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Communication

Effects of Nitrogenous Fertilizer Filling Material Particle Sizes on Fertilizer Particles

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Abstract: The most important problem during fertilizer packing in the fertilizer industry is non-uniform fertilizer granule size. This problem of different particle sizes occurs with varying frequency in each bag during packaging and is known to market users as the "negative effect". In this study, the effect of calcium carbonate, dolomite, and magnesium carbonate, which are used as filling materials during fertilizer manufacture, on fertilizer particle size is researched and bond formation between fertilizer particles and filling materials is investigated using instrumental analysis methods.

Keywords: filling material; nitrogenous fertilizer; bond energy; particle; calcium carbonate; dolomite; magnesium carbonate.

1. Introduction

Filling materials are used in the fertilizer industry to dilute aqueous fertilizer solutions to desired ratios according to requirements. The most used filling materials are dolomite, magnesium carbonate, and calcium carbonate [1]. Each filling material has a specific density, so reactions between these filling materials and nitrogenous fertilizer will show variations [2].

If magnesium carbonate is used as the filling material, the reaction shown below has been known to occur:

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$$2MgCO_3 + 4NH_4NO_3 \rightarrow Mg(NH_4NO_3)_2 + Mg(NO_3)_2 + 2NH_4CO_3$$

If calcium carbonate is used as the filling material, the following reaction has been known to occur:

$$2CaCO_3 + 4NH_4NO_3 \rightarrow Ca(NH_4NO_3)_2 + Ca(NO_3)_2 + 2NH_4CO_3$$

If dolomite is used as the filling material, the following reaction has been known to occur:

$$CaMg(CO_3)_2 + 6NH_4NO_3 \rightarrow Ca(NH_4NO_3)_2 + Mg(NH_4NO_3)_2 + Ca(NO_3)_2 + Mg(NO_3)_2 + 2NH_4CO_3$$

The bulk density of ammonium nitrate fertilizer manufactured using magnesium carbonate is between 1.30 g/cm^3 and 1.40 g/cm^3 [3]; that manufactured using dolomite is between 1.36 g/cm^3 and 1.51 g/cm^3 [4], while that manufactured using calcium carbonate is between 1.40 g/cm^3 and 1.65 g/cm^3 [5]. These density values are closely related to the fertilizer particle size during fertilizer packing. According to marked requirements, fertilizer particles should not cover large volumes. This has the opposite effect on fertilizer particle mass to the market requirement. Hence, the filling material is added at definite time periods to obtain the desired dilution ratio. Accordingly, the amount of calcium carbonate in calcium ammonium nitrate has 20% nitrogen (100 ton/h manufacturing capacity) when the amount of each filling material is calculated at a given range is below:

1.42 g/cm^3 < density ($CaCO_3$) < 1.65 g/cm^3

42.86 cm^3 * 1.42 g/cm^3 < $CaCO_3$ < 42.86 cm^3 * 1.65 g/cm^3

60.8612 g < the amount of $CaCO_3$ < 70.719g

When $Ca(NH_4NO_3)_2$ is produced, the amount of $CaCO_3$ should be between 60.8612 g and 70.719 g.

When dolomite is used as the filling material in a production process with the same capacity, the amount of dolomite that should be used in a fertilizer solution having 20% nitrogen is below:

1.36 g/cm^3 < density ($CaMg(CO_3)_2$) < 1.51 g/cm^3

42.86 cm^3 * 1.36 g/cm^3 < $CaMg(CO_3)_2$ < 42.86 cm^3 * 1.51 g/cm^3

58.2896 < the amount of $CaMg(CO_3)_2$ < 64.7186

When $Mg(CO_3)$ is used in the fertilizer solution,

1.30g/cm^3 < density ($MgCO_3$) < 1.40 g/cm^3

42.86 cm^3 * 1.3 g/cm^3 < $MgCO_3$ < 42.86 cm^3 * 1.4 g/cm^3

55.718 < the amount of $Mg(CO_3)_2$ < 60.004

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In this study, the effect of calcium carbonate, dolomite, and magnesium carbonate as filling materials on fertilizer particle size is researched and bond formation between fertilizer particles and filling materials is investigated using instrumental analysis methods.

2. Materials and Methods

SEM images of the nitrogenous fertilizer were obtained using a Jeol 6060 Scanning Electron Microscope.

Each bond between the filling material and fertilizer has different bond energy according to the kind of filling material used because particle volume changes and this change directly affects particle size. The SEM image shown in Fig. 1 depicts the use of calcium carbonate as the filling material, that of $MgCO_3$ is shown in Fig. 2, and that of $CaMg(CO_3)_2$ is shown in Fig. 3. For working quality and a sharp view, the $CaCO_3$ image was taken at a wavelength of 520 nm, that of $MgCO_3$ was taken at a 560 nm wavelength, and that of $CaMg(CO_3)_2$ was taken at a 600 nm wavelength.

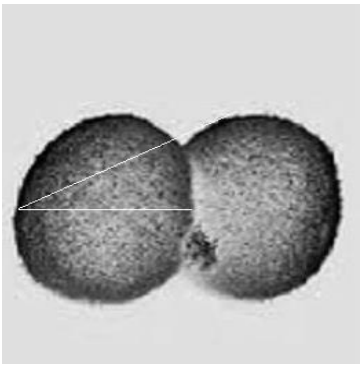


Figure 1. 45-Degree angle between calcium carbonate and the fertilizer surface

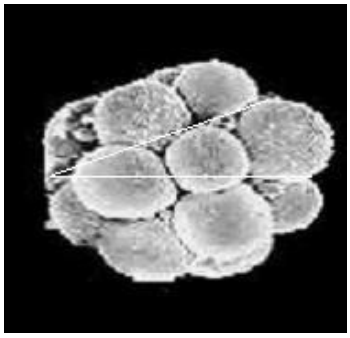


Figure 2. 45-Degree angle between magnesium carbonate and the fertilizer surface

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Figure 3. 45-Degree angle between dolomite and the fertilizer surface

3. Results and Discussion

In this study, the type and amount of filling material used to dilute the fertilizer solution in the fertilizer manufacturing process was determined to affect fertilizer particle size. Filling material is added to the reaction in the fertilizer manufacturing processes after the main fertilizer component is produced [6]. Fertilizer particle size will change dramatically according to the forms and amounts of additions and reaction ambience.

In the reaction ambience of ammonium nitrate, the amount of filling material that should be in the unit volume and the angle between ammonium nitrate and the filling material on the fertilizer particle surfaces depend on the density of the filling material used and the solution temperature [7]. Depending on market requirements, the average fertilizer particle diameter should be 2 mm [8]. Obtaining this particle size is one of the most important problems and was a central focus of the fertilizer prilling process.

Another feature of this study is the improvement of the process conditions before the prilling process to obtain uniform sized particles [9]. It is possible to produce fertilizer types such as calcium ammonium nitrate or magnesium ammonium nitrate according to the kinds of filling material used. It was understood from SEM that the angles of all filling material particles used to dilute the ammonium nitrate solution are connected to the fertilizer particle surfaces under the same conditions (50 °C and pH 6.7) and resemble each other.

According to the SEM images, the angle at which the filling material was connected to the ammonium nitrate surface was 45 degrees at a 500 nm wavelength. Moreover, if the dilution ratio increases, the amount of filling material in a unit volume of fertilizer solution increases and the angle at which the filling material is connected to the fertilizer surface increases, so the particle size increases [10]. According to the market requirements for 100 t/h and a fertilizer solution having 20% nitrogen, between 60.8612 g and 70.719 g of calcium carbonate, between 55.718 g and 60.004 g of

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magnesium carbonate, and between 5.2896g and 64.7186 g of dolomite should be used to obtain the desired fertilizer particle diameter of 2 mm.

4. Conclusions

In this study, obtaining optimum particle size productivity is accepted as one of the most important problems in the fertilizer industry and so, to meet market requirements, the influence of filling materials added to dilute fertilizer solutions in the production process was investigated. Accordingly, it was determined that 65.7901 g $CaCO_3$; 57.861 g $MgCO_3$, and 61.5041 g dolomite ($CaMg(CO_3)_2$) should be added during the production process of ammonium nitrate having 20% nitrogen and produced at 100 t/h in order to obtain an average fertilizer particle diameter of 2 mm.

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