Also this allows for premature product exploration of interference between components enabling quick design iterations that result in product optimisation.

However, this requires the adoption manner of standard deviation to all of the processes. Additionally, use of the process capability (CP) to form the rate of the spread among the process specifications (the specification width) to the spread of process values equal to 6 α, as was pointed out in the literature review previously. This is depending on Taguchi's function manners in column formation of multi-levels for the factors affecting the quality of the product. This method is used to measure the financial impact (process deviation) from target value via exhibit, examining how each non-perfect part is produced leading to the loss of the company.

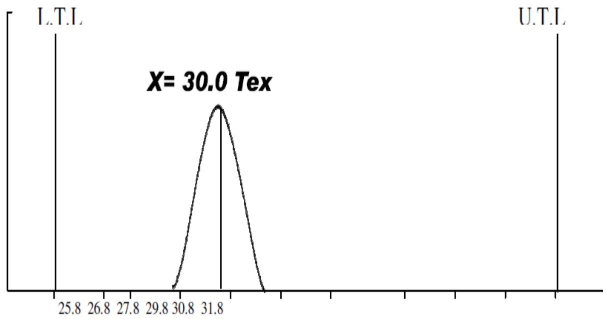


Fig. 17 The target value for the machinery thread count/open engine.

Ultimately, Taguchi's function looks at maintenance engineering from a positive standpoint, and clarifies its elevated status as a highly technical, scientific, and complex field, but doesn't use only failure maintenance or lack condition-based maintenance programs. This requires monitoring of indicators of failure continually, such as vibration, temperature, or some other factors before the cessation of machinery from the work, especially if the machines are old and extinct. Machines will have a reduced reliability over time.

10. Further Work

The research has used methods of quality control in general and Taguchi's function in particular, for the purpose of improving the quality of production in the companies studied through the application of standard deviation (S-chart) and the quality loss function (R-Chart). In conclusion, more research should be conducted on selecting the appropriate target-mean ratio for different types of quality characteristics. This requirement does not use only failure maintenance or absence in condition-based maintenance programs.

However, this requires monitoring of indicators of failure continually, such as vibration, temperature, or some other factors before the cessation of machinery from the work especially if the machines are old and extinct. In this case, the machines will have a reduced reliability over time that means; creating a mathematical model will be formulated that combines knowledge systems, quality cost (in its four types) and labour productivity. The aim, establishing a quality system for institutions, companies or groups dedicated to research and development activities and need to fulfill ISO9001:2000 standard.

On this premise, the future research will use some non-parametric methods. These methods rely on the fact that the distribution function will approximate from the normal distribution, whether it was the distribution of a natural community or the sample size was large. Accordingly, for the purpose of ascertaining the homogeneity of the samples, they will be drawn from production line in the application side.

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