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A binder additional process in urea granule fertilizer by using adaptive fuzzy logic control

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Abstract. This paper presents the effect of binder feed rate addition towards ammonia gas released during urea granulation process. The binder feed rate as manipulated variable with few other constant parameters such as pressure and temperature of fluidized bed granulator. These parameters, binder flow rate and NH_3 emission were used to indicate the function ability of the designated fuzzy logic. The performance index of this study is then defined with percentage error from experimental value and actual value. An adaptive Fuzzy Logic Controller (FLC) is proposed to control the system conditions closed to the reference values. As binder flow rate increases the higher is the emission of NH3. The average of error percentage for whole project was 6.91%. The highest and lowest error in percentages are 81.5 and 0 respectively. The result shows that the proposed method can be efficiently implemented in the real-time determination and control of optimal conditions for granulation processes with efficient energy and to minimize the amount of ammonia gas (NH_3) release to the environment.

Introduction

Urea granule is used as fertilizers to supply additional nitrogen for paddy plant growth and sustaining the soil fertility [1]. The utilization of urea fertilizers on paddy fields has been well accepted for producing high rice grain yields and improved the nutrient availability. Urea fertilizer is also cost effective and having high Nitrogen content comparing to the other resources [2].

Granulation is a process for enlargement from small particles into larger diameter particles which called granules [3]. In fluidized bed granulation process, ammonia gas was distinguished. There are two contribution of ammonia gas emission which are binder solution added by spraying into powder particles and evaporation of the urea syntheses process [4]. Figure 1 shows the reaction process of fluid bed granulation where the ammonia gas released was detected during the mixing of urea powder with the urea binder solution. The ammonia gas was formed when the urea solution was heated by temperature under high pressure. The ammonia gas was released through the output ventilation from the fluid bed granulation's chamber.

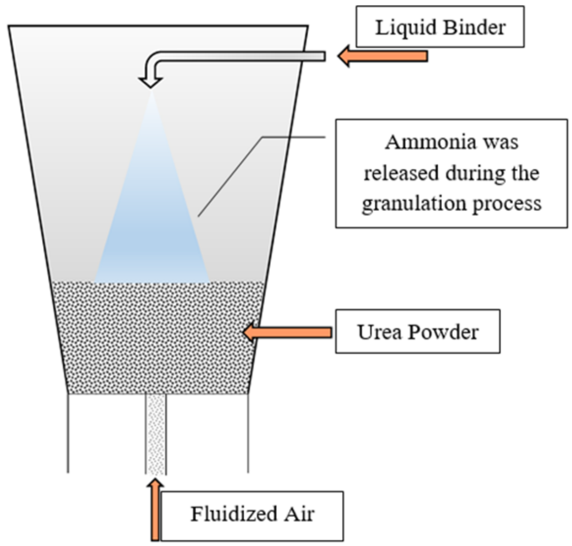

Fig. 1: Schematic of fluidized bed granulation process

In spite of this, during processing the urea fertilizer, a binder liquid solution was added to urea powders. The powder particles adhere to one another to form agglomerates, and the size of the particles is enlarged to form as a urea granule [5]. The binder fluid contains a carbon content that must be volatile due to unstable state of operating conditions. The involvements of heat, pressure and water existence was considered as the main factor of the gas released based on experimental observations.

A fuzzy logic control is constructed from a set of fuzzy If–Then rules using fuzzy logic principles and the learning algorithm adjusts parameters of the fuzzy logic control based on numerical information for better performance on tracking the desired outputs [6]. The objective of this paper is to apply adaptive fuzzy logic control in the fluidized bed granulation process and study the correlation between binder addition flow rate and ammonia gas emission

Ammonia (NH_3) emisssions

Urea melts due to process spraying and drying towards the completion of the granulation process. The air in the granulator contains urea dust and NH_3 [4]. The NH_3 emission due to evaporation section of the urea synthesis process which contribution from urea powder and the urea binder solution [5]

Ammonia (NH_3) reactions with urea

This research analyze of binder addition in fluidized bed granulation which focus on the emission of ammonia gas and condition that affect from it. Combination of ammonia (NH_3) and carbon dioxide (CO_2) can produce urea which also known as ammonia carbamide. Solution synthesis in which the reactions are as follows [6]:

$$2NH_2 + CO_2 \longrightarrow NH_2\,CO_2\,NH_4 \tag{1}$$

$$NH_2\,CO_2\,NH_4 \longrightarrow NH_2\,CO\,NH_4 + H_2O \tag{2}$$

The use of urea solution from solution synthesis process is produce solid urea by concentrated. Concentrate the urea “melt” by evaporation process of the solution [7]. According to F. T et. al [8], high temperature is to prevent the melt to solidify and the temperature able to breaks down to ammonia and biuret. Emission of ammonia from breakdown will transfer to the gas phase in the finishing step [9]. Besides that, another side reaction that occur is the hydrolysis reaction of urea [10]. Temperature is vital factor for the reaction which urea needs to be guard from expose [11]. The hydrolysis reaction is reversed reaction of the urea transformation [12]

Additionally, the fuzzy logic which include construction of the system that include variables, the set of rules require and also knowledge base use. An adaptive fuzzy logic was designed as a platform in Matlab-Simulink environment to control the granulation system conditions.

Methodology

A fuzzy logic has been designed to study relationship between one input and one output which are binder flow rate and NH_3 Emission. Mamdani inference system was chosen to develop this fuzzy logic controller. The characteristic of this fuzzy logic system was based on fuzzy inference system, a few fuzzy sets, input and output variables, type of membership functions, and definition of if-then rules which explained in the further part of the chapter. The total of 50 data set has been collected from the system which will be compare with actual data value. Each of data obtain will be compare with the actual data value for further analysis. Table 1 shows an experimental work conducted via Fuzzy Logic Toolbox in Mathworks Matlab software.

Table 1: Experimental Data for Fuzzy Values

No	Binder Flow rate (ml/min)	NH_3 Emission (ppm)	No	Binder Flow rate (ml/min)	NH_3 Emission (ppm)
1	0.2	0.0484	26	5.2	3.15
2	0.4	0.0968	27	5.4	3.29
3	0.6	0.145	28	5.6	3.44
4	0.8	0.194	29	5.8	3.53
5	1	0.242	30	6	3.68
6	1.2	0.29	31	6.2	3.82
7	1.4	0.581	32	6.4	3.92
8	1.6	0.726	33	6.6	4.07
9	1.8	0.871	34	6.8	3.92
10	2	1.02	35	7	4.16
11	2.2	1.21	36	7.2	4.21
12	2.4	1.5	37	7.4	4.31
13	2.6	1.65	38	7.6	4.4
14	2.8	1.79	39	7.8	4.45
15	3	1.94	40	8	4.5
16	3.2	2.03	41	8.2	4.55
17	3.4	2.13	42	8.4	4.6
18	3.6	2.18	43	8.6	4.65
19	3.8	2.27	44	8.8	4.65
20	4	2.37	45	9	4.69
21	4.2	2.42	46	9.2	4.74
22	4.4	2.52	47	9.4	4.79

23	4.6	2.61		48	9.6	4.79
24	4.8	2.71		49	9.8	4.79
25	5	2.52		50	10	4.79

An actual data collection of 50 sets contains of two different variables which are binder flow rate and NH_3 Emission. These data have been gathered from granulation process whereas fixed value of the parameters in the process are:

Inlet Temperature =65 °C
Spray Angle = 90 °C
Binder Viscosity = 0.236 µPa.s
Binder Atomizing Pressure = 0.5kg/ cm2
Binder Volume =250 ml
Nozzle Size = 5 mm

Around 50 sets of data were collected by using the designated fuzzy logic system in this project. The starting value of 0.2 for input variable and increase by 0.2 until reach the value of 10. These experimental values will be compared with actual value in the Table 4.3. The percentage error will be calculated based on an equation.

$$\%\ error = \frac{Experimental\ value - Actual\ value}{Actual\ value} \times 100\%$$

Result and Discussions

Based on the value obtained from designated fuzzy logic showed that as binder flow rate increase the higher NH_3 emission. This trend can be seen in Figure 2. Many factors that influenced the experimental value data for each set such as number of fuzzy sets, range of the fuzzy sets, specification of membership function, and defuzzification methods applied. A single input and a single output have been sets as parameters for designing fuzzy logic. The input and output variables are binder flow rate and NH_3 emission respectively. The measure of binder flow rate on a scale of 0.2 to 10 while NH_3 emission on a scale 0 to 4.84. The smallest of maximum was defuzzification method used in this fuzzy logic.

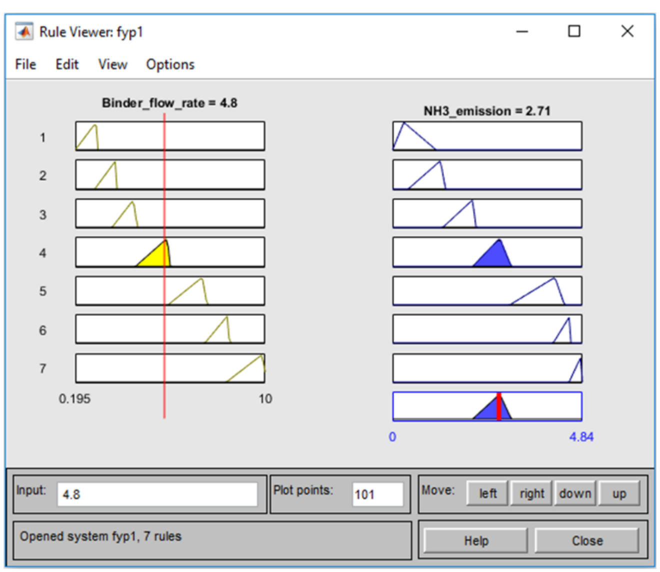

Fig. 2: Rule viewer of the designated fuzzy logic

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The output for experimental value in this project was based on Figure 3 since the input value will correspond to their output. The Figure 3 shows that crisp value of both input and output variables in graphical presentation. It also can be used for finding the output crisp by choosing value for input variables in their respective axes.

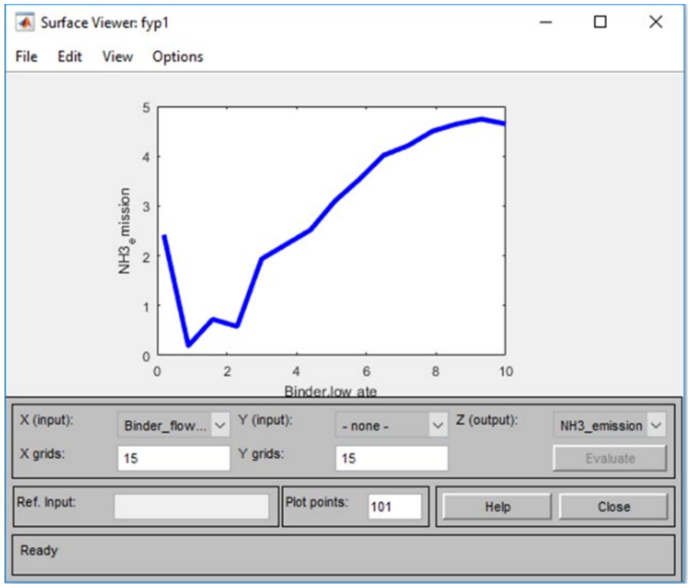

Fig. 3: Surface viewer of the designated fuzzy logic

According to the data collected result data in Figure 4, the NH_3 emission tends to increase with binder flow rate. The experimental data is closed to the actual data as discussed in this part. The influence of binder flow rate with the specific value of constant variables were used enhance the released of NH_3 gas during the granulation process. The impact of binder flow rate also improves completion time of granulation process and improved the size of granule [13].

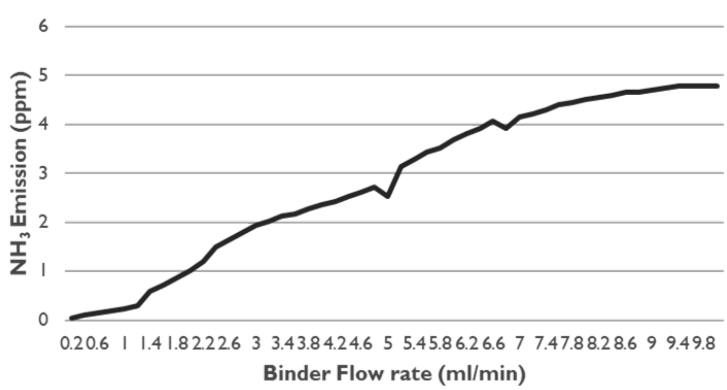

Fig. 4: Graph on NH_3 Emission vs Binder flow rate

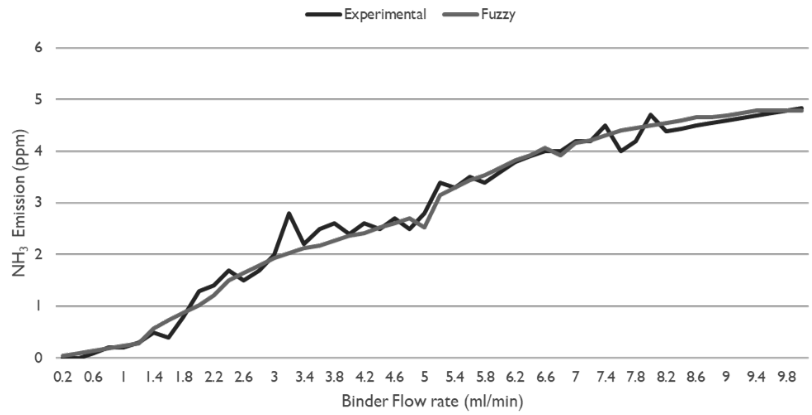

Fig. 5: Graph of comparison value of the NH_3 Emission

The trends of percentage errors are lessened along the input variables. Based on Figure 5 and Figure 6, around 6.91% of error in average in 50 sets of data.

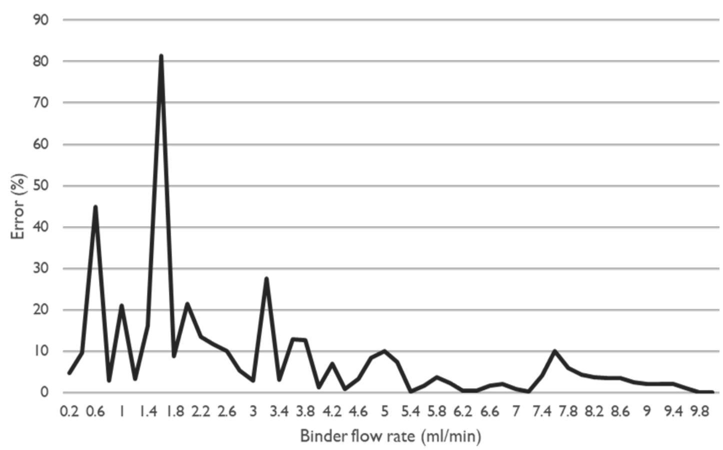

Fig. 6: Graph of percentage error of the NH_3 Emission

Based on data collection presented, the NH_3 emission tends to increase with binder flow rate. The experimental data is closed to the actual data as discussed in this part. The influence of binder flow rate with the specific value of constant variables were used enhance the released of NH_3 gas during the granulation process [14]. The impact of binder flow rate also improves completion time of granulation process and also improved granule size [15]. The defuzzification method which was small of maximum stand gives experimental value close to actual data. The selection of defuzzification method was a trial and error process to find better results [16].

Conclusion

An adaptive fuzzy logic controller has been successfully completed in this project. 50 sets of fuzzy values with different of binder flow rate which varies from 0.2 to 10 in ml/min. The results obtained by Mamdani inference system acceptable and close with experimental value thus the fuzzy designed applied was acceptable in this designing the project. As binder flow rate increases higher emission of NH_3. The average of percentage error for whole project was 6.91%. The highest and lowest error in percentage are 81.5 and 0 respectively

Extension of research with different properties and concentration of binder parameters are recommended. This project can be further studied by using other systems such as Takagi-Sugeno controller, Neural network or combination of fuzzy and neural which is Adaptive neuro fuzzy inference system (ANFIS) for better system comparison.

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