

# The Use of Fuzzy Logic Theory in Control Charts (A Comparative Study)

Afraa Abbas Hamada<sup>a</sup>, Hameedah Naeem Melik<sup>b</sup>, Saif Hosam Raheem<sup>c</sup>,  
<sup>a,b,c</sup>Department of Statistics. university of al- Qadisiyah.college of Management  
and Economics. Iraq, Email: <sup>a</sup>[AFRAA103@Yahoo.com](mailto:AFRAA103@Yahoo.com),  
<sup>b</sup>[hameedah.naeem@qu.edu.iq](mailto:hameedah.naeem@qu.edu.iq), <sup>c</sup>[saif.hosam@qu.edu.iq](mailto:saif.hosam@qu.edu.iq)

One of the concepts used in the production process is statistical process control (SPC), in which statistical methods are used to control production. Therefore, control charts have been developed as an important method in diagnosing and controlling non-random deviations if any exist. And among these charts are the average plate  $\bar{x}$ - and the range R. Where these charts were called control charts for the variables, which consist of upper, lower and middle limits for control represented by numerical values. The productive process in institutions is either under control or out of control, depending on the values of digital observations that can be calculated, but in many cases that limit cannot be calculated accurately. Therefore, the use of the fuzzy set theory came to deal with uncertainty and inaccuracy as a result of workers or measuring devices, and environmental conditions. This was achieved by converting the numerical control boundaries to fuzzy control boundaries using fuzzy logic to give the boundaries accurate and more flexible values in making the appropriate decision for the production process when compared to traditional control charts. This research was applied in a mineral water purification plant in the design of the fuzzy control panel.

**Key words:** *Statistical control, fuzzy logic, fuzzy control charts.*

## Introduction

The statistical method is one of the important methods in the control of production, which reveals the extent of conformity of the situation with the specifications determined by the relevant authority. Also, it is one of the methods that affect decision-making according to the specifications set for it from the beginning of the stage until the completion. The aim of this is to limit the deviation from Specific features (1). The scientist Walter A. Shewhart developed

the statistical control panel in the twenties, as it is one of the methods in controlling quality and discovering non-random deviations if it existed (Abdul Rahim). The statistical method used in industrial and health facilities is to withdraw random samples from the cases to be studied and, based on measurements, the cases are then examined with one variable or characteristic using control charts (1). Fuzzy logic has been relied upon in quality control when the age of the industry is the same as the age of quality control. Therefore, continuous training for trainees and workers functions so that the commodity gets to the best quality through proficiency, in addition to the continuous control of the product during the manufacturing stages. For instance, Heaters and washing machines, which have been proven to be used for industrial products, depend on its advantages of simplicity, low cost, and high production. It is an appropriate technology in applications within control units. There are many industrial facilities with automatic production lines that rely on fuzzy logic in technology to decrease development time and product quality. And its use has proven to be an indispensable technology in increasing the efficiency of production lines and diagnosing their defaults as being intended to address complex systems in obtaining highly accurate results (5). The Fuzzy Logic model is one of the techniques used in complex systems that describe the system by forming relationships between the variables in the system for its clear analysis and interpretation (5).

### ***Statistical Quality Control***

It is a scientific method in statistics that is used to monitor production processes by using control charts in terms of product quality, and the diagnosis and removal of causes that led to poor product quality, whether the cause is artistic or technical. Quality control can be divided into two types: the first is control overproduction, and the second is control over the production process. It is a decision-making process on the production process, as it is one of the factors that determine the ability of industrial or productive institutions to compete in the long run.

### ***Quality Control Charts***

It is one of the scientific means to control the quality of the product (medical, service, production) to reach the best services according to the required and particular features. The preparation of quality control charts is based on the use of the arithmetic mean, range or standard deviation and the main objective of its use is to diagnose actual abnormal changes in scientific parameters, which are the average and standard deviation, and work to remove them. Thus, the goal of using control charts by Walter A. Shewhart was to control a high-quality level of the product or deviations in quality (1)

### Fuzzy Control charts ( $\tilde{x}, \tilde{R}$ )

The X-bar chart is the most used scheme for controlling the process. It means the quality level as well. It is the first chart designed for Walter A. Shewhart and named the rate panel to control the production process and the level of quality. Also, the process variation can be controlled either through a control scheme for samples, called - chart R or the control pattern for the standard deviation, which is called the S-chart:

It can formulate the chart of  $\tilde{X}$  – chart ( $\tilde{R}$ ) as follows (4)

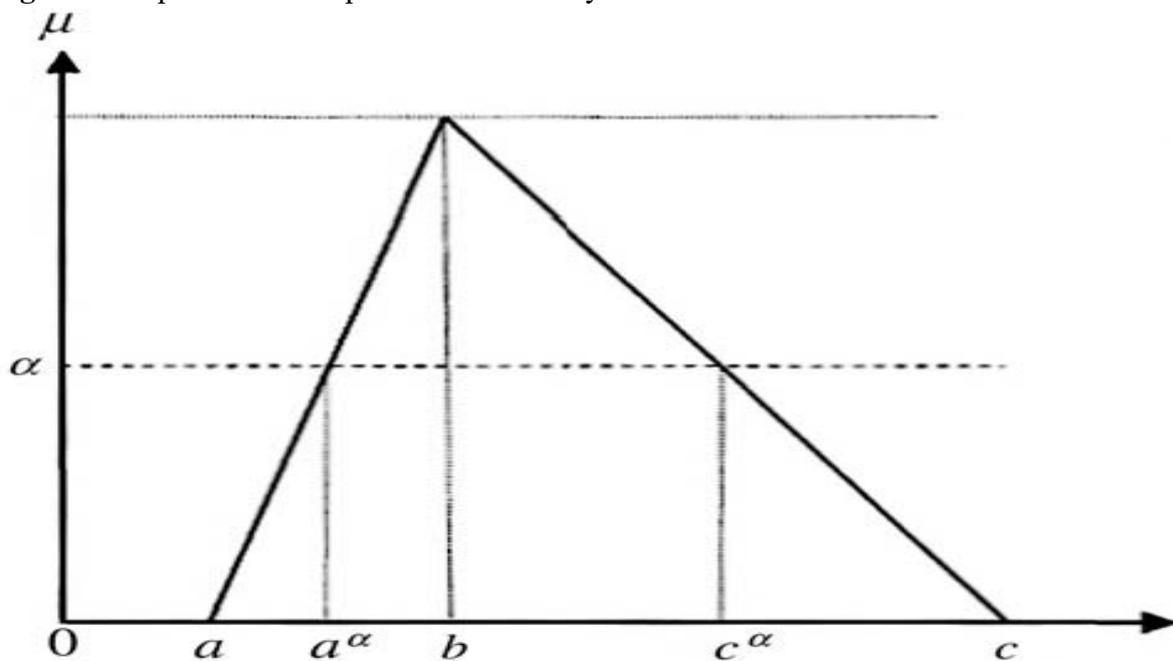
$$UCL_{\tilde{X}} = \bar{\bar{X}} + A_2 \bar{R} \quad (1)$$

$$CL_{\tilde{X}} = \bar{\bar{X}} \quad (2)$$

$$LCL_{\tilde{X}} = \bar{\bar{X}} - A_2 \bar{R} \quad (3)$$

Where  $A_2$  is the control chart parameter in the graph, and  $\bar{R}$  is the average mean of the samples in the fuzzy state, where each sample is represented by triple or quadruple fuzzy numbers  $(a, b, c)$  where  $(a \leq b \leq c)$ , as shown in the figure (1):

**Figure 1.** Represents a sample with three fuzzy numbers



The main objective of this study is to define a general picture of fuzzy control schemes with fuzzy control boundaries which achieve a more accurate and flexible evaluation, where the numerical plate boundaries have been able to convert to the boundaries of fuzzy charts by using the organic function, and where triple fuzzy numbers are represented. The triple ambiguous numbers have been represented by  $(x_a, x_b, x_c)$ .

Each fuzzy view where  $cl \sim$  is a midline of the fuzzy samples

The upper limit of control is known as:

$$\begin{aligned} U\tilde{C}L_{\bar{X}} &= \tilde{C}L_{\bar{X}} + A_2 \bar{R} = (\bar{X}_a, \bar{X}_b, \bar{X}_c) + A_2 (\bar{R}_a, \bar{R}_b, \bar{R}_c) \\ &= (\bar{X}_a + A_2 \bar{R}_a, \bar{X}_b + A_2 \bar{R}_b, \bar{X}_c + A_2 \bar{R}_c) \\ &= (U\tilde{C}L_1, U\tilde{C}L_2, U\tilde{C}L_3) \dots \dots (4) \end{aligned}$$

While the mid limit as follows:

$$\tilde{C}L_{\bar{X}} = (\bar{X}_a, \bar{X}_b, \bar{X}_c) = (\tilde{C}L_1, \tilde{C}L_2, \tilde{C}L_3) \dots \dots (5)$$

And the minimum control limit is defined as follows:

$$\begin{aligned} L\tilde{C}L_{\bar{X}} &= \tilde{C}L_{\bar{X}} - A_2 \bar{R} = (\bar{X}_a, \bar{X}_b, \bar{X}_c) - A_2 (\bar{R}_a, \bar{R}_b, \bar{R}_c) : \\ &= (\bar{X}_a - A_2 \bar{R}_c, \bar{X}_b - A_2 \bar{R}_b, \bar{X}_c - A_2 \bar{R}_a) \\ &= (L\tilde{C}L_1, L\tilde{C}L_2, L\tilde{C}L_3) \dots \dots (6) \end{aligned}$$

Where:

$$R_i = \sum_{j=1}^m R_{ij} \quad i=a,b,c \quad ,j=1,2,3,\dots,m$$

And its been measured  $R_{ij}$  as

$$R_{aj} = X_{\max aj} - X_{\min cj}$$

$$R_{bj} = X_{\max bj} - X_{\min cj}$$

$$R_{cj} = X_{\max cj} - X_{\min aj}$$

Where  $(X_{\max aj}, X_{\max bj}, X_{\max cj})$  are high limits for fuzzy numbers for each  $j^{th}$  sample  
Note that

$$\bar{R}_a = \sum R_{aj} / m, \bar{R}_b = \sum R_{bj} / m, \bar{R}_c = \sum R_{cj} / m \quad ..(7)$$

### Formulation Limits of Fuzzy Control Charts in the Cut Rate ( $\alpha$ )

The  $\alpha$ -cut level is in non-fuzzy sets and for all elements in the set which their membership is greater than or equal to ( $\alpha$ ). Where  $A_\alpha$  is identified as It represents the cutting set level ( $\alpha$ )

Where:

$$\{ A_\alpha = x \mid \mu_A(x) \geq \alpha \geq 0, \quad \alpha \leq 1 \}$$

When applying the Fuzzy Cut Level on the control charts ( $\tilde{X}$ ), the main control limits according to the levels  $(U\tilde{C}L, \tilde{C}L, L\tilde{C})$  are as follows (3):

The maximum limit for control is

$$= U\tilde{C}L_x^\alpha = C\tilde{L}_x^\alpha + A_2 \bar{R}_x^\alpha$$

$$(\bar{X}_a^\alpha, \bar{X}_b, \bar{X}_c^\alpha) + A_2 (\bar{R}_a^\alpha, \bar{R}_b, \bar{R}_c^\alpha) \quad ....(8)$$

$$=(+A_2 \bar{R}_a^\alpha, \bar{X}_b + A_2 \bar{R}_b, \bar{X}_c^\alpha + A_2 \bar{R}_c^\alpha) \bar{X}_a^\alpha$$

$$=(U\tilde{C}L_1^\alpha, U\tilde{C}L_2, U\tilde{C}L_3, )$$

So, the central limit for control is

$$\tilde{C}L_x^\alpha = (\bar{X}_a^\alpha, \bar{X}_b, \bar{X}_c^\alpha) = (\tilde{C}L_1^\alpha, \tilde{C}L_2, \tilde{C}L_3) \quad ....(9)$$

While the minimum limit for control will be

$$= L\tilde{C}L_x^\alpha = C\tilde{L}_x^\alpha - A_2 \bar{R}_x^\alpha$$

$$= (\bar{X}_a^\alpha, \bar{X}_b, \bar{X}_c^\alpha) - A_2 (\bar{R}_a^\alpha, \bar{R}_b, \bar{R}_c^\alpha)$$

$$=(-A_2 \bar{R}_a^\alpha, \bar{X}_b - A_2 \bar{R}_b, \bar{X}_c^\alpha - A_2 \bar{R}_c^\alpha) \bar{X}_a^\alpha$$

$$:=(L\tilde{C}L_1^\alpha, L\tilde{C}L_2, L\tilde{C}L_3) \quad ....(10)$$

Whereas

$$\begin{aligned}\bar{X}_a^\alpha &= \bar{X}_a + \alpha (\bar{X}_b - \bar{X}_a) \\ &= \bar{X}_c + \alpha (\bar{X}_c - \bar{X}_b) \quad \bar{X}_c^\alpha \\ \bar{R}_a^\alpha &= \bar{R}_a + \alpha (\bar{R}_b - \bar{R}_a) \\ \bar{R}_c^\alpha &= \bar{R}_c + \alpha (\bar{R}_c - \bar{R}_b)\end{aligned}$$

**Control Charts for the Level of Fuzzy Cut (A-CUT) For Medium ( $\tilde{X}$ ) and Average Fuzzy Range ( $\bar{R}$ )**

Average Fuzzy Cut ( $\alpha$ -CUT) is a technology among the four that are used to define the boundaries of Fuzzy Control, and also Control Boundaries are used to decide whether operations are under control or out of control.

To obtain the limits of the control charts for the fuzzy cut level through the following (6):

$$U\tilde{C} L_{mr-\bar{x}}^\alpha = C \tilde{L}_{mr-\bar{x}}^\alpha + A_2 \left( \frac{\bar{R}_a^\alpha + \bar{R}_c^\alpha}{2} \right) \dots (11)$$

$$\tilde{C} L_{mr-\bar{x}}^\alpha = f_{mr-\bar{x}}^\alpha (C\tilde{L}) = \left( \frac{\bar{X}_a^\alpha + \bar{X}_c^\alpha}{2} \right) \dots (12)$$

$$L\tilde{C} L_{mr-\bar{x}}^\alpha = C \tilde{L}_{mr-\bar{x}}^\alpha - A_2 \left( \frac{\bar{R}_a^\alpha + \bar{R}_c^\alpha}{2} \right) \dots (13)$$

With condition of achieving the equation (14) below for each sample as follows:

$$P \text{ rocess control} = \{ \text{incontrol} ; \text{for } L\tilde{C} L_{mr-\bar{x}}^\alpha \leq S_{mr-\bar{x}.j}^\alpha \leq U\tilde{C} L_{mr-\bar{x}}^\alpha \} \quad (14)$$

Whereas

$$S_{mr-\bar{x}.j}^\alpha = \frac{(\bar{x}_{aj} + \bar{x}_{cj}) + \alpha [(\bar{x}_{bj} - \bar{x}_{aj}) - (\bar{x}_{cj} - \bar{x}_{bj})]}{2}$$

According to the  $S_{mr-\bar{x}.j}^\alpha$  value , for each sample to choose a suitable decision for each control process.

**Control Fuzzy Chart to the Range  $\tilde{R}$**

$$UCL_R = D_4 \bar{R} \dots (16)$$

$$CL_R = \bar{R} \dots (17)$$

$$LCL_R = D_3 \bar{R} \dots (18)$$

$D_3, D_4$  represent control chart parameters. These effective values are obtained by using the efficient common table presented by Montgomery in (2005). Using the traditional procedure with control charts (R), the limits of the fuzzy control charts to the range ( $\tilde{R}$ ) with the three fuzzy numbers are as follows:

$$= D_4(\bar{R}_a, \bar{R}_b, \bar{R}_c) \dots (19) U\tilde{C}L_R = D_4\bar{R}$$

$$= \bar{R} = (\bar{R}_a, \bar{R}_b, \bar{R}_c) \dots (20) \tilde{C}L_R$$

$$L\tilde{C}L_R = D_3\bar{R} = D_3(\bar{R}_a, \bar{R}_b, \bar{R}_c) \dots (21)$$

### ***Control Limits for fuzzy a-Cut Level ( $\alpha$ ) in the control chart to the fuzzy Range ( $\tilde{R}$ )***

Control charts boundaries for fuzzy triple numbers to the average fuzzy range are calculated as follows (7):

$$U\tilde{C}L_R^\alpha = D_4(\bar{R}_a^\alpha, \bar{R}_b^\alpha, \bar{R}_c^\alpha) \dots (22)$$

$$= (\bar{R}_a^\alpha, \bar{R}_b^\alpha, \bar{R}_c^\alpha) \dots (23) \tilde{C}L_R^\alpha$$

$$L\tilde{C}L_R^\alpha = D_3(\bar{R}_a^\alpha, \bar{R}_b^\alpha, \bar{R}_c^\alpha) \dots (24)$$

### ***The Average Fuzzy A-Cut Level in the Control Chart at the Fuzzy Range Chart ( $\tilde{R}$ )***

Control chart limits for fuzzy numbers to the triple average fuzzy range that are calculated as follows (7):

$$U\tilde{C}L_{mr-R}^\alpha = D_4 f_{mr-R}^\alpha (\tilde{C}L) \dots (25)$$

$$= \tilde{C}L_{mr-R}^\alpha f_{mr-R}^\alpha (\tilde{C}L) = \frac{\bar{R}_a^\alpha + \bar{R}_d^\alpha}{2} \dots (26)$$

$$= D_3 f_{mr-R}^\alpha (\tilde{C}L) \dots (27) L\tilde{C}L_{mr-R}^\alpha \dots (27)$$

Fuzzy techniques are used to determine the control charts as under control or out of control after measuring the control charts limits. The ambiguous sample means of the (j) sample for the average of fuzzy range is used to convert fuzzy numbers according to fuzzy conversion methods and transform them to specific numbers.

Therefore, the main requirement in each process for each sample can be defined as follows:

$$\left\{ \begin{array}{l} \text{process incontrol : for } L\tilde{C}L_{mr-R}^\alpha \ll S_{mr-R,j}^\alpha \ll U\tilde{C}L_{mr-R}^\alpha \dots (28) \\ \text{Out of control : otherwise} \end{array} \right.$$

In this paper, a modern method has used for the average fuzzy range, the level of average  $\alpha$  that and defined as:

$$\frac{(R_{aj}+R_{cj})+\alpha[(R_{bj}+R_{aj})-(R_{cj}-R_{bj})]}{2} \dots (29) S_{mr-R,j}^{\alpha}$$

Therefore, the values of  $S_{mr-R,j}^{\alpha}$  are compared to all samples and the appropriate decision is made about the production process.

### Practical Application

This research looks at applying the properties of the fuzzy model to control charts through documented data from a mineral water laboratory in Baghdad for the substance (hypo) in the water bottles, where a graph formulation has been designed for fuzzy control charts consisting of samples. The size of each sample is 4, and the total views are (40 = 4 \* 10), which were taken from production operations in a mineral water factory, as shown in Table No. 1 below:

Table No.1: Shows the percentage of chlorine in the water bottle for ten days.

samples	$x_1$	$x_2$	$x_3$	$x_4$	$\bar{x}$	R
1	19.52	19 .61	14 .2	13. 5	16. 7	6. 11
2	23 .1	24 .07	17 .75	15. 33	20. 0	8. 74
3	5.22	21 .22	16 .15	13. 55	18. 3	8. 95
4	24 .1	23 .22	15. 23	22. 22	21 .1	8. 87
5	11.17	20 .33	12 .66	16. 77	16. 7	7. 67
6	21 .31	19 .52	18. 15	23. 07	20. 5	4. 92
7	19 .07	19 .08	17 .55	24 .07	19. 9	6. 52
8	19 .23	22. 61	17. 22	15. 95	18. 7	6. 66
9	19 .52	20. 55	23. 23	19. 08	20. 5	4. 15
10	25 .11	19. 07	17. 15	23. 55	21. 22	7. 96

Whereas

$$(n = 4, \bar{R} = 7.055, \bar{X} = 19.3, A_2 = 0.73, D_4 = 2.3, D_3 = 0)$$

When we apply the equations (1,2,3) we get the following

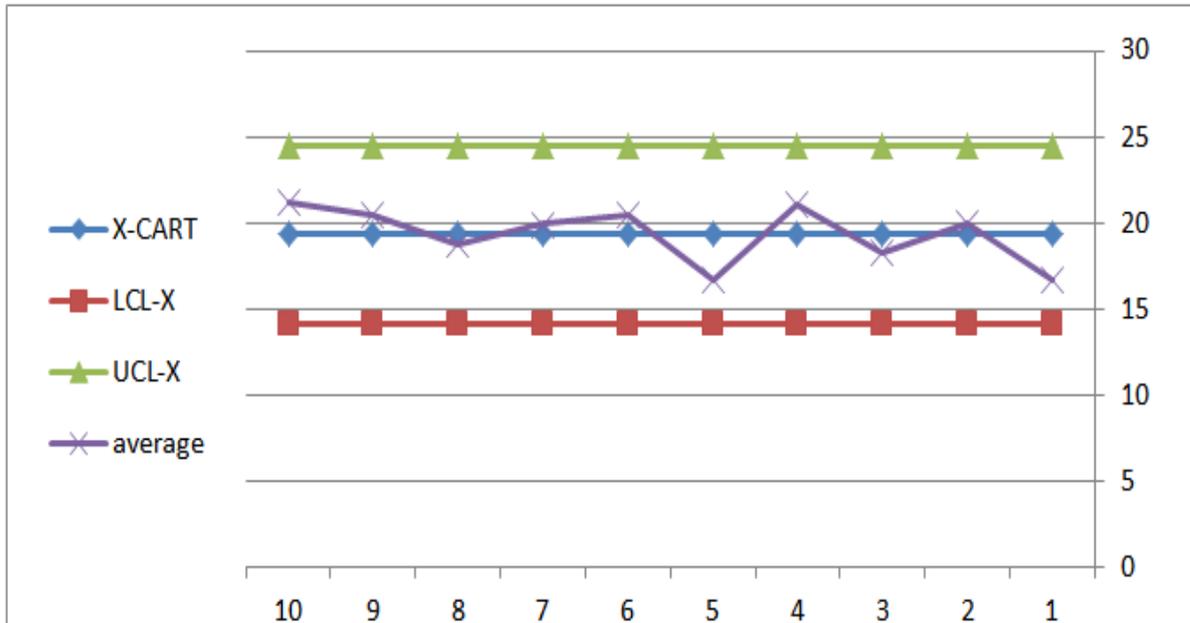
$$= 24.45 \quad UCL_{\bar{x}}$$

$$CL_{\bar{x}} = 19.3$$

$$= 14.15 \quad LCL_{\bar{x}}$$

Through what we have got above we draw the following graph to the control chart

**Graph 2.** shows the control chart to average



**Table 2:** shows the values of fuzzy views

Sample no.	$x_a$				$x_b$				$x_c$			
	1	2	3	4	1	2	3	4	1	2	3	4
1	14.5	15.1	14.9	14.9	19.5	15.2	19.2	15.9	23.0	19.5	21.3	23.0
				7	5			5	7	2		7
2	19.0	17.3	16.5	20.0	19.5	21.0	19.5	21.6	24.0	23.3	22.52	22.3
	8			7	52	7		1	7			1
3	17.7	15.7	17.5	19.3	19.5	17.7	23.5	20.3	21.5	17.9	25.07	21.2
	5				3	5		3	2	7		2
4	17.0	20.85	14.0	17.5	23.5	23.0	17.7	19.3	25.7	24.0	23.2	24.0
	7		7	2	5	7	5	5	5	7		7
5	15.9	17.07	16.7	14.5	17.0	19.7	23.5	17.0	17.3	23.5	23.17	23.7
					0	5		5	3	2		5
6	19.0	15.3	15.5	13.0	21.0	19.5	17.7	14.2	24.3	21.5	19.75	21.3
	6			7	52	2	6					
7	22.0	17.6	13.3	23.0	23.0	25.9	17.9	26.3	25.9	17.7	27.75	29.5
	7			7	06	5	7	3	5	5		
8	21.5	18.3	16.1	15.9	23.0	24.0	19.1	23.0	23.0	26.3	19.52	26.3
				7	07	7	6	5	7	3		1

9	15.3	20.55	17.7 5	17.7 5	24. 07	21.3	20.8 5	20.7	29.5 2	21.5 5	24.07	21.5 1
10	20.0	14.31	21.3	7.75	20. 15	24.2	25.7	15.3 1	21.3	25.7 5	29.33	22.9 5

Through Table (3), it shows the arithmetic mean and the fuzzy range after calculating it from the above table:

**Table 3:** Shows the fuzzy range and arithmetic mean

samples	$\bar{x}_a$	$\bar{x}_b$	$\bar{x}_c$	$R_a$	$R_b$	$R_c$
1	14.86	17.46	21.74	0.6	4.3	3.55
2	18.23	20.42	23.05	3.57	2.11	1.76
3	17.56	20.22	21.44	3.6	5.75	7.1
4	17.37	20.91	24.27	6.78	5.75	2.55
5	16.04	19.32	21.94	2.57	6.5	6.42
6	15.73	18.25	21.71	5.99	7.32	4.55
7	19.01	23.32	25.23	9.77	8.36	11.75
8	17.96	22.33	23.80	5.53	4.91	6.81
9	17.83	21.73	24.16	5.25	3.37	8.01
10	15.84	21.34	24.83	13.55	10.39	8.03
average	17.043	20.53	23.217	5.721	5.876	6.053

By applying the equations (4), (5) and (6) mentioned previously, "the results are as follows:

$$U\tilde{C}L_{\bar{X}} = (21.21, 24.81, 27.62)$$

$$\tilde{C}L_{\bar{X}} = (17.04, 20.53, 23.21)$$

$$l\tilde{C}L_{\bar{X}} = (12.63, 16.25, 19.04)$$

By using the results of the fuzzy control charts  $\tilde{x}$  we obtain the results for the operations on the control charts.

And by the availability of the information below, the level of fuzzy a-cut in the control chart for average mean is provided.

$$= 19.3 \bar{X}^{\alpha}_a$$

$$= 21.47 \bar{X}^{\alpha}_c$$

$$5.81 \bar{R}^{\alpha}_a =$$

$$= 5.94 \bar{R}^{\alpha}_c$$

By applying the equations (8,9 and 10) we get the following

$$\begin{aligned}
 UC \tilde{L}_{\bar{x}}^{\alpha} &= (23.54, 24.81, 25.8) \\
 &= (19.3, 20.53, 21.47) \tilde{CL} \\
 LC \tilde{L}_{\bar{x}}^{\alpha} &= (15.06, 16.25, 17.14)
 \end{aligned}$$

While measuring the average of the level of fuzzy a-cut in the control chart ( $\tilde{x}$ )  
And by applying the equations (11, 12, 13) we get the following

$$\begin{aligned}
 &= 24.81 UC \tilde{L}_{mr-\bar{x}}^{\alpha} \\
 &= 20.53 \tilde{C} L_{mr-\bar{x}}^{\alpha} \\
 &= 16.25 LC \tilde{L}_{mr-\bar{x}}^{\alpha}
 \end{aligned}$$

Through equation (14) and (15), we get the decision according to Table No. (4) below

Table 4: Shows the decision to use the fuzzy a-cut level in the control chart for the average.

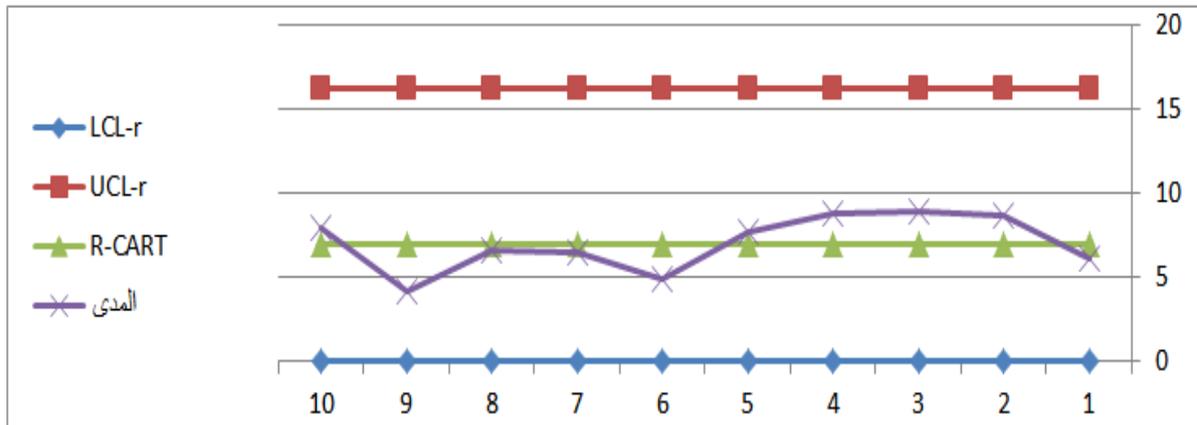
samples	$S_{mr-\bar{x}.j}^{\alpha}$	Decision
1	17.754	Under control
2	20.497	Under control
3	19.968	Under control
4	20.8785	Under control
5	19.2045	Under control
6	18.4145	Under control
7	22.9	Under control
8	21.8225	Under control
9	20.25775	Under control
10	20.98825	Under control

To calculate the control fuzzy chart ( $\tilde{R}$ ) in the control chart.

After documenting the data in the control chart for ( $\tilde{R}$ ) and applying them on the following equations (16, 17, 18).

$$\begin{aligned}
 &= 16.2265 UCL_R \\
 &= 7.055 CL_R \\
 LCL_R &= 0
 \end{aligned}$$

**Figure 2.** Shows the control chart for the range.



Then we extract the fuzzy control chart for the range (R) according to equations (19), (20), (21).

$$U\tilde{C}L_R = (13.1583, 13.5148, 13.9219)$$

$$\tilde{C}L_R = (5.721, 5.876, 6.053)$$

$$L\tilde{C}L_R = (0, 0, 0)$$

Control chart by using the fuzzy a-cut level of  $\tilde{R}$  according to equations (22, 23, 24).

According to the condition of fuzzy control operations according to equation (28), let

$$U\tilde{C}L_{mr-R}^\alpha = 13.7$$

$$L\tilde{C}L_{mr-R}^\alpha = 0$$

$$= 5.876\tilde{C}L_{mr-R}^\alpha$$

Therefore, we document the control decision according to Table (5) using the fuzzy a-cut level in the control chart  $\tilde{R}$

**Table 5:** shows the decision of control by using the fuzzy a-cut level

Sample	$S_{mr-R,j}^{\alpha}$	Decision
1	3.52125	In control
2	4.6085	In control
3	5.61	In control
4	5.37025	In control
5	5.88825	In control
6	6.6025	In control
7	9.2	In control
8	5.86	In control
9	4.510675	In control
10	10.53	In control

## Conclusions and Recommendations

### Conclusions

1- Through this research, the fuzzy model was applied to the variables of the control chart of the substance (hypo) in the water bottles. The method used and the fuzzy observations used are easy to apply mathematically and more appropriate in making a suitable decision in the production processes of production facilities than the traditional charts. The reason for this is that the same results are given since fuzzy logic does not require complicated mathematical operations.

2 - Fuzzy logic is a more objective method, as it deals with complex systems and is more suitable for product charts.

### Recommendations

The researcher recommends, through what I conclude by the study, the following:

1- Applying the method used in this study to control production for its efficiency and comparability in most productive processes in economic establishments, since the appropriate decision-making process requires accuracy and speed in controlling the production process.

2- We recommend using the fuzzy logic method, as it gives more clarity in interpreting and analysing the results .



## REFERENCES

### Arab sources

- Al-Rawi, Omar Fawzi Saleh Badr, (2004), "The use of the discriminatory function in quality control with an application to the births of premature infants", Master Thesis / College of Computer Science and Mathematics, University of Mosul.
- Al-Ani, Ban Ghanem, (2001), "The effect of the blockade on the weights and congenital deformities of newborn babies using quality control", Master Thesis, University of Mosul.
- Rahi, Abdul Rahim Khalaf, (2011), "The Use of Fuzzy Group Theory in Developing and Creating Control Panels (A Comparative Study)," Journal of Administration and Economics, Thirty-fourth Year, Issue (89), pp. 1-9.
- Suleiman, Muthanna Subhi, Qassem, Omar Saber, Hussein, Talal Fadel, (2011), "A comparison between the fuzzy control method and the discriminatory function, classification of some wells in Nineveh Governorate," Iraqi Journal of Statistical Sciences (20) p. (315 - 330)
- Mustafa, Muthayna Abdullah, (2010), "A comparison between the discriminatory function and fuzzy logic in controlling the production of soft drinks", Iraqi Journal of Statistical Sciences (18) p. (273-296).

### Foreign Resources

- Alakoc . N.P,Apaydin.A, (2018), "A Fuzzy Control Chart Approach for A tributes and Variables", Engineering Technology & Applied Science Research .vol(8), no.5,p.p:3360-3365.
- R.Kawa . Jamal ,Haydar ,Suzan,(2015), " Use Fuzzy Midrange Transportation Method to Construction Fuzzy Control Charts limits", International journal of scientific and statistical computing (ijssc), volume(6) :issue(1).