International Journal of Mechanical, Industrial and Aerospace Sciences
ISSN: 2517-9950
Vol:12, No:1, 2018

Optimizing and Evaluating Performance Quality Control of the Production Process of Disposable Essentials Using Approach Vague Goal Programming

Hadi Gholizadeh, Ali Tajdin

Abstract**—**To have effective production planning, it is necessary to control the quality of processes. This paper aims at improving the performance of the disposable essentials process using statistical quality control and goal programming in a vague environment. That is expressed uncertainty because there is always a measurement error in the real world. Therefore, in this study, the conditions are examined in a vague environment that is a distance-based environment. The disposable essentials process in Kach Company was studied. Statistical control tools were used to characterize the existing process for four factor responses including the average of disposable glasses' weights, heights, crater diameters, and volumes. Goal programming was then utilized to find the combination of optimal factors setting in a vague environment which is measured to apply uncertainty of the initial information when some of the parameters of the models are vague; also, the fuzzy regression model is used to predict the responses of the four described factors. Optimization results show that the process capability index values for disposable glasses' average of weights, heights, crater diameters and volumes were improved. Such increasing the quality of the products and reducing the waste, which will reduce the cost of the finished product, and ultimately will bring customer satisfaction, and this satisfaction, will mean increased sales.

Keywords**—**Goal programming, quality control, vague environment, disposable glasses' optimization, fuzzy regression.

I. Introduction

PRODUCTION begins with the decision to produce and continues until the final product is complete. To have effective production planning, it is necessary to calculate the quality control and chart control. For this purpose, the study of Kach Packaging Industries, as one of the subsidiaries of the Solico Industrial Group, is in charge of manufacturing polymer containers for packing products from Kaleh Dairy Company. Kaleh Dairy Company is one of the largest dairy and protein production plants in Iran. Due to its high production, timely and without delay, it has a significant impact on reducing its costs (Cost Stop Lines, Capital Sleep, etc.). Therefore, as part of the company's supply chain, Kach Company is required to provide the company with the most important requirements for packaging in a timely manner and with high quality. Thus, due to its constraints, the company should always provide these supplies to Kaleh Company with the highest possible output. As a result, the importance of quality in this organization has been one of the main goals.

Statistical quality control is an important approach that helps by using statistical tools to illustrate the process. Chevrolet control charts are one of the most important quality control methods used to illustrate deviations with reason. Fuzzy diagrams with the ability to formulate expert experiences and use vague and imprecise data increase the ability to control quality to improve the quality of products and services. In this research, fuzzy theory is used to empower the statistical control charts. Because of the limitation of measurement tools and uncertainty in the measurement system, such as operators, confusions, environmental conditions, etc. operators cannot provide a precise number for these characteristics, and they inevitably record them in an approximate manner. The processing ability is based on fuzzy measurements and analysis control charts. The fuzzy fashion method and the proposed method of fuzzy rules are used to create fuzzy control graphs [1]. A fuzzy method is provided for vague data in monitoring the mean and variance of fuzzy charts by [2]. One method for calculating fuzzy standard deviations is to obtain a graph for cases provided by $\bar{x} - s$, as well as explained by the theoretical structure of fuzzy control $\bar{x} - s$ which is known as local parameters [3].

Several approaches have been proposed to optimize process performance with multiple responses [4]. Therefore, multiple formularizations of goal programming (GP) models were shown for deciding the fuzzy GP (FGP) problems obtaining into account the decision maker's (DM's) priority [5]. An effective FGP technique is the weighted additive model, which considers all shapes of membership functions, with the objective to minimize the weighted deviations from the imprecise fuzzy values for all quality responses and process factors [6]. FGP has been utilized for optimizing process performance in many business applications [7]. A vague set, as well as an Intuitionistic fuzzy set, is a further generalization of a fuzzy set. We describe the Optimization of queuing theory based on vague environment [8]. In this research study, an empirical study of the fuzzy regression model was conducted to better estimate and predict. We explained fuzzy regression model for the evaluation of the functional relation between related and independent variables in the fuzzy environment, practical to diverse problems, such as prediction engineering [9]. The first engineering usage of GP was explained, due to the design and commissioning of spacecraft in the aerospace

Hadi Gholizadeh is with the Department of Industrial Engineering Mazandaran University of Science and Technology, Babol, Iran (e-mail: Hadi.gh1988@gmail.com).
Ali Tajdin is with the Department of Industrial Engineering Mazandaran University of Science and Technology, Babol, Iran (corresponding author, e-mail: ali_tajdin@ustmb.ac.ir).

sciences via [10].

In reality, determining the combination of optimal factor settings for disposable glasses' manufacturing processes to improve multiple quality responses is a real challenge. This paper, therefore, aims at optimizing the performance of direct production process for multiple quality characteristics using statistical techniques (statistical quality control, fuzzy regression model) and weighted additive model in GP in a vague environment.

The continuation of this study is as follows. In Section II, the various concepts of the vague set theory are discussed. In Section III, vague process capability analysis and fuzzy regression models are introduced. The vague GP is introduced, and the process capability is expressed in Section IV. We conclude the subject in Section V.

II. Vague Environment

Definition 1: [8] (**Fuzzy Set**) A fuzzy set $\tilde{A}$ = {< u, $\mu_{\tilde{A}}$ (u) > |u ∈ U} in a universe of discourse U is characterized by a membership function, $\mu_{\tilde{A}}$, as follows:

$\mu_{\tilde{A}}$: U → [0, 1].

Definition 2: [8] A vague set $\tilde{A}$ in a universe of discourse U is characterized. It is expressed by two membership functions, which is a true membership,$T_{\tilde{A}}$,function and a false membership function, $F_{\tilde{A}}$, as follows: $T_{\tilde{A}}: U \to [0,1]$, $F_{\tilde{A}}: U \to$ [0,1], and $T_{\tilde{A}}(u) + F_{\tilde{A}}(u) \leq 1$, where $T_{\tilde{A}}(u)$ is a lower bound on the grade of membership of u derived from the evidence for u, $F_{\tilde{A}}(u)$ is a lower bound on the grade of membership of the negation of u derived from the evidence against u. Suppose U={u_1,u_2,… u_n }. A vague set $\tilde{A}$ of the universe of discourse U can be represented by$\tilde{A} = \frac{\sum_{i=1}^{N}[T_{\tilde{A}}(u_i),1-F_{\tilde{A}}(u_i)]}{u_i}$, where 0≤ T($u_i$)≤1−F($u_i$)≤1 and 1 ≤$i$≤$n$. In this case, the degree of membership in u_i will be limited to a period of time, $[T_{\tilde{A}}(u_i), 1 - F_{\tilde{A}}(u_i)]$ of [0,1]. Therefore, generalized vague collections have fuzzy sets of membership degrees $\mu_{\tilde{A}}(u)$ of u in Definition 1 may be inexact in a vague set. We now depict a vague set in Fig. 1.

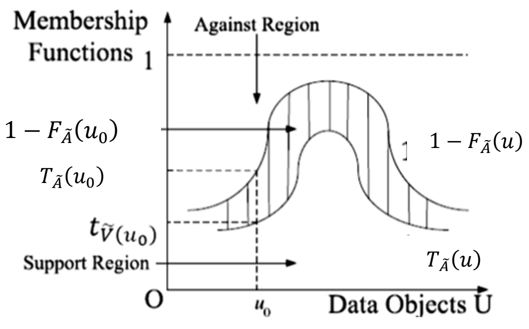


Fig. 1 Membership Functions of a vague set

Definition 3: [8]. The complement of a vague set $\tilde{A}$ is denoted by $\widetilde{A'}$ and is defined by

$$T_{\widetilde{A'}}(u) = F_{\tilde{A}}(u), 1 - F_{\widetilde{A'}}(u) = 1 - F_{\tilde{A}}(u) \quad (1)$$

Definition 4: [8]. Let $\tilde{A}_{T_{\tilde{A}}F_{\tilde{A}}}$ be a vague set of U. Then, we define α_T –cuts and α_F –cuts of $\tilde{A}$ as the crisp sets of U given by

$$\tilde{A}_{\alpha_T} = \{u: T_{\tilde{A}}(u) \geq \alpha_T \} \qquad \alpha_T \in [0,1] \quad (2)$$

$$\tilde{A}_{\alpha_F} = \{u: F_{\tilde{A}}(u) \geq \alpha_F \} \qquad \alpha_F \in [0,1] \quad (3)$$

Definition 5: [8]. A vague set $\tilde{A}_{T_{\tilde{A}}F_{\tilde{A}}}$of $\mathscr{R}$ with continuous membership functions $T_{\tilde{A}}$ and $F_{\tilde{A}}$ is called a vague number if and only if $\tilde{A}_{\alpha_T}$and $\tilde{A}_{\alpha_F}$, for all α_T, α_F ∈ (0,1], are bounded closed intervals; i.e.

$$\tilde{A}_{\alpha_T} = \left[\tilde{A}^L_{\alpha_T}, \tilde{A}^U_{\alpha_T}\right], \ \tilde{A}_{\alpha_F} = \left[\tilde{A}^L_{\alpha_F}, \tilde{A}^U_{\alpha_F}\right] \quad (4)$$

We denote the class of all vague numbers by A($\mathscr{R}$).

Definition 6: [8]. The vague number $\tilde{A}_{T_{\tilde{A}}F_{\tilde{A}}}$ is called a trapezoidal vague number, if

$$T_{\tilde{A}}(u) = \begin{cases} \frac{u-a_1}{w(a_2-a_1)} & a_1 \leq u \leq a_2 \\ 1 & a_2 \leq u \leq a_3 \\ \frac{a_4-u}{w(a_4-a_3)} & a_3 \leq u \leq a_4 \\ 0 & otherwise \end{cases} \quad (5)$$

$$1 - F_{\tilde{A}}(u) = \begin{cases} \frac{u-a_1}{(a_2-a_1)} & a_1 \leq u \leq a_2 \\ 1 & a_2 \leq u \leq a_3 \\ \frac{a_4-u}{(a_4-a_3)} & a_3 \leq u \leq a_4 \\ 0 & otherwise \end{cases} \quad (6)$$

where w∈ [1,∞). We denote such a vague number by $\tilde{A} = (a_1, a_2, a_3, a_4, w)_T$

A. Control Charts

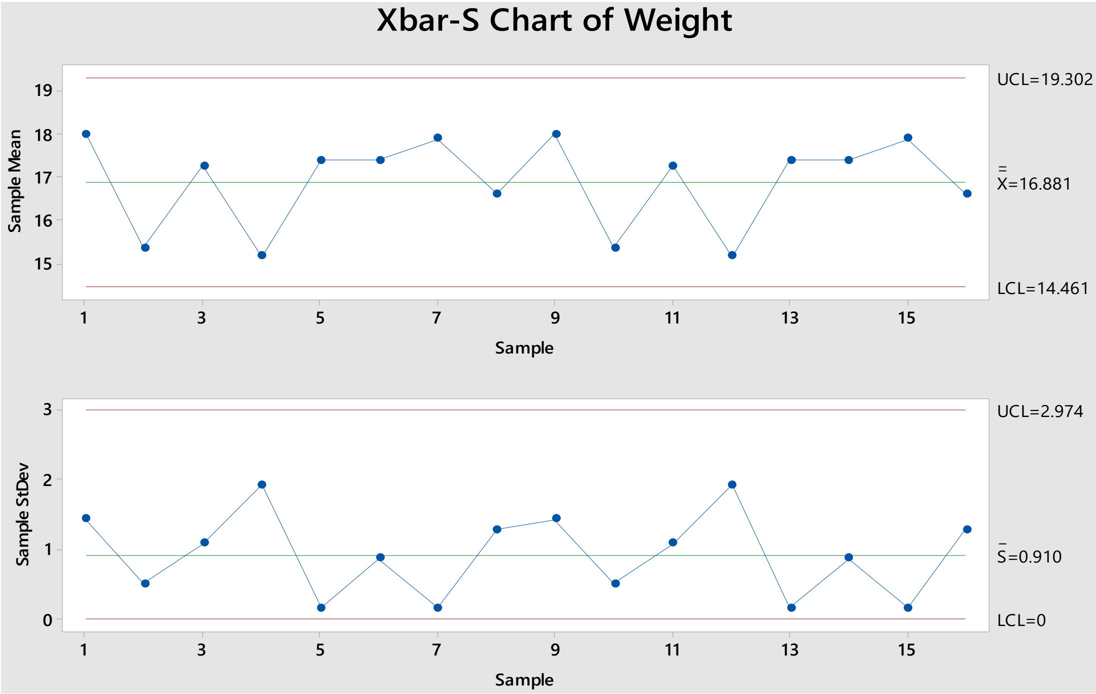
A control chart is one of the primary monitoring techniques of Statistical Process Control (SPC). Control charts plot the points where statistics (such as an average, range, ratio, etc.) measure qualitative and quantitative characteristics of samples that have been obtained at different times of the process. The chart has a central line is in the mean values (CL) as well as the upper and lower levels of control (sometimes called the "natural part of the process"), which represents the threshold "unlikely" of the resulting process and they are drawn in three standard errors from the central line (UCL and LCL, respectively). At initial factor, settings have been explained by the $\bar{x} - s$ charts for averages disposable glasses' weight, height, crater diameter, and volume [11].

$$CL_{\bar{X}} = \bar{\bar{X}}, UCL_{\bar{X}} = \bar{\bar{X}} + A_1\bar{S}, LCL_{\bar{X}} = \bar{\bar{X}} - A_1\bar{S} \quad (7)$$

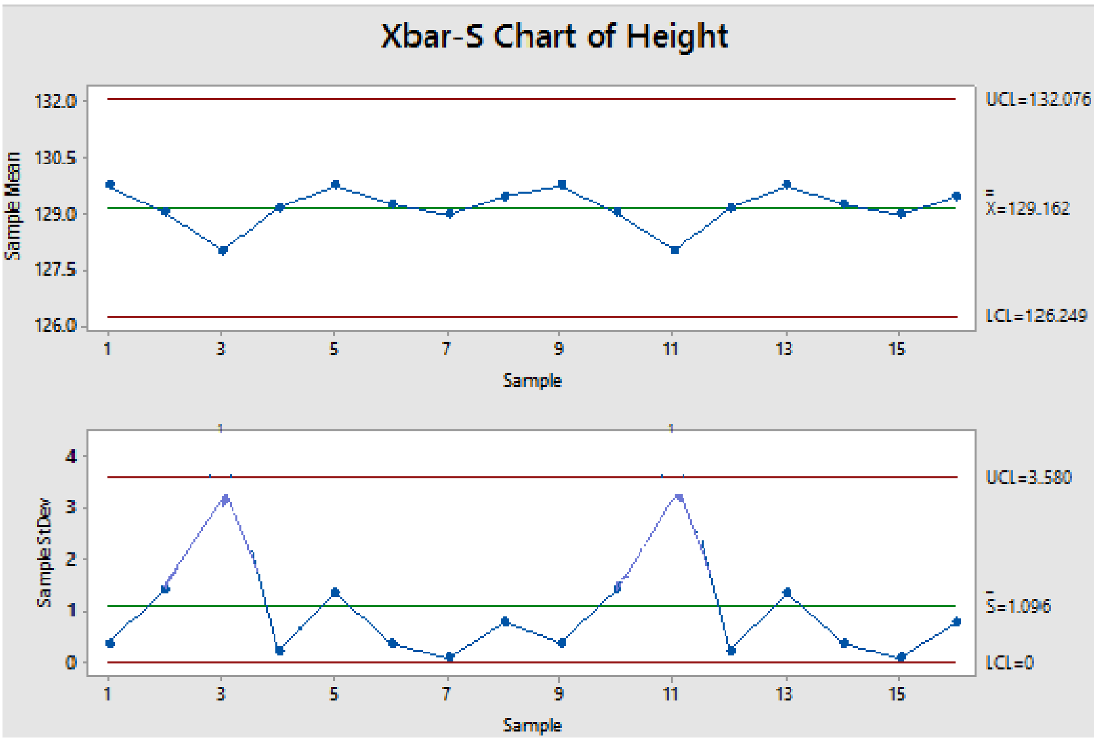
B. Vague Control Charts

This paper develops vague as a control chart which is one of the primary (SPC) monitoring tools. Control charts plot the averages of measurements of quality characteristic in samples taken from the process versus the sample vague number. The chart has a center line ($\widetilde{CL}$) as well as upper and lower control limits ($\widetilde{UCL}$ and $\widetilde{LCL}$, respectively).

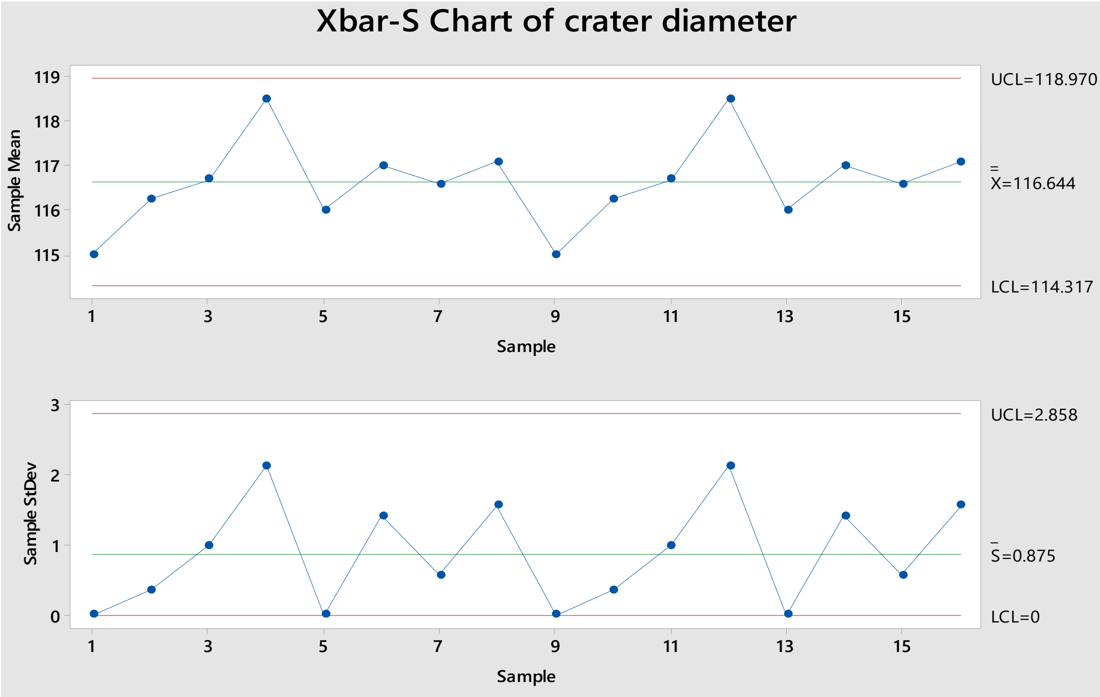
The control chart for the four factors of weight, height, crater diameter and volume is shown in Fig. 2.



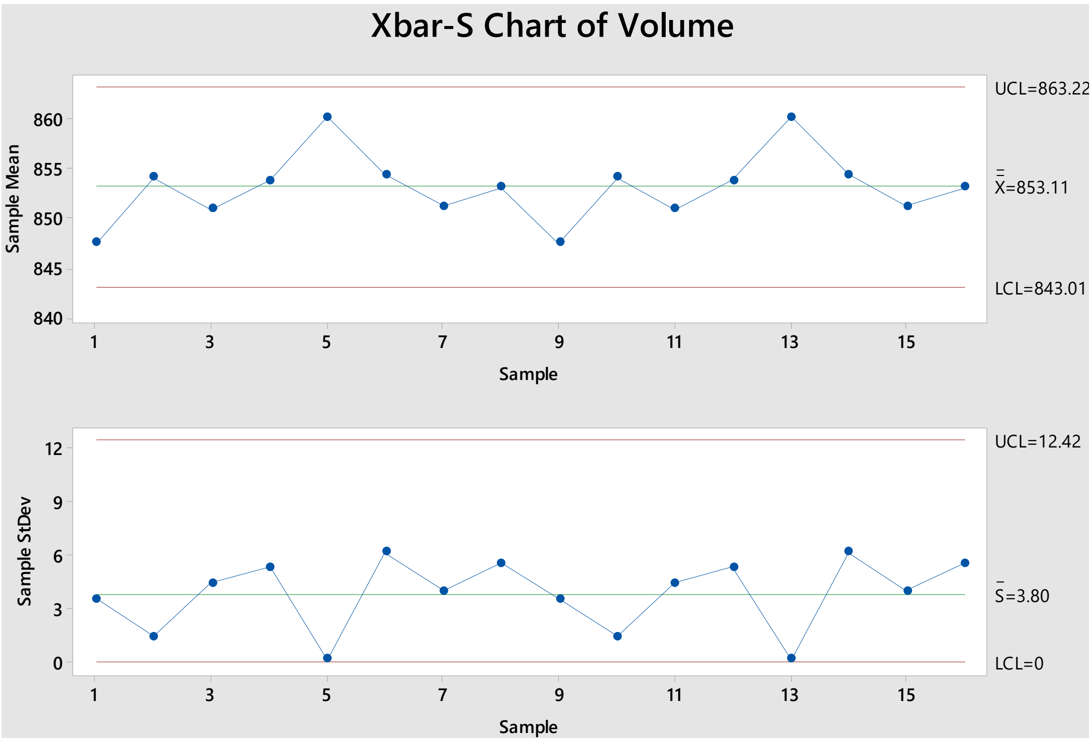
(a)



(b)



(c)



(d)

Fig. 2 The $\bar{x} - s$ charts for average disposable glasses at initial factory settings

III. Vague Process Capability Analysis

Capability analysis is used to assess whether a process is statistically capable to meet a set of customer desired product specifications. In practice, the process standard deviation, $\tilde{\sigma}$, is unknown and is frequently estimated by:

$$\tilde{\hat{\sigma}} = \frac{\tilde{\bar{S}}}{C_2} \qquad \left(\tilde{\hat{\sigma}}\right)_{\alpha_T}^{L,U} = \frac{\left(\tilde{\bar{S}}\right)_{\alpha_T}^{L,U}}{C_2} \qquad \left(\tilde{\hat{\sigma}}\right)_{\alpha_F}^{L,U} = \frac{\left(\tilde{\bar{S}}\right)_{\alpha_F}^{L,U}}{C_2} \tag{8}$$

where C_2 is a constant related to the sample size, The C_{pk} estimator, $\tilde{\hat{C}}_{pk}$, can be expressed mathematically by:

$$\tilde{\hat{C}}_{pk} = min\left\{\frac{\tilde{\hat{\mu}}-\widetilde{LCL}}{3\tilde{\hat{\sigma}}}, \frac{\widetilde{UCL}-\tilde{\hat{\mu}}}{3\tilde{\hat{\sigma}}}\right\}$$

$$\left(\tilde{\hat{C}}_{pk}\right)_{\alpha_T}^{L,U} = min\left\{\frac{\left(\tilde{\hat{\mu}}\right)_{\alpha_T}^{L,U}-\left(\widetilde{LCL}\right)_{\alpha_T}^{L,U}}{3\left(\tilde{\hat{\sigma}}\right)_{\alpha_T}^{L,U}}, \frac{\left(\widetilde{UCL}\right)_{\alpha_T}^{L,U}-\left(\tilde{\hat{\mu}}\right)_{\alpha_T}^{L,U}}{3\left(\tilde{\hat{\sigma}}\right)_{\alpha_T}^{L,U}}\right\} \tag{9}$$

$$\left(\tilde{\hat{C}}_{pk}\right)_{\alpha_F}^{L,U} = min\left\{\frac{\left(\tilde{\hat{\mu}}\right)_{\alpha_F}^{L,U}-\left(\widetilde{LCL}\right)_{\alpha_F}^{L,U}}{3\left(\tilde{\hat{\sigma}}\right)_{\alpha_F}^{L,U}}, \frac{\left(\widetilde{UCL}\right)_{\alpha_F}^{L,U}-\left(\tilde{\hat{\mu}}\right)_{\alpha_F}^{L,U}}{3\left(\tilde{\hat{\sigma}}\right)_{\alpha_F}^{L,U}}\right\} \tag{10}$$

A. Fuzzy Regression Models

In fuzzy linear regression (FLR) analysis, uncertainty is obtained by a fuzzy relationship between the input and the output. In this paper, the approach in [12] is used, and accordingly, the regression models were calculated according to the expressed factors.

Three main process factors are identified affecting the disposable glasses' quality, including:

X_1: Speed away on the sheet from extruder hinges to the model forming machine.

X_2: The amount of wind pressure on the sheet produced from the extruder hall in the model forming machine.

X_3: Thickness sheet fluctuations produced from the extruder hall in the model forming machine.

Table I shows the initial settings for the company that in the continuation will be used, and in Table II, the selected experimental design is shown. 16 samples are selected; each of size 4 is taken for the weight, fragility, crater diameter and volume, respectively. Each experiment is repeated three times. The final average values are calculated for the four responses and recorded in Table III. Let Y_1, Y_2 , Y_3 and Y_4denote the measured averages of weight, height, crater diameter and volume, respectively. To optimize process performance, the weighted additive model GP in a vague environment was utilized. The optimization procedure is described as follows:

We formulate the mathematical relationship between each quality response and process factors.

TABLE I
UTILITY DM IN THE INITIAL SETTINGS

Quality characteristic	Mean	deviation	C_{pk}
Weight(g)	18	[17.5,18.2]	0.97
Height (mm)	130	[129,131]	0.86
crater diameter (mm)	116	[115.8,116.2]	0.65
Volume(cc)	850	[840,860]	0.76

The regression model for the average disposable glasses' weight ($\widetilde{Y_1}$) is formulated as follows:

$$\widetilde{Y_1} = (12.241,13.829,20.359)\oplus(0.130,-0.019,0.008)\otimes\tilde{X}_1 \oplus(0.137,0.079,0.144)\otimes\widetilde{X_2}\oplus(-0.188,0.184,0.038)\otimes\widetilde{X_3} \tag{11}$$

The regression model for $\widetilde{Y_2}$ is expressed as:

$$\widetilde{Y_2} = (124.828,124.050,130.935)\oplus(-0.055,0.078,0.015)\otimes\widetilde{X_1} \oplus(0.359,0.074,-0.016)\otimes\widetilde{X_2}\oplus(-0.165,0.180,0.005)\otimes\widetilde{X_3} \tag{12}$$

The regression model for $\widetilde{Y_3}$ is expressed as:

$$\widetilde{Y_3} = (111.480,113.557,116.167)\oplus(0.019,0.084,0.113)\otimes\widetilde{X_1} \oplus(0.149,0.121,0.108)\otimes\widetilde{X_2}\oplus(0.064,-0.047,-0.179)\otimes\widetilde{X_3} \tag{13}$$

Finally, the regression model for $\widetilde{Y_4}$ is expressed as:

$$\widetilde{Y_4} = (825.565,833.238,838.725)\oplus(0.768,0.540,0.170)\otimes\widetilde{X_1} \oplus(0.659,0.749,0.968)\otimes\widetilde{X_2}\oplus(-0.132,-0.241,-0.109)\otimes\widetilde{X_3} \tag{14}$$

TABLE II
EXPERIMENTAL DATA

Total Experiment	X_1	X_2	X_3	y_1	y_2	y_3	y_4
1	[18,20,22]	[11,12,13]	[10,15,16]	[15,17,19]	[129.2,130,131]	[114,115,116]	[840.5,845,850.5]
2	[18,20,22]	[11,12,13]	[11,13,15]	[16,19,22]	[125,129.5,130]	[113,115,117]	[845,850,852]
3	[18,20,22]	[12,14,16]	[8,9,10]	[14.5,15.7,16.3]	[128.3,130,132]	[114,116,118]	[848.4,855,859.6]
4	[18,20,22]	[12,14,16]	[14,13,15]	[13,15,17]	[124,128,132]	[115.5,116.5,117.5]	[850,853,860]
5	[20,25,30]	[11,12,13]	[10,15,16]	[16,18,20]	[119,125,130]	[116.1,117.4,118.6]	[839,854,860]
6	[20,25,30]	[11,12,13]	[11,13,15]	[14.5,16.5,18.5]	[130,131,132]	[113,116,119]	[842.2,847.8,850.3]
7	[20,25,30]	[12,14,16]	[8,9,10]	[12.5,16.5,20.2]	[127,129,131]	[113,117,120]	[855.6,857.5,859.1]
8	[20,25,30]	[12,14,16]	[14,13,15]	[10.7,13.8,16.9]	[126.5,129.3,131]	[115,120,121]	[849,850,855]
9	[25,26,30]	[14,16,18]	[10,15,16]	[16.3,17.3,18.3]	[124,128.8,132.4]	[115.8,116,116.2]	[859,860,861]
10	[25,26,30]	[14,16,18]	[11,13,15]	[15.5,17.5,18.2]	[130,130.7,131]	[114.8,116,117.3]	[858.7,860.2,862]
11	[25,26,30]	[16,18,20]	[8,9,10]	[17,18,19]	[126.7,129,131.8]	[114,116,118]	[855.9,858.7,860.6]
12	[25,26,30]	[16,18,20]	[14,13,15]	[14.8,16.8,18.8]	[128,129.5,130.5]	[115,118,121]	[840,850,860]
13	[15,18,21]	[14,16,18]	[10,15,16]	[16,18,20]	[127.8,128.9,130.7]	[113.8,116.2,117.2]	[844,854,860]
14	[15,18,21]	[14,16,18]	[11,13,15]	[13.9,17.8,18.5]	[127,129,131]	[115,117,119]	[843.5,848.4,855.1]
15	[15,18,21]	[16,18,20]	[8,9,10]	[12.9,15.7,18.2]	[129,130,131]	[116.2,118.2,120.2]	[839.7,849.2,859.7]
16	[15,18,21]	[16,18,20]	[14,13,15]	[15,17.5,18]	[126.4,128.9,130.5]	[114,116,118]	[855,857,860]

IV. VAGUE GP

FGP can be used to plan programs for solving multiple decision problems in an irregular ambiguous environment. In this method, instead of achieving objective fuzzy value goals, achieving membership goals for goals is to maximize or minimize uncertainty in a search process. In this study, the objectives of fusion-based distance-based programming are defined as a "false and true membership function" supported by "vague collections" [11].

We assign weights to the deviations according to their relative significance DM. Then write the complete model as:

$$\text{Minimize } Z_{\alpha_T}^{L,U} = 0.10[(\omega_{\tilde{y}_1}^-)_{\alpha_T}^{L,U} - (\omega_{\tilde{y}_1}^+)_{\alpha_T}^{L,U}] + 0.15[(\omega_{\tilde{y}_2}^-)_{\alpha_T}^{L,U} - (\omega_{\tilde{y}_2}^+)_{\alpha_T}^{L,U}] + 0.25[(\omega_{\tilde{y}_3}^-)_{\alpha_T}^{L,U} - (\omega_{\tilde{y}_3}^+)_{\alpha_T}^{L,U}] + 0.35[(\omega_{\tilde{y}_4}^-)_{\alpha_T}^{L,U} - (\omega_{\tilde{y}_4}^+)_{\alpha_T}^{L,U}] + 0.10[(\delta_{\tilde{X}_1}^-)_{\alpha_T}^{L,U} + (\delta_{\tilde{X}_1}^+)_{\alpha_T}^{L,U} + (\delta_{\tilde{X}_2}^-)_{\alpha_T}^{L,U} + (\delta_{\tilde{X}_2}^+)_{\alpha_T}^{L,U} + (\delta_{\tilde{X}_3}^-)_{\alpha_T}^{L,U} + (\delta_{\tilde{X}_3}^+)_{\alpha_T}^{L,U}] \quad (15)$$

$$\tilde{T}_{\tilde{X}_{1\alpha_T}^{L,U}} + \frac{(\delta_{\tilde{X}_1}^-)_{\alpha_T}^{L,U}}{1.2} + \frac{(\delta_{\tilde{X}_1}^+)_{\alpha_T}^{L,U}}{1.2} = 1\,, \tilde{X}_{1\alpha_T}^{L,U} + \frac{(\delta_{\tilde{X}_1}^-)_{\alpha_T}^{L,U}}{1.2} \geq 26\ , \tilde{X}_{1\alpha_T}^{L,U} - \frac{(\delta_{\tilde{X}_1}^+)_{\alpha_T}^{L,U}}{1.2} \leq 26.6\,, (\delta_{\tilde{X}_1}^-)_{\alpha_T}^{L,U}, (\delta_{\tilde{X}_1}^+)_{\alpha_T}^{L,U} \leq 1.2 \quad (16)$$

$$\tilde{T}_{\tilde{X}_{2\alpha_T}^{L,U}} + (\delta_{\tilde{X}_2}^-)_{\alpha_T}^{L,U} + (\delta_{\tilde{X}_2}^+)_{\alpha_T}^{L,U} = 1\,, \tilde{X}_{2\alpha_T}^{L,U} + (\delta_{\tilde{X}_2}^-)_{\alpha_T}^{L,U} \geq 15\,, \tilde{X}_{2\alpha_T}^{L,U} - (\delta_{\tilde{X}_2}^+)_{\alpha_T}^{L,U} \leq 15.5\,, (\delta_{\tilde{X}_2}^-)_{\alpha_T}^{L,U}, (\delta_{\tilde{X}_2}^+)_{\alpha_T}^{L,U} \leq 1 \quad (17)$$

$$\tilde{T}_{\tilde{X}_{3\alpha_T}^{L,U}} + \frac{(\delta_{\tilde{X}_3}^-)_{\alpha_T}^{L,U}}{2} + \frac{(\delta_{\tilde{X}_3}^+)_{\alpha_T}^{L,U}}{2} = 1\,, \tilde{X}_{3\alpha_T}^{L,U} + \frac{(\delta_{\tilde{X}_3}^-)_{\alpha_T}^{L,U}}{2} \geq 16\,,\ \tilde{X}_{3\alpha_T}^{L,U} - \frac{(\delta_{\tilde{X}_3}^+)_{\alpha_T}^{L,U}}{2} \leq 17\,,\ (\delta_{\tilde{X}_3}^-)_{\alpha_T}^{L,U}, (\delta_{\tilde{X}_3}^+)_{\alpha_T}^{L,U} \leq 2 \quad (18)$$

$$0 \leq \alpha_T \leq 0.5$$

$$\text{Minimize } Z_{\alpha_F}^{L,U} = 0.10[(\omega_{\tilde{y}_1}^-)_{\alpha_F}^{L,U} - (\omega_{\tilde{y}_1}^+)_{\alpha_F}^{L,U}] + 0.15[(\omega_{\tilde{y}_2}^-)_{\alpha_F}^{L,U} - (\omega_{\tilde{y}_2}^+)_{\alpha_F}^{L,U}] + 0.25[(\omega_{\tilde{y}_3}^-)_{\alpha_F}^{L,U} - (\omega_{\tilde{y}_3}^+)_{\alpha_F}^{L,U}] + 0.35[(\omega_{\tilde{y}_4}^-)_{\alpha_F}^{L,U} - (\omega_{\tilde{y}_4}^+)_{\alpha_F}^{L,U}] + 0.10[(\delta_{\tilde{X}_1}^-)_{\alpha_F}^{L,U} + (\delta_{\tilde{X}_1}^+)_{\alpha_F}^{L,U} + (\delta_{\tilde{X}_2}^-)_{\alpha_F}^{L,U} + (\delta_{\tilde{X}_2}^+)_{\alpha_F}^{L,U} + (\delta_{\tilde{X}_3}^-)_{\alpha_F}^{L,U} + (\delta_{\tilde{X}_3}^+)_{\alpha_F}^{L,U}] \quad (19)$$

$$\left[1 - \tilde{F}_{\tilde{X}_{1\alpha_F}^{L,U}}\right] + \frac{(\delta_{\tilde{X}_1}^-)_{\alpha_F}^{L,U}}{0.6} + \frac{(\delta_{\tilde{X}_1}^+)_{\alpha_F}^{L,U}}{0.6} = 1\,, \tilde{X}_{1\alpha_F}^{L,U} + \frac{(\delta_{\tilde{X}_1}^-)_{\alpha_F}^{L,U}}{0.6} \geq 26\ , \tilde{X}_{1\alpha_F}^{L,U} - \frac{(\delta_{\tilde{X}_1}^+)_{\alpha_F}^{L,U}}{0.6} \leq 26.6\ , (\delta_{\tilde{X}_1}^-)_{\alpha_F}^{L,U}, (\delta_{\tilde{X}_1}^+)_{\alpha_F}^{L,U} \leq 0.6 \quad (20)$$

$$\left[1 - \tilde{F}_{\tilde{X}_{2\alpha_F}^{L,U}}\right] + \frac{(\delta_{\tilde{X}_2}^-)_{\alpha_F}^{L,U}}{0.5} + \frac{(\delta_{\tilde{X}_2}^+)_{\alpha_F}^{L,U}}{0.5} = 1, \tilde{X}_{2\alpha_F}^{L,U} + \frac{(\delta_{\tilde{X}_2}^-)_{\alpha_F}^{L,U}}{0.5} \geq 15\,, \tilde{X}_{2\alpha_F}^{L,U} - \frac{(\delta_{\tilde{X}_2}^+)_{\alpha_F}^{L,U}}{0.5} \leq 15.5\,, (\delta_{\tilde{X}_2}^-)_{\alpha_F}^{L,U}, (\delta_{\tilde{X}_2}^+)_{\alpha_F}^{L,U} \leq 0.5 \quad (21)$$

$$\left[1 - \tilde{F}_{\tilde{X}_{3\alpha_F}^{L,U}}\right] + (\delta_{\tilde{X}_3}^-)_{\alpha_F}^{L,U} + (\delta_{\tilde{X}_3}^+)_{\alpha_F}^{L,U} = 1, \tilde{X}_{3\alpha_F}^{L,U} + (\delta_{\tilde{X}_3}^-)_{\alpha_F}^{L,U} \geq 16\,, \tilde{X}_{3\alpha_F}^{L,U} - (\delta_{\tilde{X}_3}^+)_{\alpha_F}^{L,U} \leq 17, (\delta_{\tilde{X}_3}^-)_{\alpha_F}^{L,U}, (\delta_{\tilde{X}_3}^+)_{\alpha_F}^{L,U} \leq 1 \quad (22)$$

$$0.5 \leq \alpha_F \leq 1$$

The obtained optimal process conditions were found to be:

TABLE III
THE OBTAINED OPTIMAL PROCESS CONDITIONS

		$\tilde{X}_1$		$\tilde{X}_2$		$\tilde{X}_3$	
α_t	w	$(\tilde{X}_1)_{\alpha_t}^L$	$(\tilde{X}_1)_{\alpha_t}^u$	$(\tilde{X}_2)_{\alpha_t}^L$	$(\tilde{X}_2)_{\alpha_t}^U$	$(\tilde{X}_3)_{\alpha_t}^L$	$(\tilde{X}_3)_{\alpha_t}^U$
0.15	2	19.603	25.443	14.767	17.631	9.031	13.401
0.45	2	20.991	26.005	15.007	18.465	11.121	13.964
α_f	w	$(\tilde{X}_1)_{\alpha_f}^L$	$(\tilde{X}_1)_{\alpha_f}^u$	$(\tilde{X}_2)_{\alpha_f}^L$	$(\tilde{X}_2)_{\alpha_f}^U$	$(\tilde{X}_3)_{\alpha_f}^L$	$(\tilde{X}_3)_{\alpha_f}^U$
0.55	1	21.228	27.123	15.555	19.369	12.008	14.785
0.95	1	21.701	27.789	16.010	19.899	12.897	15.888

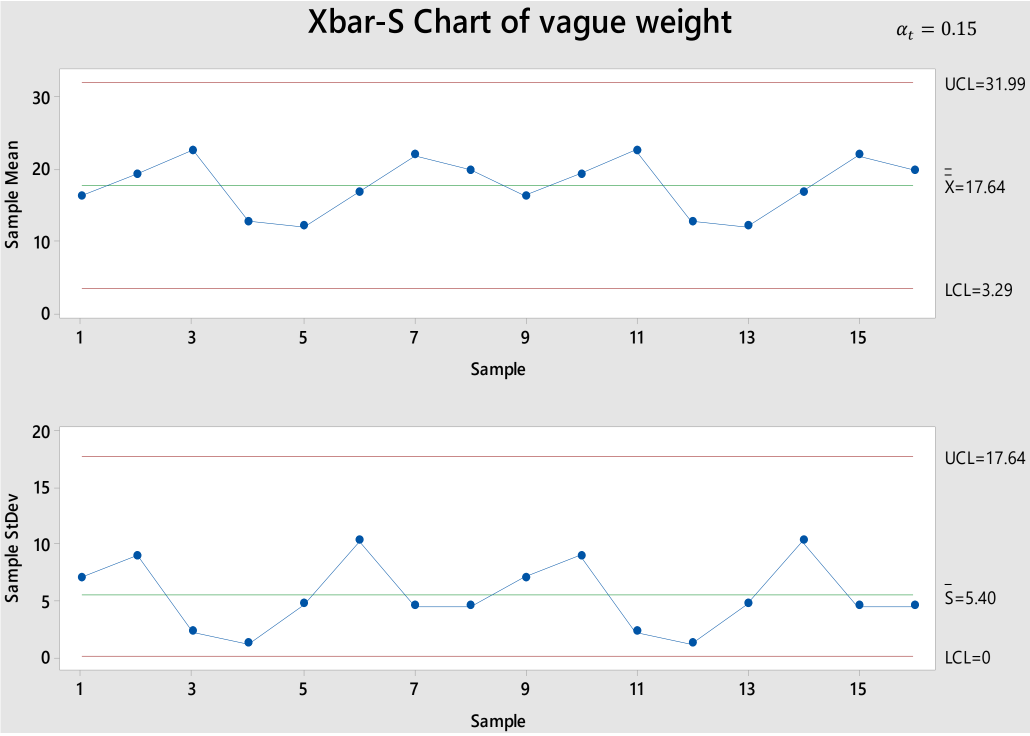
The expected values for the Weight (g), Height (mm), Crater diameter (mm), and Volume (cc) are calculated as 18 g, 130 mm, 116 mm and 850 cc, respectively.

The vague control chart for the four factors of weight, height, crater diameter and volume is shown in Fig. 3.

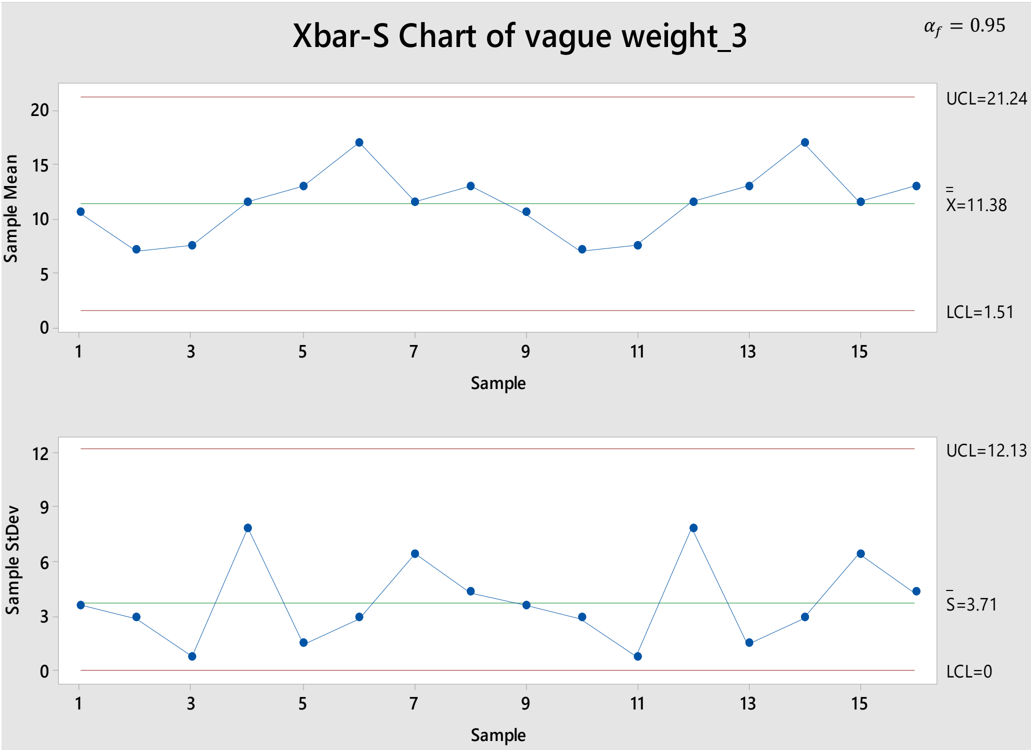
A. Discussion

Organizations are able to make the best decisions in a variety of ways and have the best performance in order to adopt the process' effectiveness and the ability and efficiency of the production process. Considering the calculations and the control charts, we analyzed the sensitivity of the system function by considering the vague conditions of the distancing based uncertainty. The CP_k values for the averages of disposable glasses' weight, height, crater diameter, and volume are 1.38, 1.89, 1.80 and 2.28, respectively. The corresponding improvement relations were found to be 69.5%, 45.5%, 36% and 33.3%, respectively. Thus, results will affect in significant recovery in quality and thereby they increase productivity. By increasing the amount ofα_t, α_f and$w$, the amount of CP_k decreases, as a result, the amount of dispersion increases and the process acts out of the center, which increases the amount of waste and we are at Level2σ, at this level, customers are satisfied with the organization, but they are putting a lot of pressure on the organization, such as low-profit margins, high operating costs, and a lot waste. Regarding the average deviation, we find that this deviation are due to machine error and is not related to sampling error and requires 100% inspection. Regarding waste recycling, the cost of rebuilding and rework increases. Therefore, in general, when we increase the amount ofα_t, α_f and$w$, the processing ability becomes less and the process will be less accurate, but it will work properly.

The main reason for these problems can be attributed to the accuracy of the device due to its exhaustion or the operator's skill changes (losing skill).

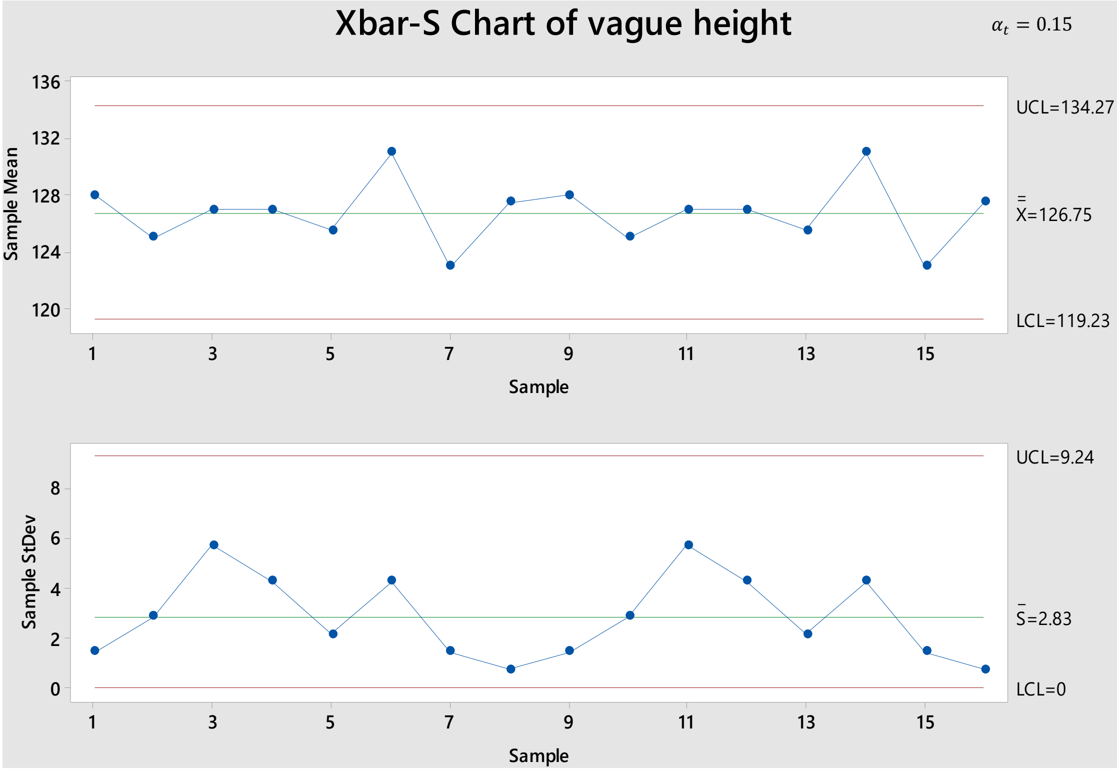


(a-1)

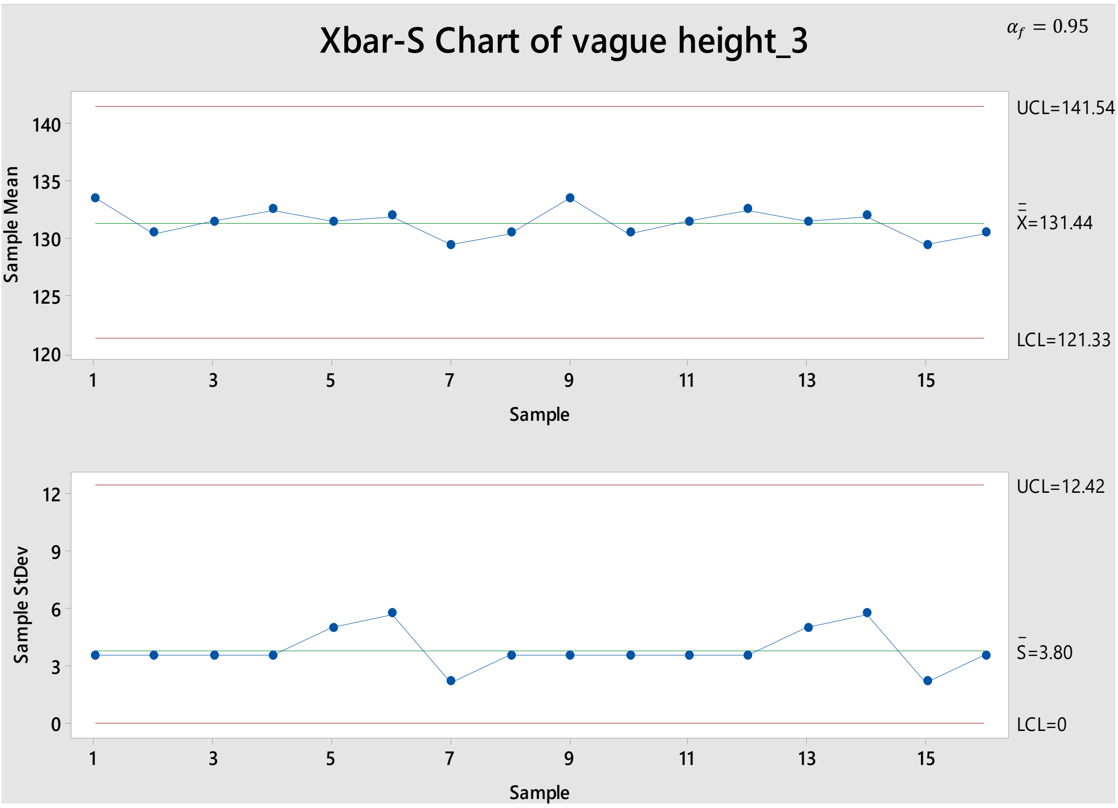


(a-2)

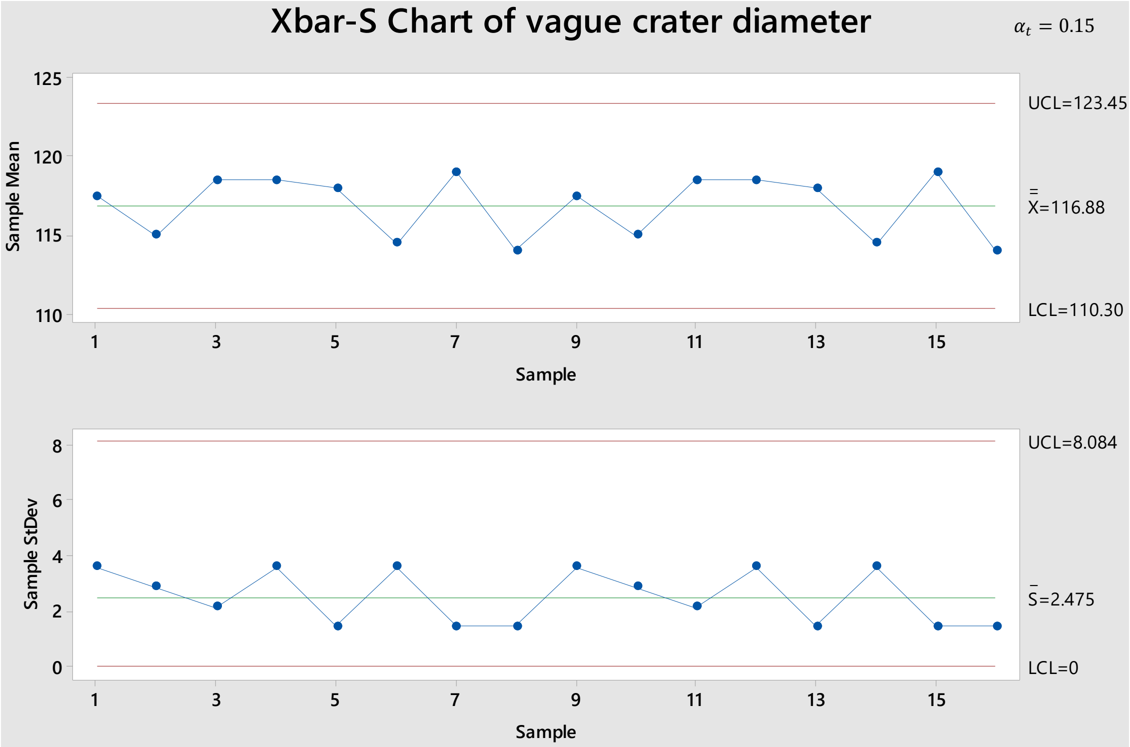
International Journal of Mechanical, Industrial and Aerospace Sciences
ISSN: 2517-9950
Vol:12, No:1, 2018



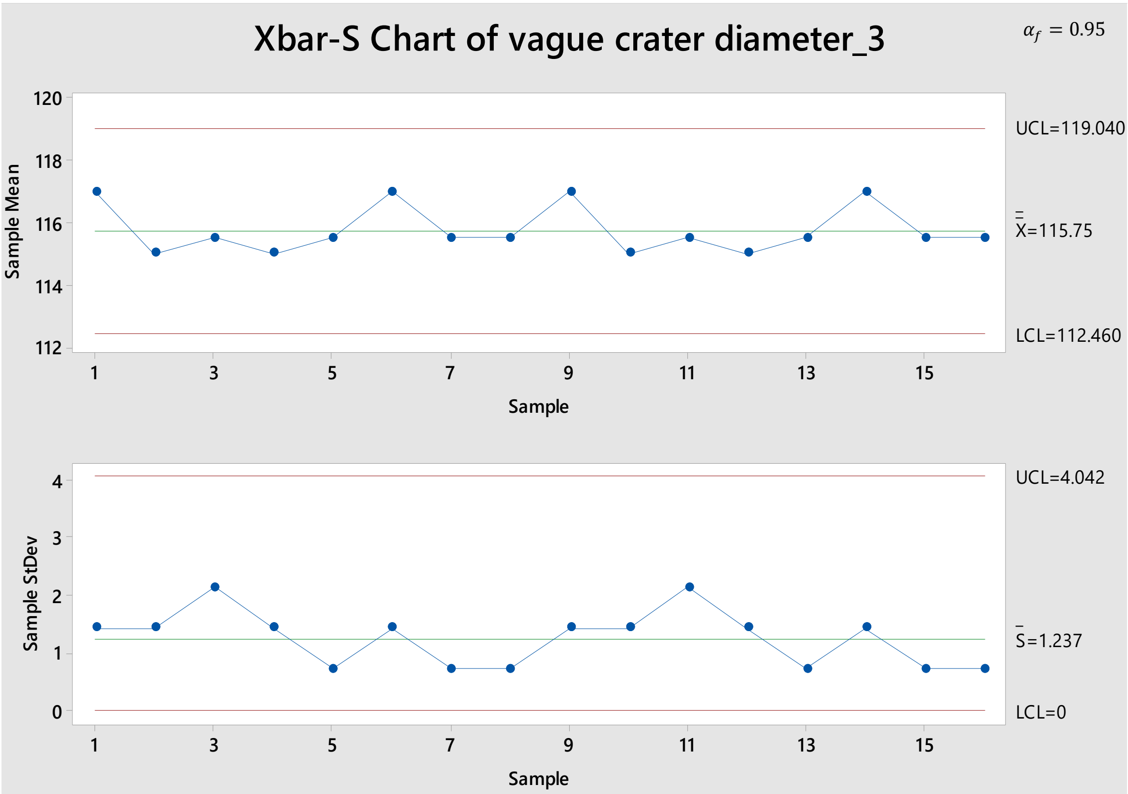
(b-1)



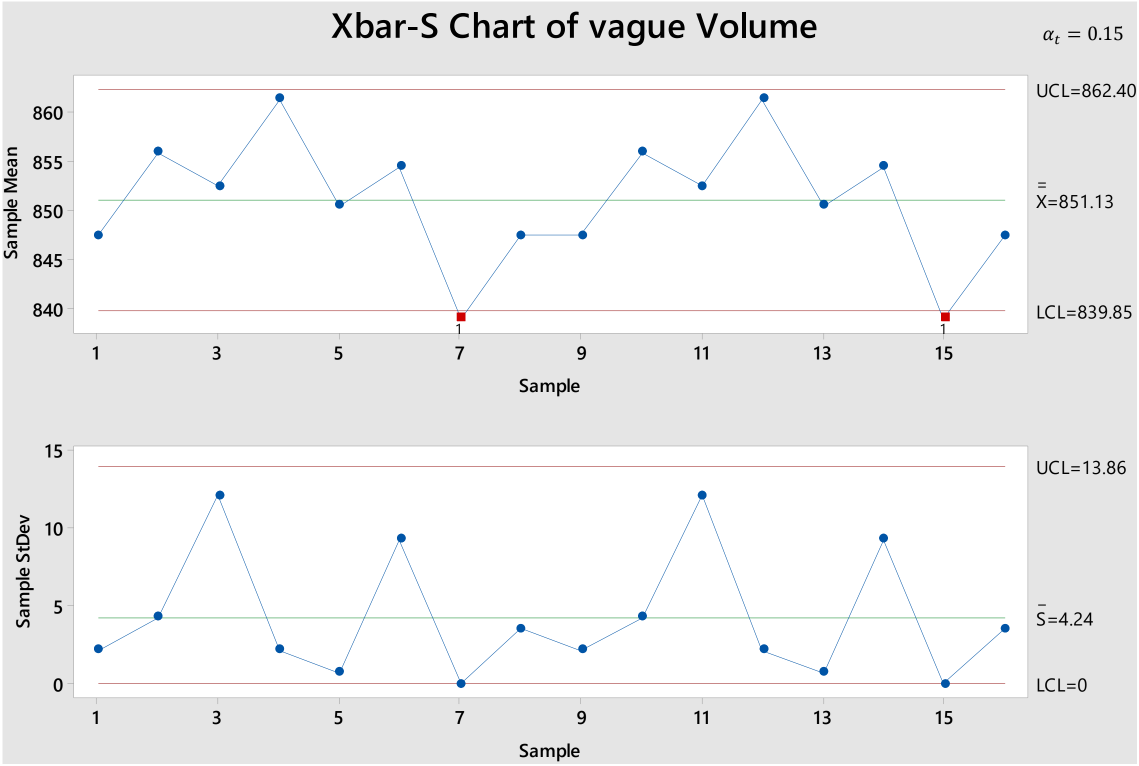
(b-2)


Xbar-S Chart of vague crater diameter
$\alpha_t = 0.15$
Sample Mean
125
120
115
110
UCL=123.45
X=116.88
LCL=110.30
1
3
5
7
9
11
13
15
Sample
Sample StDev
8
6
4
2
0
UCL=8.084
S=2.475
LCL=0
Sample

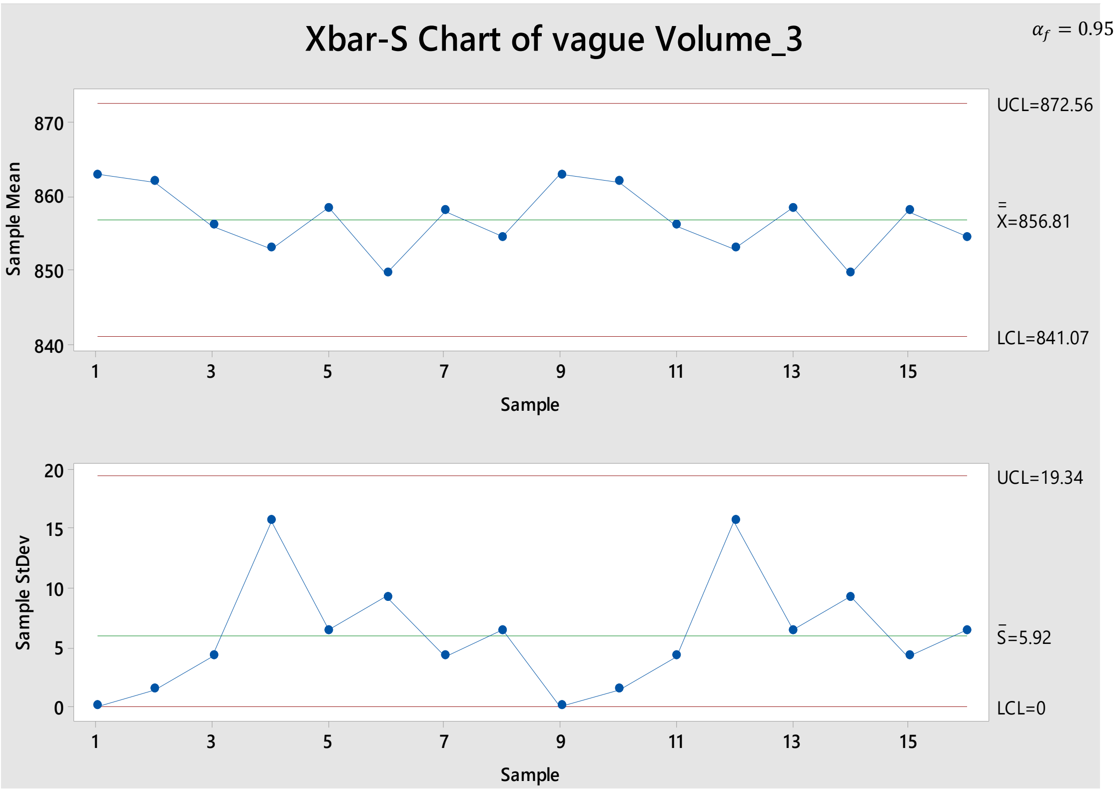
(c-1)


Xbar-S Chart of vague crater diameter_3
$\alpha_f = 0.95$
Sample Mean
120
118
116
114
112
UCL=119.040
X=115.75
LCL=112.460
1
3
5
7
9
11
13
15
Sample
Sample StDev
4
3
2
1
0
UCL=4.042
S=1.237
LCL=0
Sample

(c-2)



(d-1)



(d-2)

Fig. 3 The $\bar{x} - s$ charts for average disposable glasses at vague factor settings

V. Conclusion

Given that the fuzzy quality control charts have greater flexibility than classical control charts; their use reduces the time needed to detect abnormalities in the process being investigated. This paper explains improving the performance of the disposable essentials process using statistical quality control and GP in an unclear environment. Therefore, in this study, the conditions are examined in a vague environment that is an environment based on distance. The statistical quality control tools were used for the four factors referred to the disposable glasses production process. Optimization results showed that the process capability index values for disposable glasses' averages of weight, height, crater diameter and volume relative to the classical model were improved accordingly. Such improvements resulted in significant savings in production costs and increase quality. The CP_k values for the averages of disposable glasses' weight, height, crater diameter, and volume were improved, respectively. In this way, the results will have a significant effect on improving quality and thus increasing productivity.

The value goal of the membership function is almost equal in both conditions, which shows that the distance between these two membership functions is relatively little and they found a heuristic fuzzy membership function.

References

[1] Kaya I., Kahraman C. (2011). Process capability analyses based on fuzzy measurements and fuzzy control charts. Expert Systems with Application7s, Vol. 38, pp. 3172–3184.

[2] Hung Shu. M, Chung Wu. H. (2011). Fuzzy X and R control charts: Fuzzy dominance approach. Computers & Industrial Engineering, Vol. 61, pp. 676–685.

[3] Erginel, N., Sentürk, S., Kahraman, C., & Kaya. I. (2011). Evaluating the Packing Process in Food Industry Using Fuzzy and [Stilde] Control Charts. International Journal of Computational Intelligence Systems ,4 (4), 509-520.

[4] Lin H-C. Su C-T. Wang C-C. Chang B-H. and Juang R-C. "Parameter optimization of continuous sputtering process based on Taguchi methods, neural networks, desirability function, and genetic algorithms," Expert Systems with Applications, Vol. 39(17): 2012, pp. 12918–12925.

[5] AL-Refaie A., T. Chen, R. Al-Athamneh, H. C. Wu, "Fuzzy neural network approach to optimizing process performance by using multiple responses," Journal of Ambient Intelligence and Humanized Computing, Vol. 7 (6), 2016, pp. 801-816.

[6] Al-Refaie A. and A. Diabat, "Optimizing convexity defect in a tile industry using fuzzy goal programming," Measurement, Journal of the International Measurement Confederation, Vol. 46 (8), 2013, pp. 2807-2815.

[7] Al-Refaie A., "Optimizing multiple quality responses in the Taguchi method using fuzzy goal programming: modeling and applications," International Journal of Intelligent Systems, Vol. 30(6), 2015a, pp. 651–675.

[8] V. A. Gonzalez-Lopez, R. Gholizadeh, A. M. Shirazi: Optimization of queuing theory based on vague environment, International Journal of Fuzzy System Applications, Volume 5 Issue 1, 1-26, 2016.

[9] A. B. Ubale, S. L. Sananse. "Fuzzy Regression Model and Its Application: A Review", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, Issue 11, November 2015.

[10] Jones D. F, Tamiz M. (2010) Practical Goal Programming, Springer Books.

[11] Abbas Al-Refaie," Optimizing Performance of Tablet's Direct Compression Process Using Fuzzy Goal Programming", International Journal of Computer, Electrical, Automation, Control and Information Engineering Vol:11, No:5, 2017.

[12] A. R. Arabpour and M. Tata (2008). Estimating the Parameters Of A Fuzzy Linear Regression Model. Iranian Journal of Fuzzy Systems Vol. 5, No. 2, (2008) pp. 1-19.