THE UNIVERSITY OF JORDAN

FACULTY OF ENGINEERING AND TECHNOLOGY

SCHOOL OF ENGINEERING

DEPT.OF CHEMICAL ENGINEERING

Chemical Engineering laboratory 2 (0915461)

Section no. (1)

Experiment Number (4)

Mixing of Powder

Short report

Done by:

Instructor's Name: Prof. Dr. Motasem Saidan & Eng. Arwa Sandouqa

Date of Submission: 14/12/2022

Table of content

List of Tables

List of Figure

1. ABSTRACT

Mixing is a unit operation in which a heterogeneous physical system is manipulated with the goal of making it more homogeneous.

In this experiment, the KCl salt was mixed with sand for different periods of time by using a double-cone mixer, and the factors affecting the mixing process were considered, including the mixing time, the size, shape, and weight of the particles. Then, three samples were taken from different locations (Top , middle, Bottom) and different times .The samples were analyzed by titration using $AgNO_3$.

The main objective of this experiment to study the process of mixing and see how the properties of ingredients - the particle size and shape distribution as example - will affect the process. Also investigate the effect of mixing time, and mixing speed on the state of mixing.

2. RESULTS

(1)

Table (1) : Data and properties for calculations

KCl average diameter ((500 - 850)*10^-6) m	675
Sand average diameter ((250 - 350)*10^-6) m	300
Density of KCl (g/cm^3)	1.89
Density of the sand (g/cm^3)	1.602
particle volume of kcl (cm^3)	1.61E-04
particle volume of sand (cm^3)	1.41E-05
mass of sand particle (g/particle)	2.25882E-05
mass of kcl particle (g/partilce)	3.04E-04
weight of kcl (g)	286.9
weight of sand (g)	141.49
number of sand particles	9.42E+06
number of KCl particles	6.26E+06
Total number of particles	1.57E+07
up sand	6.01E-01
up KCl	3.99E-01

Table (2) : Results at t= 5 mins

at Time = 5 min.												
Total weight (g)		V of AgNO3 (mL)	moles of AgNO3	moles of KCl	mass of KCl	mass of sand	x (KCl)	x (sand)	x avg	(x - xavg)	(x -xavg)^2	index
top	0.27	3.6	0.00036	0.00036	0.02684	0.24316	0.0994	0.9006	0.639402522	0.2606	0.0679124	0.000304
bottom	0.16	17.8	0.00178	0.00178	0.1327	0.0273	0.8294	0.1706		-0.46937	0.220307	
mid	0.19	3.9	0.00039	0.00039	0.02907	0.16093	0.153	0.847		0.206976	0.0428392	
										sum =	0.3310586	

Table (3) : Results at t= 10 mins

at Time = 10 min.												
Total weight (g)		V of (mL)	moles of AgNO3	moles of KCl	mass of KCl	mass of sand	x (KCl)	x (sand)	x avg	(x - xavg)	(x -xavg)2	index
top	0.17	9.9	0.00099	0.00099	0.0738	0.0962	0.4341	0.5659	0.619479567	-0.05362	0.0028755	0.002630598
bottom	0.19	9.2	0.00092	0.00092	0.06859	0.12141	0.361	0.639		0.019541	0.0003819	
mid	0.17	7.9	0.00079	0.00079	0.05889	0.11111	0.3464	0.6536		0.034082	0.0011616	
										sum =	0.004419	

Table (4) : Results at t= 15 mins

at Time = 15 min.												
Total weight (g)		V of AgNO3 (mL)	moles of AgNO3	moles of KCl	mass of KCl	mass of sand	x (KCl)	x (sand)	x avg	(x - xavg)	(x -xavg)^2	index
top	0.21	9.9	0.00099	0.00099	0.0738	0.1362	0.3515	0.6486	0.632888235	0.01566	0.0002452	0.003917527
bottom	0.17	9.2	0.00092	0.00092	0.06859	0.10141	0.4034	0.5966		-0.03634	0.0013204	
mid	0.17	7.9	0.00079	0.00079	0.05889	0.11111	0.3464	0.6536		0.020672	0.0004273	
										sum =	0.0019929	

Table (5) : Results at t= 20 mins

at Time = 20 min.												
Total weight (g)		V of AgNO3 (mL)	moles of AgNO3	moles of KCl	mass of KCl	mass of sand	x (KCl)	x (sand)	x avg	(x - xavg)	(x -xavg)^2	index
top	0.17	13.6	0.00136	0.00136	0.10139	0.06861	0.5964	0.4036	0.689375	-0.2854	0.0814532	0.000494111
bottom	0.16	2.8	0.00028	0.00028	0.02087	0.13913	0.1305	0.8695		0.180538	0.0325938	
mid	0.2	5.5	0.00055	0.00055	0.041	0.159	0.205	0.795		0.105988	0.0112334	
										sum =	0.1252803	

Table(6) : Results at t= 30 mins

at Time = 30 min.													
Total weight (g)		V of AgNO3 (mL)	moles of AgNO3	moles of KCl	mass of KCl	mass of sand	x (KCl)	x (sand)	x avg	(x - xavg)	(x -xavg)^2	index
top	0.23	2.4	0.00024	0.00024	0.01789	0.21211	0.0778	0.9222	0.832876383	0.089409	0.0079939	0.001349348
bottom	0.22	4.8	0.00048	0.00048	0.03578	0.18422	0.1627	0.8373		0.004545	2.066E-05	
mid	0.2	7	0.0007	0.0007	0.05219	0.14782	0.2609	0.7391		-0.09373	0.0087844	
										sum =	0.016799	

Table(7) : Results at t= 45 mins

at Time = 45 min.												
Total weight (g)		V of AgNO3 (mL)	moles of AgNO3	moles of KCl	mass of KCl	mass of sand	x (KCl)	x (sand)	x avg	(x - xavg)	(x -xavg)^2	index
top	0.15	13	0.0013	0.0013	0.09692	0.05309	0.6461	0.3539	0.459044479	-0.1051	0.011046	0.00108502
bottom	0.17	12.7	0.00127	0.00127	0.09468	0.07532	0.5569	0.4431		-0.01593	0.0002538	
mid	0.19	10.7	0.00107	0.00107	0.07977	0.11023	0.4198	0.5802		0.121166	0.0146811	
										sum =	0.025981	

Table(8) : Results at t= 60 mins

at Time = 60 min.												
Total weight (g)		V of AgNO3 (mL)	moles of AgNO3	moles of KCl	mass of KCl	mass of sand	x (KCl)	x (sand)	x avg	(x - xavg)	(x -xavg)^2	index
top	0.21	6.2	0.00062	0.00062	0.04622	0.16378	0.2201	0.7799	0.702176515	0.07772	0.0060404	0.001105757
bottom	0.22	7.3	0.00073	0.00073	0.05442	0.16558	0.2474	0.7526		0.05045	0.0025452	
mid	0.14	8	0.0008	0.0008	0.05964	0.08036	0.426	0.574		-0.12818	0.0164301	
										sum =	0.0250157	

(2)

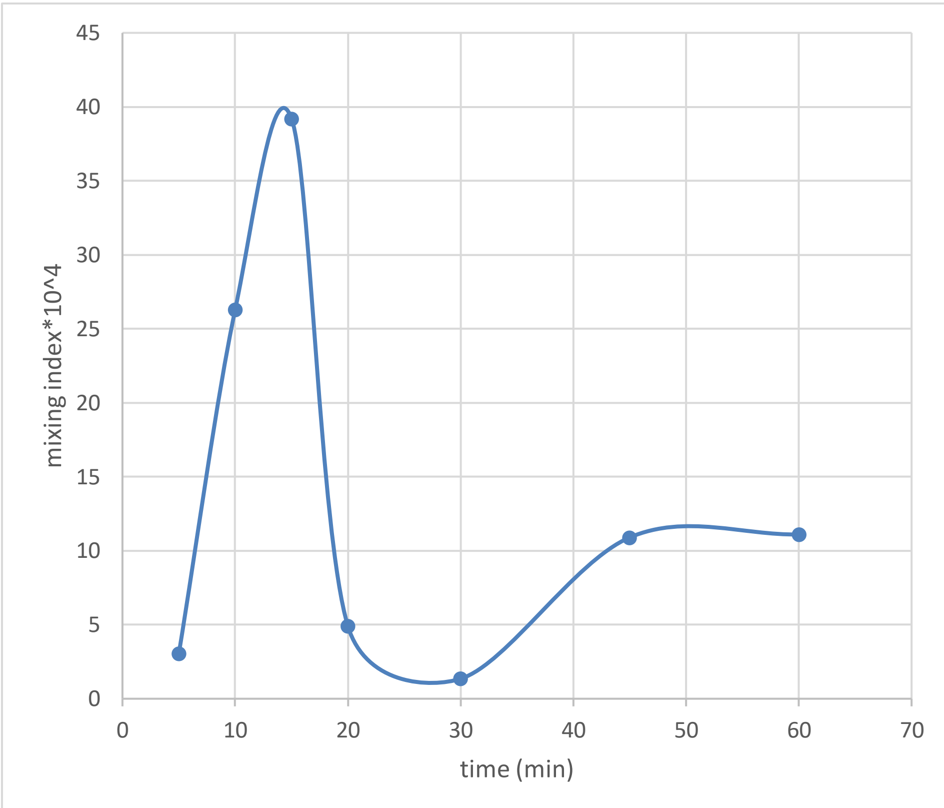

Figure (1) : Mixing Index Vs Time.

3. Discussion

The mixing process aims to create a homogeneous distribution in the mixture .

This experiment goal to see how the properties of the ingredients will affect the process and to estimate the effect of mixing time at constant speed.

In this experiment, a double-cone mixer was used to mix two substances (sand and KCl salt), and the mixing process took place for different times. After the mixing , three samples were taken from three different locations (Top , middle, Bottom) to ensure that the sample was completely represented. After that, the samples were calibrated by using $AgNO_3$ and $K_2Cr_2O_7$ (use it as an indicator) .

To measure how far the mixing has proceeded towards equilibrium , mixing index was calculated which is the equilibrium standard deviation for complete mixing over the standard deviation.

Through titrations of each time different volumes at top, middle and bottom have

been used to reach the equilibrium at each. and that related to the differences

between concentrations of solids used. Where calibration is used to find the composition of KCl and then composition of Sand .Through it, the homogeneity of the mixture is judged using the mixing index.

The tables (2-8) show the compositions of solids in the whole sample and the value of the mixing index after mixing for different times .

The index of mixing versus time was drawn to find the relation between them as shown in the figure (1) the mixing index was directly proportional to the time until the time reached 15 minutes at this time the mixing index equal 0.0039 which is the maximum value , this means the greatest possible homogeneity between the two components , and after this time, the mixing index began to decrease ,this mean the homogeneity between the components decreased due to the electrostatic force formed between particles which force the mixing process to give non-homogenous mixture.

4. CONCLUSIONS

- The mixing index is measure the homogeneous of mixture and how far mixing has produced toward equilibrium . In this experiment The mixing index have the most value at 15 mine so is the best time to mixing .
- the mixing time factor effect on mixing and should to find the optimum time .the best time to mixing is not determined by the longest time .
- Increase the spot sample make the result more accurate.
- The electrostatic force repulsion causes the mixing to achieve a maximum value at the optimal mixing period, and then it lowers as a result of the electrostatic force repulsion.

5. REFERENCES

1. Coulson and Richardson," Chemical Engineering ", Vol.II, Pergamon Press

2. McCabe and Smith," Unit Operation of Chemical Engineering", 3rd edition.

6. APPENDICES

Sample of calculation:

To find μ_p

$$d_{avg}\ of\ sand = \frac{200+350}{2} = 300\ \mu m$$

$$d_{avg}\ of\ KCl = \frac{500+850}{2} = 675\ \mu m$$

$$Volume_{KCl} = \frac{\pi d_{avg}^3}{6} = 1.61 * 10^{-4}\ cm^3$$

$$Volume_{sand} = \frac{\pi d_{avg}^3}{6} = 1.41 * 10^{-5}\ cm^3$$

$$\rightarrow mass\ of\ KCl = \rho * Volume = 1.89 * 1.61 * 10^{-4} = 3.04 * 10^{-4}\ g/particle$$

$$\rightarrow mass\ of\ sand = \rho * Volume = 1.602 * 1.41 * 10^{-5} = 2.26 * 10^{-5}\ g/particle$$

$$number\ of\ particles\ of\ KCl = \frac{weight\ of\ KCl}{mass\ of\ KCl} = \frac{286.9}{3.04 * 10^{-4}} = 6.26 * 10^{6}\ particle$$

$$number\ of\ particles\ of\ sand = \frac{weight\ of\ sand}{mass\ of\ sand} = \frac{141.49}{2.26 * 10^{-5}} = 9.42 * 10^{6}\ particle$$

$$\rightarrow Total\ number\ of\ particles = 6.26 * 10^{6} + 9.42 * 10^{6} = 1.57 * 10^{7} particle$$

$$\mu_{p\ of\ sand} = \frac{\text{Number of sand particles}}{\text{Total number of Particles}} = \frac{9.42 * 10^{6}}{1.57 * 10^{7}} = 0.601$$

$$\mu_{p\ of\ KCl} = \frac{\text{Number of KCl particles}}{\text{Total number of Particles}} = \frac{6.26 * 10^{6}}{1.57 * 10^{7}} = 0.399$$

To find the index:

For first trial for top location (at 5 min)

$The\ weight\ of\ the\ sample\ =\ 0.27\ g$

$Volume\ of\ AgNO3 = 3.6\ mL,\ \ Concentration\ of\ AgNO3 = 0.1\ mol/L$

$$moles\ of\ AgNO3 = Volume * Concentration = 3.6 * \frac{0.1}{1000} = 4 * 10^{-4} mol$$

$$no.of\ mole\ of\ AgNO3 = no.of\ mole\ of\ KCl = 4 * 10^{-4} mol$$

$mass\ of\ KCl = n * MW = 4 * 10^{-4} * 74.55 = 0.0268\ g\ of\ KCl$

$$\rightarrow\ mass\ of\ sand = weight\ of\ sample - mass\ of\ KCl = 0.27 - 0.0268 = 0.2432\ g\ of\ sand$$

$$x_{KCl} = \frac{mass\ of\ KCl}{weight\ of\ sample} = \frac{0.0268}{0.27} = 0.0994$$

$$x_{sand} = 1 - x_{KCl} = 1 - 0.0994 = 0.9006$$

Do the same thing for mid and bottom, we had:

$$x_{sand}\ in\ the\ mid = 0.847$$

$$x_{sand}\ in\ the\ bottom = 0.1706$$

$$\rightarrow x_{avg} = \frac{0.9006 + 0.847 + 0.1706}{3} = 0.6394$$

$(x_{sand\ in\ top} - x_{avg}) = 0.261 \rightarrow\ (x_{sand\ in\ top} - x_{avg})^2 = 0.06791$

$(x_{sand\ in\ mid} - x_{avg}) = 0.207 \rightarrow\ (x_{sand\ in\ mid} - x_{avg})^2 =\ 0.0428$

$(x_{sand\ in\ bottom} - x_{avg}) = -0.469 \rightarrow\ (x_{sand\ in\ bottom} - x_{avg})^2 = 0.2203$

$$\sum (x_i - x_{avg})^2 = 0.06791 + 0.0428 + 0.2203 = 0.33106$$

$$I_s = \sqrt{\frac{\mu_p \cdot (1 - \mu_p) \cdot (N - 1)}{n \sum_{i=1}^{N} (x_i - x_{ave})^2}} = \sqrt{\frac{0.601 * 0.399 * (3 - 1)}{0.33106 * 1.57 * 10^7}} = 0.000304$$