CHAPTER 6

FACTOR SCREENING EXPERIMENTS

6.1 Experiment and Data Collection

These experiments are divided into two parts by different ranges of melamine crystal pH, pH 8.0-8.7 and pH 8.7-9.5 in part 1 and part 2, respectively.

6.1.1 Factor Screening Experiment Part 1

The four factors with the two levels, minimum and maximum level, of each factor are determined as follows.

F/M ratio is factor A, and the two levels are :

F/M ratio of 1.6 represented by -1.

F/M ratio of 2.0 represented by +1.

Melamine crystal pH is factor B , and the two levels are :

Melamine crystal pH of 8.0 represented by -1.

Melamine crystal pH of 8.7 represented by +1.

However, it is difficult to gain exactly pH 8.0 and 8.7 of melamine crystal, so melamine crystal pH 8.0-8.1 and 8.6-8.7 are used in this experiment to represent pH 8.0 and 8.7, respectively.

Formalin pH is factor C, and the two levels are :

Formalin pH of 4.5 represented by -1.

Formalin pH of 4.8 represented by +1.

However, it is difficult to gain exactly pH 4.50 and 4.80 of formalin, so formalin pH 4.50-4.55 and 4.75-4.80 are used in this experiment to represent pH 4.5 and 4.8, respectively.

Water pH is factor D, and the two levels are :

Water pH of 7.3 represented by -1.

Water pH of 7.9 represented by +1.

However, it is difficult to gain exactly pH 7.30 and 7.90 of water, so water pH 7.30-7.35 and 7.85-7.90 are used in this experiment to represent pH 7.3 and 7.9, respectively.

And a response variable is the curing time, and the three replicates are chosen. Therefore, a table for data collection of the experiment is designed as shown in Table 6.1.

Curing time (in seconds)

Run	Factor A	Factor B	Factor C	Factor D	Replicates		
					1	2	3
1	-1	-1	-1	-1			
2	+1	-1	-1	-1			
3	-1	+1	-1	-1			
4	+1	+1	-1	-1			
5	-1	-1	+1	-1			
6	+1	-1	+1	-1			
7	-1	+1	+1	-1			
8	+1	+1	+1	-1			
9	-1	-1	-1	+1			
10	+1	-1	-1	+1			
11	-1	+1	-1	+1			
12	+1	+1	-1	+1			
13	-1	-1	+1	+1			
14	+1	-1	+1	+1			
15	-1	+1	+1	+1			
16	+1	+1	+1	+1			

Table 6.1 : The Table for Data Collection of Factor Screening Experiment.

6.1.2 Factor Screening Experiment Part 2

The four factors with the two levels, minimum and maximum level, of each factor are determined as follows.

F/M ratio is factor A, and the two levels are :

F/M ratio of 1.6 represented by -1.

F/M ratio of 2.0 represented by +1.

Melamine crystal pH is factor B , and the two levels are :

Melamine crystal pH of 8.7 represented by -1.

Melamine crystal pH of 9.5 represented by +1.

However, it is difficult to gain exactly pH 8.7 and 9.5 of melamine crystal, so melamine crystal pH 8.7-8.8 and 9.4-9.5 are used in this experiment to represent pH 8.7 and 9.5, respectively.

Formalin pH is factor C, and the two levels are :

Formalin pH of 4.5 represented by -1.

Formalin pH of 4.8 represented by +1.

However, it is difficult to gain exactly pH 4.50 and 4.80 of formalin, so formalin pH 4.50-4.55 and 4.75-4.80 are used in this experiment to represent pH 4.5 and 4.8, respectively.

Water pH is factor D, and the two levels are :

Water pH of 7.3 represented by -1.

Water pH of 7.9 represented by +1.

However, it is difficult to gain exactly pH 7.30 and 7.90 of water, so water pH 7.30-7.35 and 7.85-7.90 are used in this experiment to represent pH 7.3 and 7.9, respectively.

And a response variable is the curing time, and replicates of 3 are chosen. Therefore, a table for data collection of this experiment is the same as that of the factor screening experiment part 1 as shown in Table 6.1.

6.2 Collected Data

6.2.1 Factor Screening Experiment Part 1

The collected data from the experiment part 1 are shown in Table 6.2 , and the four factors that are F/M ratio, pH of melemine crystal , pH of formalin, and pH of water and the levels of the factors are represent as follows.

- Factor A is F/M ratio, -1 and +1 respresent F/M ratio of 1.6 and 2.0, repectively.
- Factor B is melamine crystal pH, -1 and +1 represent pH 8.0 and 8.7, respectively.
- Factor C is formalin pH, -1 and +1 represent pH 4.5 and 4.8, respectively.
- Factor D is water pH, -1 and +1 represent pH 7.3 and 7.9, respectively.

Run	Factor A	Factor B	Factor C	Factor D	Curing time (seconds)		
					1	2	3
1	-1	-1	-1	-1	250	243	238
2	+1	-1	-1	-1	185	201	190
3	-1	+1	-1	-1	243	249	234
4	+1	+1	-1	-1	183	194	198
5	-1	-1	+1	-1	242	241	252
6	+1	-1	+1	-1	194	190	201
7	-1	+1	+1	-1	241	239	252
8	+1	+1	+1	-1	197	198	186
9	-1	-1	-1	+1	253	242	241
10	+1	-1	-1	+1	188	196	191
11	-1	+1	-1	+1	247	241	236
12	+1	+1	-1	+1	204	191	190
13	-1	-1	+1	+1	246	236	246
14	+1	-1	+1	+1	192	184	197
15	-1	+1	+1	+1	249	237	245
16	+1	+1	+1	+1	198	189	186

Table 6.2 : The Data of Factor Screening Experiment Part 1.

Remark : 1) NaOH 2.5 % concentration of 6.2 milliliters used for a batch of reactor in the conditions of F/M ratio of 1.6.

2) NaOH 2.5 % concentration of 7.0 milliliters used for a batch of reactor in the conditions of F/M ratio of 2.0.

6.2.2 Factor Screening Experiment Part 2

The collected data from the experiment part 2 are shown in Table 6.3 , and the four factors that are F/M ratio, pH of melemine crystal , pH of formalin, and pH of water and the levels of the factors are represent as follows.

- Factor A is F/M ratio, -1 and +1 respresent F/M ratio of 1.6 and 2.0, repectively.
- Factor B is melamine crystal pH, -1 and +1 represent pH 8.7 and 9.5, respectively.
- Factor C is formalin pH, -1 and +1 represent pH 4.5 and 4.8, respectively.
- Factor D is water pH, -1 and +1 represent pH 7.3 and 7.9, respectively.

Run	Factor A	Factor B	Factor C	Factor D	Curing time (seconds)		
					1	2	3
1	-1	-1	-1	-1	210	221	220
2	+1	-1	-1	-1	182	173	183
3	-1	+1	-1	-1	223	225	212
4	+1	+1	-1	-1	185	177	169
5	-1	-1	+1	-1	229	222	217
6	+1	-1	+1	-1	181	170	181
7	-1	+1	+1	-1	215	215	228
8	+1	+1	+1	-1	170	178	181
9	-1	-1	-1	+1	221	226	214
10	+1	-1	-1	+1	182	171	171
11	-1	+1	-1	+1	219	214	226
12	+1	+1	-1	+1	183	171	179
13	-1	-1	+1	+1	228	225	214
14	+1	-1	+1	+1	173	184	181
15	-1	+1	+1	+1	219	228	215
16	+1	+1	+1	+1	178	173	187

Table 6.3 : The Data of Factor Screening Experiment Part 2.

Remark : 1) NaOH 2.5 % concentration of 5.2 milliliters used for a batch of reactor in the conditions of F/M ratio of 1.6.

2) NaOH 2.5 % concentration of 6.2 milliliters used for a batch of reactor in the conditions of F/M ratio of 2.0.

6.3 Data Analysis of Experiment

6.3.1 Factor Screening Experiment Part 1

From the collected data of the factor screening experiment part 1, The analysis of variance is employed to draw conclusion about the effect of the four factors on the curing time as shown in Table 6.4.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F_0
F/M ratio (A)	31,008.33	1	31,008.33	722.52
Melamine crystal pH (B)	3.00	1	3.00	0.07
Formalin pH (C)	2.08	1	2.08	0.05
Water pH (D)	5.33	1	5.33	0.12
AB	10.08	1	10.08	0.23
AC	1.33	1	1.33	0.03
AD	0.75	1	0.75	0.02
BC	0.33	1	0.33	0.01
BD	4.08	1	4.08	0.10
CD	33.33	1	33.33	0.78
ABC	18.75	1	18.75	0.44
ACD	6.75	1	6.75	0.16
ABD	5.33	1	5.33	0.12
BCD	0.75	1	0.75	0.02
ABCD	8.33	1	8.33	0.19
Error	1,373.33	32	42.92	

Table 6.4 : The Analysis of Variance for Factor Screening Experiment Part 1.

Because of $F_{0.05,\ 1,\ 32} = 4.14$, we conclude that F/M ratio significantly affects the curing time, pH of melamine crystal can be classified as a group of pH 8.0 to 8.7, and the effects of formalin pH and water pH and interaction on curing time are not significant.

6.3.2 Factor Screening Experiment Part 2

From the collected data of the factor screening experiment part 2, The analysis of variance is employed to draw conclusion about the effect of the four factors on the curing time as shown in Table 6.5.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F_o
F/M ratio (A)	21,802.69	1	21,802.69	515.02
Melamine crystal pH (B)	1.69	1	1.69	0.04
Formalin pH (C)	25.52	1	25.52	0.60
Water pH (D)	4.69	1	4.69	0.11
AB	1.02	1	1.02	0.02
AC	3.52	1	3.52	0.08
AD	1.69	1	1.69	0.04
BC	15.19	1	15.19	0.36
BD	3.52	1	3.52	0.08
CD	9.19	1	9.19	0.22
ABC	6.02	1	6.02	0.14
ACD	22.69	1	22.69	0.54
ABD	13.02	1	13.02	0.31
BCD	0.19	1	0.19	0.00
ABCD	17.52	1	17.52	0.41
Error	1,354.67	32	42.33	

Table 6.5 : The Analysis of Variance for Factor Screening Experiment Part 2.

Because of $F_{0.05,\ 1,\ 32} = 4.14$, we conclude that F/M ratio significantly affects the curing time, pH of melamine crystal can be classified as a group of pH 8.7 to 9.5, and the effects of formalin pH and water pH and interaction on curing time are not significant.

In conclusion, the pH of formalin and the pH of water are screened out. Consequently, the effect of F/M ratio and pH of melamine crystal on the curing time will be tested in the next experiment.