Modeling of Spray Angle and Nozzle Size to Gas Release in Processing Urea Fertilizers by Using Fluidized Bed Granulator

Norhidayah.Mohamad[1,2*], A. Shaaban[2]

[1]Faculty of Engineering Technology, Multimedia University, Jalan Ayer Keroh Lama, 75450, Melaka, Malaysia

[2]Advanced Manufacturing Centre, Fakulti Kejuruteraan Pembuatan, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka.

*Corresponding e-mail: nhidayah.mohamad@gmail.com

Keywords: Fluidized Bed Granulation; Ammonia release; Simulation

ABSTRACT – The fluidized bed granulation process is used in various applications in areas like pharmaceuticals, chemical, fertilizer and various industries. This process takes place inside a fluidized bed column where a binder solution is sprayed onto the powder in order to granulate the powder. Controlled spraying and optimum nozzle diameter of the binder solution is necessary for an optimal process. It is important to determine dependence of spray angle and nozzle properties at different scales used during development, as this information can be used as a basis for establishing process parameters for the manufacturing process. This paper presents the influence of ammonia release with multiple parameters used for spray angle and nozzle size characteristics of starch urea solution sprayed for the top spray granulation process in a fluidized bed chamber.

1. INTRODUCTION

The most common method of fluid bed granulation is top spray granulation where the binder solution is spread from a nozzle located above the fluidized bed [1-4]. Droplets from the spray nozzle get deposited onto the solids in the bed or chamber. The fluidization is carried out using hot air, and hence liquid from the droplets is vaporized which is the ammonia gases [5].

The granulation process in the fluidized bed is a complex process since there are a number of parameters that can affect the product output and increase the number of waste [6]. A list of most of the important process and apparatus parameters is presented by Rambali et.al, which includes atomization nozzle parameters such as nozzle air pressure, nozzle height position, nozzle air cap position, nozzle diameter and spray rate of binder solution [7]. They showed that atomization pressure and air cap position were significant parameters affecting the geometric mean granule size. This research, models were developed to simulate the spray angle and nozzle size with the effect of ammonia amount release by using starch urea binder solution for top spray granulation.

2. METHODOLOGY

The binder solution was made by adding with ratio of deionized water, starch and urea. There was spraying of binder solution through the nozzle on to the fluidized bed of granulating material. The nozzle was located in the upper port above the bed, facing downward. Batch size for fluid bed granulation powder was 150grams. Spray rate, atomizing air pressure was set to 0.5kg/ cm2. The inlet air temperature was set to 65^0 C and the inlet air humidity was not controlled and generally constant. The inlet air temperature was monitored throughout the granulation process. Samples were taken at regular intervals in order to collect the ammonia gas (NH3) release. The scope of the modelling and simulation is based solely on previous experiment. Thus, the parameters and the data from the experiment will be used to generate graphs using Matlab12b. Once the graphs were drawn, equations were generated so that Simulink models can be developed.

2.1 Modelling for the spray angle

The equation for spray angle versus NH_3 emission is

$$Y= 0.0111x^2 - 1.7667x + 110 \quad (1)$$

Thus a suitable mathematical model of block diagram is needed where 'A' is replaced to *x* and is the spray angle. The arrangement for the block diagrams is as shown below.

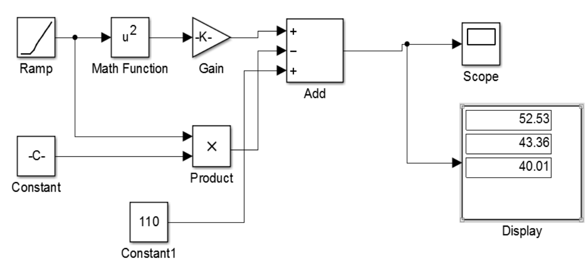

Figure 1 Simulink Diagram of Spray Angle

Each block is modified to form the equation for spray angle versus NH_3 emission. The blocks are then connected to each other with signal lines accordingly to the figure above. Before the model is ready to be run, the spray angles needed to be determined first. At Matlab command window, the codes for plotting the graph for spray angle are to be used. After entering the codes, a command 'Enter the values of spray angles' is prompted. The spray angle values as in Table 1 are entered which are 45, 60 and 90. The NH_3 emission is then calculated and compared with experimental data.

2.2 Modelling for the nozzle size

The equation for size of nozzle versus NH3 emission is

$$Y= 0.3726x^3 – 5.2143x^2 + 25.956x + 7e\text{-}12. \qquad (2)$$

where x is replaced by 'd' which is the nozzle size. The complete block diagram is as shown below.

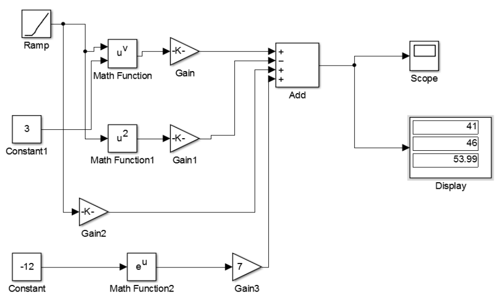

Figure 2 Simulink Diagram of Nozzle Variable

3. RESULT AND DISCUSSION

Table 1 Indicator of Parameters

No	Symbol	Parameter	SI Unit
1	A	Spray Rate	(ml/min)
2	B	Binder Viscosity	(µPa.s)
3	C	Binder Volume	(ml)
4	D	Nozzle Size	(mm)
5	E	Spray Angle	Degree
6	F	NH3 Emission	(ppm)

Table 1 is a reference of parameter used in this research**.**

3.1 Manipulated Variable: Spray Angle

Table 2 Spray Angle

No	A	B	C	D	E	F
1	8	0.236	250	3	45^o	5.3
2	8	0.236	250	3	60^o	4.4
3	8	0.236	250	3	90^o	4.1

Spray angle 45^o will give 5.3 ppm of ammonia emission, 60^o will make the ammonia emission 4.4 ppm and lastly, the spray angle at 90^o is the best angle when releases about 4.1 ppm only of ammonia emission.

3.2 Manipulated Variable: Nozzle Size

Table 3 Nozzle size

No	A	B	C	D	E	F
1	8	0.236	250	3	90^o	4.1
2	8	0.236	250	5	90^o	4.6
3	8	0.236	250	7	90^o	5.4

From the table 3, by using nozzle size of 3mm, ammonia amount release is 4.1 ppm followed by 5mm diameter of nozzle which is 4.6 ppm. The 7mm nozzle diameter produces the 5.4 ppm ammonia amount release.

4. CONCLUSION

From the experiment conduct, the optimum angle of the spray nozzle is 90^o. It directly sprays the binder to the center of the chamber and the urea particles absorbed the binder proportionately. Sprayed the nozzles angles such 45^o and 60^o, the binder solutions attached to the wall of chamber and escapes as ammonia gas and returns to the atmosphere.

The nozzle diameters are less significant towards the process. It is time consuming by using 3mm nozzle diameter and the size of the granule is uneven. Nozzle size 7mm, contribute higher ammonia release amount. In general, increase in nozzle size diameter, gas release also will rise. Thus it also prolonged the drying process.

ACKNOWLEDGMENT

The project is supported by Ministry of Education Malaysia LRGS/2011/FKP/TK02/1 R00001 driven by Universiti Teknikal Malaysia Melaka (UTeM)

REFERENCES

[1] Saurabh Srivastava, Garima Mishara, Fluid Bed Technology: *Overview and Parameters for Process Selection*, *J. Pharmaceutical Sciences and Drug Research* 2010, pp. 236-246.

[2]. M. F. Irfan, F. S. Mjalli, and S. D. Kim, "*Modeling of NH_3–NO–SCR reaction over CuO/γ-Al_2O_3 catalyst in a bubbling fluidized bed reactor using artificial intelligence techniques*," *Fuel*, vol. 93, 2012, pp. 245–251.

[3]. F. Mariani, C. N. Grimaldi, and M. Battistoni, "*Diesel engine NOx emissions control: An advanced method for the O2 evaluation in the intake flow*," *Appl.Energy*, vol. 113, 2014, pp. 576–588.

[4]. D. Niu, M. Li, and F. Wang, "*Optimization of fluidized bed spray granulation process based on a multiphase hybrid model*," *Chemom. Intell. Lab. Syst.*, vol.131, 2014, pp. 7–15,

[5]. A. Faure, P. York, and R. C. Rowe, "*Process control and scale-up of pharmaceutical wet granulation processes: a review*." *Eur. J. Pharm. Biopharm.*, vol.52, no. 3, 2001, pp. 269–77.

[6]. Tejas B Patel et. al, "*Influence Of Process Variables On Physicochemical Properties Of The Granulation Mechanism Of Diclofenac Sodium In Fluid Bed Granulation," Int. J. Pharm.,* vol. 3, no. 1–2, 2010, pp. 149–60,

[7]. B. Rambali, L. Baert, and D. L. Massart, "*Using experimental design to optimize the process parameters in fluidized bed granulation on a semi-full scale*.," *Int. J. Pharm.*, vol. 220, no. 1–2, 2001, pp. 149–60.