Developing an Interactive Graphical User Interface for The Flexible Acceptance Sampling Plan

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Abstract
Acceptance sampling plan is one popular approach since decades ago to determine the quality of the lot. Many researchers have developed the acceptance sampling plan in various perspectives and contexts. Generally, two performance measurements are used to evaluate the performance of the acceptance sampling plan including the operational characteristics (OC) and average sample number (ASN). The developed acceptance sampling plan can be used by practitioners to select the appropriate acceptance sampling plan to sentence the quality of the lot. The practitioner can access the tables provided to see the sample requirement and the critical value as the threshold to sentence the lot's quality, then conduct measurements and calculate the sample critical value manually. Further, the practitioner can compare the measured critical value and the threshold critical value. This process is time-consuming, needs several stages, and tends to open human errors in calculating. In this study, the interactive system is developed to reduce the time-consuming, eliminate the stages, and prevent human error. The interactive system is friendly-used, easy to calculate, and provides quick decision-making.

Keywords: *Acceptance Sampling Plan, Graphical User Interface, Operational Characteristics Curve, Quality Engineering and Management*.

Abstrak
Rencana pengambilan sampel penerimaan adalah salah satu pendekatan yang populer sejak beberapa dekade yang lalu untuk menentukan kualitas lot. Banyak peneliti telah mengembangkan rencana pengambilan sampel penerimaan dalam berbagai perspektif dan konteks. Umumnya, dua pengukuran kinerja digunakan untuk mengevaluasi kinerja rencana pengambilan sampel penerimaan termasuk karakteristik operasional (OC) dan jumlah sampel rata-rata (ASN). Rencana pengambilan sampel penerimaan yang dikembangkan dapat digunakan oleh para praktisi untuk

memilih rencana pengambilan sampel penerimaan yang sesuai dengan kualitas lot. Praktisi dapat mengakses tabel yang disediakan untuk melihat kebutuhan sampel dan nilai kritis sebagai ambang batas untuk menentukan kualitas lot, kemudian melakukan pengukuran dan menghitung nilai kritis sampel secara manual. Selanjutnya, praktisi dapat membandingkan nilai kritis yang diukur dan nilai kritis ambang batas. Proses ini memakan waktu lama, memerlukan beberapa tahapan, dan cenderung membuka human error dalam proses perhitungannya. Dalam penelitian ini, sistem interaktif dikembangkan untuk mengurangi waktu proses, menghilangkan beberapa tahapan, dan mencegah terjadinya human error. Sistem interaktif ini mudah digunakan, mudah dihitung, dan menyediakan pengambilan keputusan yang cepat.

Keywords: *Acceptance Sampling Plan, Graphical User Interface, Operational Characteristics Curve, Quality Engineering and Management.*

1. Introduction

Technological advances have encouraged the industry to move quickly, be able to adapt to a climate of high competition, and be able to meet increasingly complex consumer needs (Wiengarten et al., 2022). Besides, the industry also needs to maintain the relationship along the supply chain (Schmidt et al., 2022).To meet the needs mentioned above, the industry requires the adoption of integrated technology. Currently, many industries have invested in developing technological integration, especially in human resource development, research and development, and related to core processes such as production processes. The production process in the manufacturing industry is the heart of an industry, so adapting to the latest technology is mandatory. Stages throughout the production process require attention to ensure that the production process runs according to procedures to ensure product quality meets and exceeds customer expectations.

One of the critical areas in the stages throughout the production process is the inspection process. The inspection process is the process of checking raw materials or products to ensure their quality level. In general, the inspection process is divided into two, namely 100 percent inspection and inspection with a sampling acceptance plan. Both inspection models have been used for decades. Initially, practitioners used a 100 per cent inspection model, but this model had several weaknesses, including requiring high costs, long inspection times, and manpower, and was only relevant to certain products. The acceptance sampling plan is the second model offered by researchers, which involves taking several samples and carrying out inspections to ensure the quality of the product or raw material (Montgomery, 2019).

So far, numerous researchers have created acceptance sampling plans from different viewpoints and situations. They are; Balamurali (2017), Lee et al. (2018), Wu & Liu (2018), Aslam & Aldosari (2019), Wang & Wu (2019a), Liu et al. (2021), Narayanan et al. (2022), Marques et al. (2023), Wu et al. (2023), and Wu & Darmawan (2023). Some of the primary goals in creating this sampling acceptance plan study are that the plan must be reliable, simple to design and develop, and easy to implement. Several recent studies focus on the creation of sampling acceptance plans, specifically: a multiple acceptance sampling plan with independent stages, thereby removing ties between stages. The research was conducted with the integration of the widely used capability process index, C_{pk} (Wu et al., 2023). Nevertheless, based on this comprehensive study, professionals still need to refer to the table to review the sample sizes and critical values once the required parameters have been established. This could lead to a lengthy inspection process and increase the risk of human error. In this study, a system was created to streamline processes, save time, and minimize human errors. This interactive system is user-friendly, efficient in calculations, and facilitates quick decision-making. Various research projects focusing on the creation of a sampling plan acceptance plan that has been combined with a user-friendly interface feature including Wang & Wu (2019), Luca et al. (2020), Wang et al. (2022), and Wu & Darmawan (2023).

2. Method

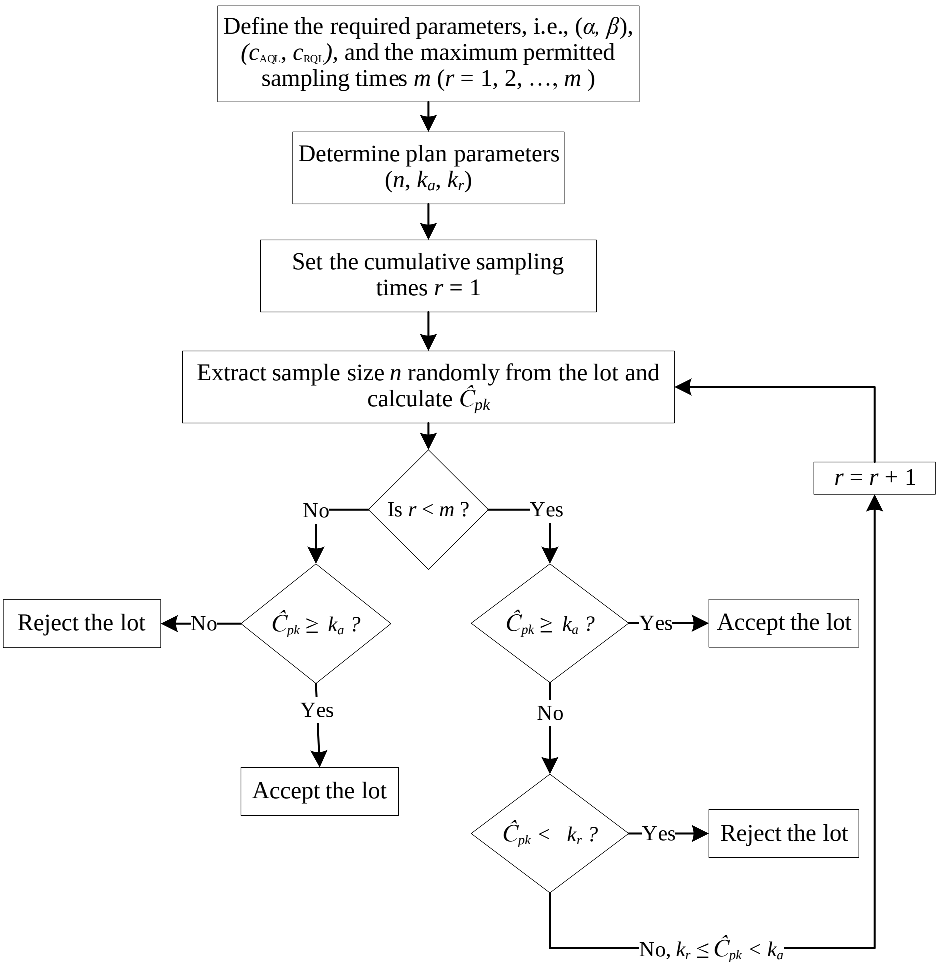

Figure 1. Procedure operational (Wu et al. 2023)

In this section, we follow the processes that were used in the study that was developed by Wu et al. (2023). We ensure precision in our analysis and calculations by conducting re-simulation. In this study, sensitivity analysis and simulation were carried out with the use of Matlab software by utilizing *fmincon* to solve nonlinear mathematical modeling problems. These problems involved a minimization equation and two constraints, which were formulated in equations 9 to 11. For detailed information, it is important to refer to the research carried out by Wu et al. (2023). The following is Figure 1 demonstrates the operational procedures that were utilized in the research that was carried out by Wu et al. (2023).

Furthermore, a graphical user interface was developed by referring to the operational procedure for developing a sampling acceptance plan (Figure 1) using Matlab software. The following Figure 2 demonstrated a flow chart for the graphical user interface (GUI) procedure:

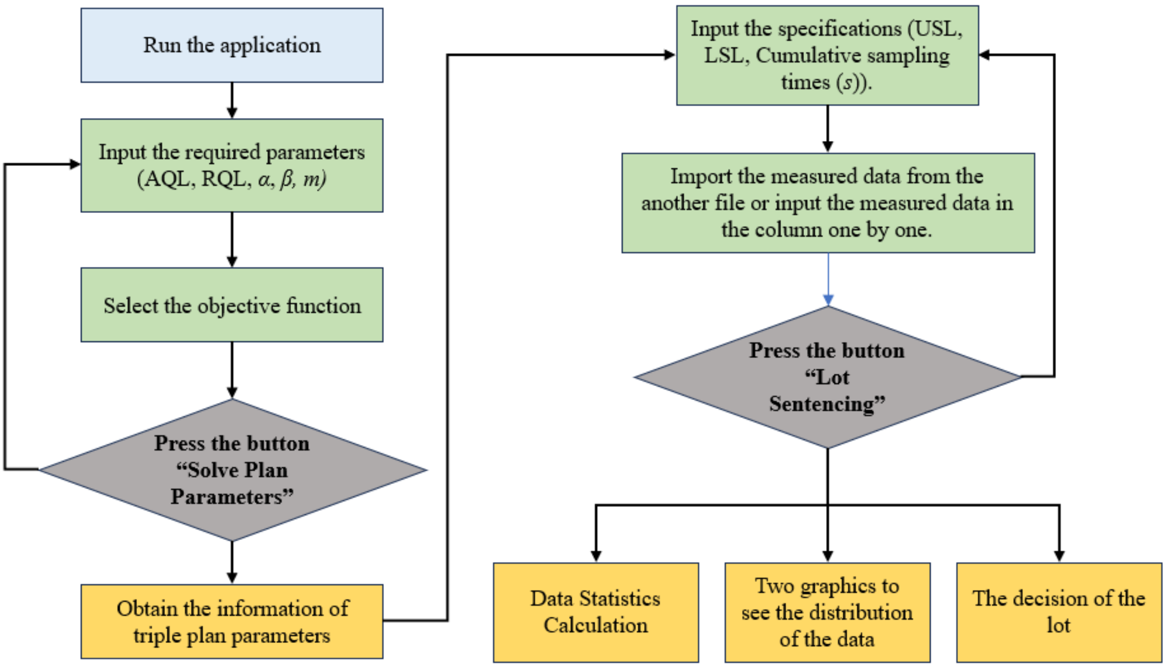

Figure 2. User Interface Flowchart

3. Result and Discussion

Graphical user interface (GUI) is an interactive feature that can be developed on several software platforms. In this case, an interactive feature was developed from *Matlab* software that can make it easier for practitioners or users to carry out the process of inspecting raw materials and products in an industry. Several modules that were previously carried out separately in several software, are now integrated in one platform so that it can make it easier for users to implement acceptance sampling plans. The development of this module refers to operational procedures for the sampling plan (Figure 1) and then adaptations are carried out in designing an interactive module that is easier to comprehend (Figure 2).

A user-friendly GUI was developed to implement the easiness of the sampling plan. In the GUI, we developed the interface for entering the required parameters (Figure 3). The required parameters are the acceptable quality level (c_{AQL}), the rejectable quality level (c_{RQL}), producer risk (α), consumer risk (β), and sampling times (m). The required parameter needs to be established by mutually decided upon by the producer and customer in the contract agreement.

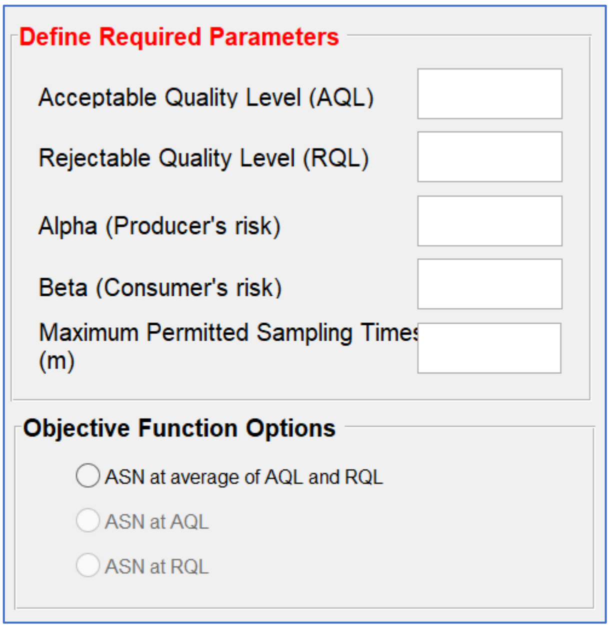

Figure 3. Define The Required Parameters, and Maximum Allowable Sampling Times (*m*), and Set The Objective Function (The First Layer).

The objective function is set to obtain the triple plan parameters (n, k_a, k_r). Objective functions are set with three options, the first one is based on ASN at average at AQL and RQL, the second is set as ASN at AQL, and the last, ASN is set at RQL perspective.

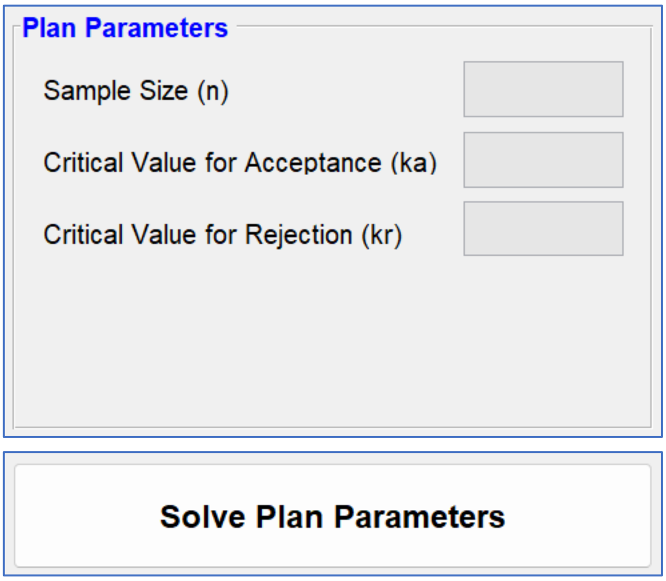

Figure 4. Push The Button ‘Solve Plan Parameters’ (The First Layer)

The triple plan parameter information will show automatically by pushing the button 'Solve Plan Parameter' (Figure 4). In the meantime, the second layer will allow the practitioner access to some important features (Figure 5).

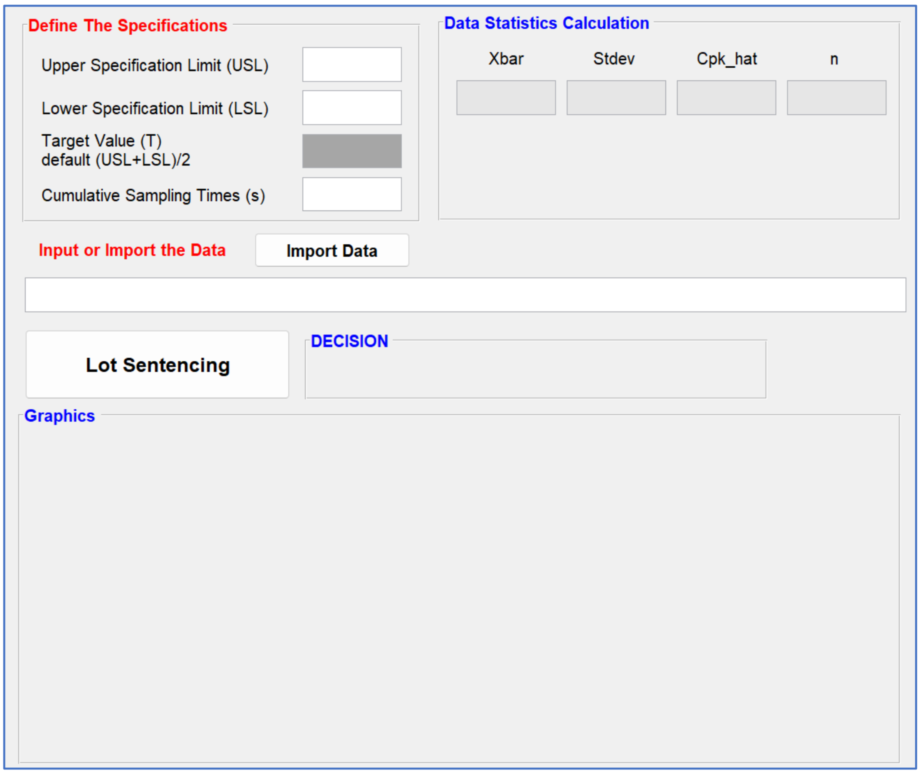

Figure 5. The Second Layer

In addition, in the second layer, we can specify the specification limits and the cumulative sampling times. Before pushing the button of 'Lot Sentencing', we need to input the data or import it from another file. The number of the measured data must be equal to the required sample size. By clicking the 'Lot Sentencing', the system will show the result of sample statistics, critical value, and decision of the lot. Besides, the system will display two figures that describe the distribution of the data. The basic assumption for this acceptance sampling plan model is the data must be normally or near normally distributed. Thus, we have to ensure that data must be normally distributed through the figures (histogram and normal probability plot).

Lastly, we implement the example to validate the GUI. The required parameters are set (c_{AQL}=1.33, c_{RQL}=1.00, α=0.05, β=0.10, m=3) and determine the objective function at average ASN at AQL and RQL. Based on these parameters, we should get the triple parameters (n, k_a, k_r) = (43, 1.2063, 1.0666) from the provided table (See Table 6 from Wu et al., 2023). Similarly, we can get similar information about the triple plan parameter (n, k_a, k_r) after pushing the button "Solve Plan Parameters" (See Figure 6).

Furthermore, we enter the specification (USL and LSL) and the cumulative sampling times (s=1) as first-time sampling. This is performed in accordance with the example that was taken from Wu et al. (2023). The 43 samples collected were then measured and entered into the column labeled "input data sample." The system will automatically display a number of features when the 'Lot Sentencing' button is pressed. These features include the following: data statistical computations and critical value, two visuals (normal probability plot and histogram), and the decision of the lot.

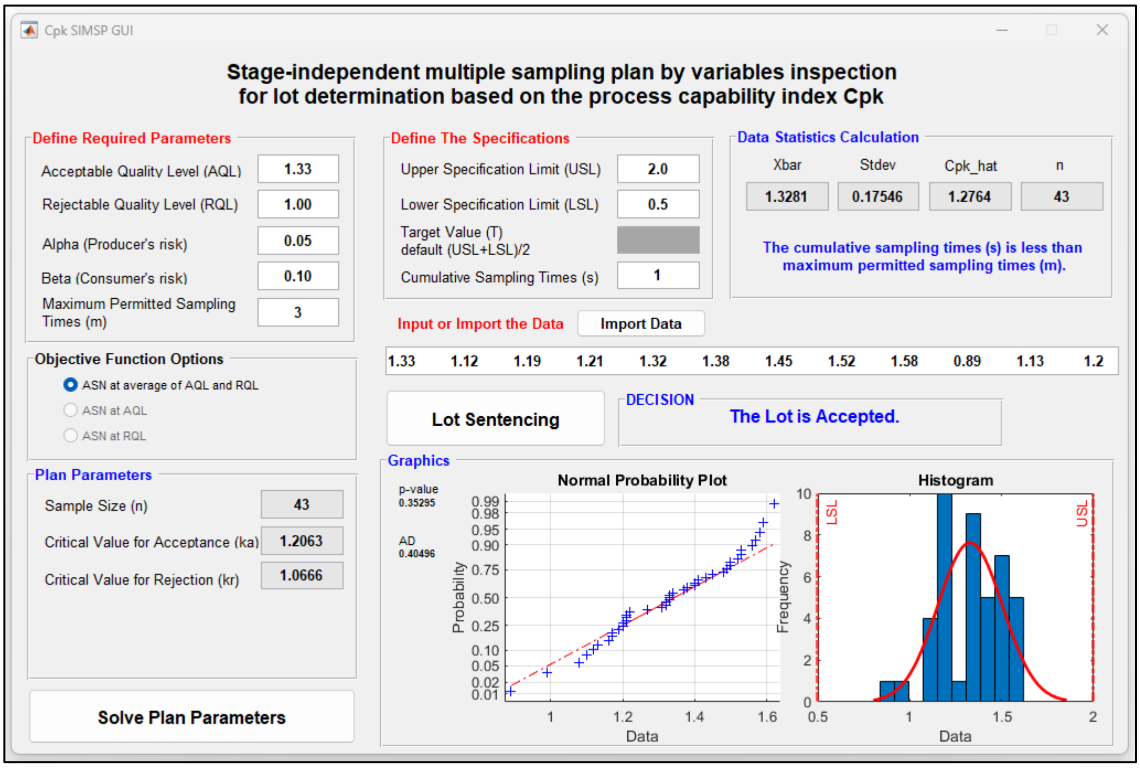

Figure 6. Graphical-User-Interface Application for Input Data Sample, Calculation, Normality Test, and Decision-Making.

According to the results of the first-stage sample, the distribution of the data is verified to be normally distributed, as indicated by the Anderson-Darling test, which indicates a p-value of 0.353. Moreover, the value that is considered essential is 1.2764. Given that the critical value is either more than or equal to the threshold value k_a (k_a = 1.2063), it may be concluded that the lot that was presented is accepted. In the meanwhile, the lot that was submitted must be rejected if the crucial value for acceptance is lower than the threshold value k_r (k_r = 1.0666). On the other hand, if the crucial value is located between the k_a and the k_r, then we need to undertake the second-stage sampling, and the decision-making process can proceed similarly to the first-stage sampling procedure. As a result of the fact that m equals three, in the event that the third and final stage is required, the sampling may be carried out, and the lot can be accepted if the critical value is more than or equal to 1,2063; when it is not, the lot must be rejected.

Using the user-friendly feature, the GUI that was designed for this study may provide the practitioner with assistance in putting the sample strategy into action. In order to determine whether or not the model is reliable, the validation of the GUI was carried out by modifying the example from the article that was referred to. As a consequence, the designed GUI is able to work smoothly and reliably, and it is also simple to implement.

4. Conclusion

The acceptance sampling strategy has been a well-liked method for determining the quality of the lot ever since it was first introduced some decades ago. The acceptance sampling strategy has been established by a large number of researchers from a variety of views and setting instances. The operational characteristics (OC) and the average sample number (ASN) are the two performances metrics that are often utilized in order to evaluate the effectiveness of the acceptance sampling strategy. An acceptance sampling plan that has been prepared may be utilized by practitioners in order to determine the most suitable acceptance sample plan for the purpose of determining the quality of the lot. The practitioner may use the tables that are supplied in order to find out the required sample and the critical value that serves as the threshold for judging the quality of the lot. After that, the practitioner can manually perform measurements and calculate the sample's critical value. The practitioner also has the ability to compare the critical value that was measured with the critical value that was used as the threshold. This procedure wastes a lot of time, requires many phases, and has a tendency to introduce human errors into the calculation process. The interactive system is being created in this project with the goals of reducing the amount of time required, removing the phases, and preventing errors caused by humans. The findings indicate that the interactive system is user-friendly, that it delivers dependable results, and that it facilitates the making of decisions in a timely manner.

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