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Temperature effects on urea granules process to produce paddy fertilizer using top spray fluidized bed granulator

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Abstract: Temperature is often used in the convergence process chamber to control the level of humidity and the mass of granulated urea formation. However, the use of the expression of absolute temperature rarely investigated in urea granulation process but is limited in previous studies are often expressed as general reading . Therefore, this study was undertaken to determine an absolute temperature readings and its impact on urea granule. Features derived of urea granule diameter consist of 2 mm to 6 mm and hardness between 2.0 kg/ grains to 4.0 kg/details. Experiments were conducted with the aid of experimental design, the One -Factor -At-A-Time (OFAT) as the initial method to determine the absolute temperature readings associated with the production of urea granule at optimum moisture and hardness. Granulation process was done experimentally using top spray fluidized bed granulator with fluidizing air profile and concentration of appropriate mechanisms commensurate with the size and hardness of the target. The information and data may be useful to study the optimization of the parameters as an inspection process and compare it with other variables to determine the optimal parameter used in the urea granulation process using Top Spray Fluidized Bed granulator (TSFBG).

Keywords: Granulation; Fluidized bed Granulator; Urea fertilizer; Urea granulation.

Introduction

Granulation activities commonly performed in the 'wet quenching' [1]. In this study, the agglomeration of urea powder made through the physical interaction using Fluidized Bed Top Spray Granulator (TSFBG) in the presence of droplets of liquid binder. The temperature is monitored as a controllable parameter to ensure its ability to contribute on the sustainability of urea powder for sufficient hardness granule [2-4]. Thus, the presence of hot air as fluidizing agent is important to control the presence of the buffer so that the weakness of interaction between binder droplets and powder urea can be avoided during the collision and bound [5-7] through the link and integration of the two elements [8-10].

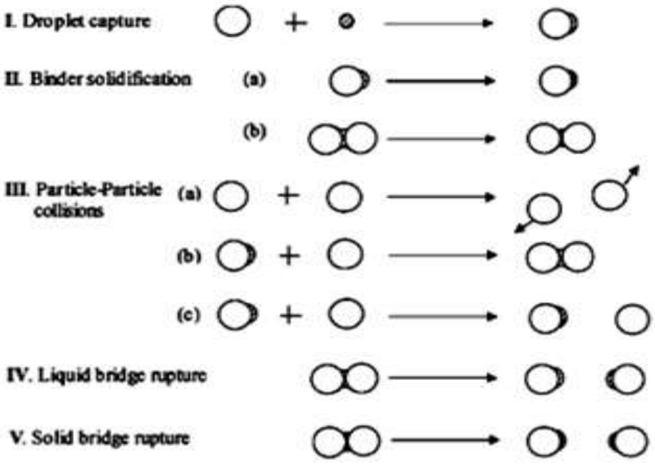

Fig.1: The stages of the agglomeration process and collision condition between powder particles and droplets binder

Fig.1 shows the agglomeration process that occurs during urea powder blown air at high pressure from the bottom of the chamber and supported by presence of viscous droplets from the spray of binder. Binder droplets are sprayed float collided with urea powder fluidizing condition specific profiles to form a granule slowly. In the on-going process of colliding particle has interacted with each other to form liquid bridge at stage IV. At the appropriate heating, excess moisture was eliminated gradually and remain at optimum levels to support the formation of solid bridges in the V where this will contribute to the widening of the granules (size - enlargement) gradually [11,12] . If the temperature greater than the level needed, then formation granule will not last long and be too dry and tend to return to normal powder form.

Materials and Method

A complete granulation process TSFBG technique is consist of a feed section line to spray liquid binder, followed by granulation section and the channel for the collection of granulated urea produced . Liquid binder was prepared in several ratios such as A : B : C in W / W % , A represents a starch , B for urea and C for deionized water . Then, to ensure a smooth flow, heating is required in the feeding line (using silicon hose) of 60 ^{0}C to ensure cassava starch remain as concentrated liquid so that the solidification does not immediately occur before reaching the nozzle head. Meanwhile, the granulation chamber was programmed with a minimum temperature of 35 ^{0}C up to a maximum of 105 ^{0}C in stages on the pressure, air velocity, time and rate of atomizing spray constant. Approximately 400 grams of urea powder need to be dried in granulation chamber for 10 minutes first. Then, the binder is sprayed gradually by 5 ml for each time interval of 5 minutes until complete 200 ml of the liquid binder provided. The binder was sprayed in ratio 100 : 200 W/ W % , as 100 grams of liquid binder sprayed onto 200 grams of urea powder. After 60 minutes of processing time, the formed granules were collected and classified physically to measure the diameter by using different mechanical filter with hole size of 1mm to 6mm made by Endecotts, United Kingdom, followed by hardness tests using analysts HT1 violence particles, Sotax, Switzerland.

Table 1: Parameters setting used in stages during granulation process

Inlet Air Temp. (^{0}C)	Outlet Air Temp. (^{0}C)	Duration (min)	Air Flow Rate (l/min)	Air Velocity (10^{-6} ms^{-1})	Fan (Hz)
35	25	60	3	3	30
50	45	60	3	3	30
65	65	60	3	3	30
80	65	60	3	3	30
95	85	60	3	3	30
105	85	60	3	3	30

Table 1 show a list of readings obtained from the previous study but have been screened and improved in this experiment for comparison and evaluation to determine the absolute temperature in the formation of urea granules. The temperature of inlet and outlet air regularly monitored through the operation panel. The other parameters were maintained as constant through OFAT method involving only one type of factors that change as well as being a major contributor in the characterization of the urea granule..

Fig. 2: The actual design of FLP 1.5 Mini Fluidized Bed Granulator used for granulation experiment, A. Exhaust Chamber, B. Top Spray Inlet, C. Granulation Chamber, D. Granules & AAI Port, E. Atomizing Pressure Gauge, F. Atomizing Pressure Regulator, G. On /Off Button, H. Touch Screen Monitor

Fig. 2 indicates the actual TSFBG used during the urea agglomeration process. Point B was the inlet liquid binder, while point C was a granulation chamber which the agglomeration occur at different temperature, point D was the granules channel been collected and monitored. The inlet and outlet air temperatures observed at point H and atomizing pressure was controlled at point E and F.

Results and Discussion

Most of the obtained data were collected from literature review and verified experimentally in stages using OFAT method. The heating process was done from room temperature until 110 ^{0}C, increased gradually every 15 ^{0}C as to reduce and optimize the heating at minimum energy consumption without allow the granules deform back to powder phase at kinetic condition.

Table 2: The effects of changes temperature onto granule features formation

Run	Temperature (^{0}C)	Granule Size (mm)	Hardness (kgf/granule)
1	35	1.0	12
2	50	3.0	22
3	65	5.0	35
4	80	4.0	40
5	95	2.0	11
6	110	0.5	6

Table 2 shows the size differences and hardness obtained from granules at varying temperature. The size increased gradually until 65 ^{0}C and decreased when the temperature exceeded than 65 ^{0}C to 110 ^{0}C. Temperature below than 65 ^{0}C capable to sustain moisture content level in supporting physical linkages between sub-particle surfaces, then easier to be agglomerated either by layering or sticking by plating to cover the entire surface of the droplet binder [13].

Table 3: The correlation of granule features obtained from repeat experiment.

Stage Number	Temperature (^{0}C)	Granule Size (mm)				Hardness (kgf/granule)			
		1	2	3	Average	1	2	3	Average
1	35	1.0	1.5	1.0	1.17	12	12	12	12.00
2	50	3.0	3.8	3.2	3.33	22	22	23	22.33
3	65	5.0	4.8	5.0	4.93	35	34	35	34.67
4	80	4.0	4.5	4.2	4.23	40	40	40	40.00
5	95	2.0	2.2	1.8	2.00	11	11	12	11.33
6	110	0.5	0.2	0.5	0.40	6	5	6	5.67

Meanwhile, Table 3 indicates that the sustainability of obtained granule size and hardness from the repeat experiments at different temperatures. At stage number 4 shown better hardness compared to the rest which influenced by the optimum linkage strength between sub-particles bound at minimum moisture content. Starch (binder) has functioning at a crucial point between solidification-liquid phases before melting at temperature beyond than 80 ^{0}C and consequently cause the granulated urea deform to powder. Glue from starch eliminated gradually when the heat increased at number 5 and 6. The evaporation occurred whenever the solidified glue transformed to the liquid condition at critical points which considered as a crucial temperature point such as targeted in this study.

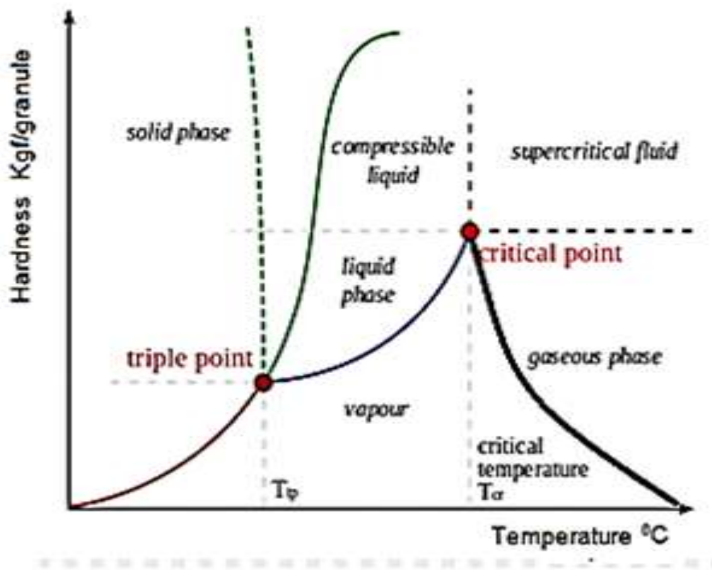

Figure. 3: Relations in the determination of the critical level before the transformation of urea granule to a powder phase which affected by temperature changes.

Figure 3 shows the critical points which contribute to the change of the phase of the urea granule into powder because the particles were too dry and weak from physical bond. The force of agglomeration has decreased gradually and in the continuous heating caused some urea powder released slowly changing as an ammonia and reduce the amount of N (nitrogen) that is required in paddy as nutrient supplements. At this level, coalescence and consolidation of wetted powder particles were growing to achieve an equilibrium state and stop at a critical point. The loss of moist binder was contributed to the breakage and attrition problems which cause to the failure of agglomeration process.

Summary

The listed temperature reading shows the significance of the heat contribution in agglomeration process. According to the discussed result and the obtained experimental data were vindicated that the influences of the absolute temperature on the potential of coalescence and consolidation interaction. If the agglomeration process too dry, it would not helpful to sustain the granulated urea for a long time, otherwise it would break and deform to the powder phase easily. At critical points indicates that the potential of binder to loss much moisture content and becomes weak in sustainability of physical strengthen bonding. Furthermore, defects factor during the agglomeration process and smaller granule size would be produced at the end of the process duration. Screening steps were proven in stages whereby OFAT method was still reliable and reasonable to evaluate the effects of absolute temperature parameter on formation the physical features of the granulated urea. Nevertheless, this study would be improved and enhanced further by using response surface methodology (RSM) and full factorial design to gain run number of each temperature reading for experimental quality control and accuracy of the measurement.

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