CHAPTER 10

CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

10.1.1 A main cause of the company's problem, which is a lot of variation of melamine compound's curing time, is the change in volume of sodium hydroxide (NaOH) used in each production batch at a reactor of the company's process.

10.1.2 The four factors involving the change in volume of sodium hydroxide are F/M ratio, melamine crystal pH, formalin pH, and water pH. These factors were chosen for performing the designed experiments that are the factor screening experiments, the preliminary experiment, the experiment for finding suitable conditions, and the confirmation experiment.

10.1.3 The method of 2^{k} factorial design for the four factors (k=4) was applied to the factor screening experiments in order to screen some factors that do not affect the curing time out. As the result of the experiments, the pH of formalin and the pH of water were screened out since these factors do not have the effect on the curing time.

10.1.4 And then, the effects of F/M ratio and pH of melamine crystal were ensured by the method of 2^{k} factorial design in the preliminary experiment. From this experiment, we conclude that there are the main effects of F/M ratio

and melamine crystal pH on the curing time; however, there is no interaction between these factors.

10.1.5 Consequently, the experiment for finding suitable conditions, the two-factor factorial design for 2 levels of melamine crystal pH and 3 levels of F/M ratio with 8 replicates was employed to find the six suitable conditions. Also the curing time standard deviation and the curing time means in each condition could be estimated by the error mean square and the collected data of this experiment, respectively.

10.1.6 As the previous experiments were performed in the laboratory, the curing time means and variances resulting from the laboratory equipment should be compared with those of the process. The method of hypotheses testing was used to test these differences between the two means and the two variances of the curing time. The results of the tests are that the two curing time means and variances of the laboratory and the process are not different.

Therefore, the results of the experiments in the laboratory can represent those in the process.

10.1.7 The result of this research can be concluded as the six suitable conditions at the reactor of the melamine compound process as follows.

Condition 1 : F/M ratio of 1.6, Melamine crystal pH 8.0-8.7, and NaOH 25 % concentration of 3.1 liters, Curing time mean of 244 $\pm$ 5 seconds.

Condition 2 : F/M ratio of 1.6, Melamine crystal pH 8.7-9.5, and NaOH 25 % concentration of 2.6 liters, Curing time mean of 224 $\pm$ 5 seconds.

Condition 3 : F/M ratio of 1.8, Melamine crystal pH 8.0-8.7, and NaOH 25 % concentration of 3.3 liters, Curing time mean of 202 ± 5 seconds.

Condition 4 : F/M ratio of 1.8, Melamine crystal pH 8.7-9.5, and NaOH 25 % concentration of 2.8 liters, Curing time mean of 192 ± 5 seconds.

Condition 5 : F/M ratio of 2.0, Melamine crystal pH 8.0-8.7, and NaOH 25 % concentration of 3.5 liters, Curing time mean of 189 ± 5 seconds.

Condition 6 : F/M ratio of 2.0, Melamine crystal pH 8.7-9.5, and NaOH 25 % concentration of 3.1 liters, Curing time mean of 177 ± 5 seconds.

And the curing time standard deviation is about 6 seconds in each condition.

10.1.8 The suitable conditions can be used as the basic data to control quality of melamine compound's curing time and to solve the company's problem by making adjustment to the volume of curing agent type 1 or/ and the quantity of curing agent type 2 in each condition, resulting in the same curing time mean. Finally, the variation of the curing time will be reduced from about ± 30 seconds to about ± 20 seconds.

10.2 Limitations

10.2.1 The pH of formalin used in this research is in the narrow range of pH 4.5 to pH 4.8. If the range of formalin was wider, it would affect the curing time since the volume of sodium hydroxide might be changed.

10.2.2 This research focuses on the control of the reactor in melamine compound process, and many factors in other machines of the process can be

controlled in the experiments. Therefore, the curing time variation of the process is likely to be more than that of this research.

10.3 Recommendations for Experiment

10.3.1 In general, melamine crystal pH 8.0-8.7 gives quicker rate of reaction than melamine crystal pH 8.7-9.5. Thus, a little volume of sodium hydroxide should be added for the melamine crystal pH 8.0-8.7 to gain the suitable reaction rate when the experiment or production begins.

10.3.2 The concentration of the curing agent type 1 should be controlled because this curing agent can be evapolated, leading to the wrong volume of this curing agent used in each production batch or experiment batch.

10.3.3 The measurement of the weight of the curing agent type 2 should be made carefully since a little change about 10 % by weight in this curing agent's quantity causes a lot of change in the curing time mean.

10.4 Recommendations for Further Study

10.4.1 The experiment in making adjustment to the volume of the curing agent type 1 in the suitable conditions shoud be done after implementing this research to reduce the curing time variation of the company's process. This experiment will be performed by the guidelines that the more volume of sodium hydroxide is used at the reactor, the more volume of curing agent type 1 is added to wet popcorn at the kneader. Also the quantity of curing agent type 2 used at the

ball mill must be a constant. The data collected from this experiment can be analyzed by the method of hypotheses testing about the difference between two means.

10.4.2 Moreover, the study of relationship between the curing time and the disk flow, which is an important quality characteristic of melamine compound, should be done as well.