KEY MATERIAL CHARACTERISTICS TO CONSIDER WHEN PELLETIZING LIMESTONE

Review
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Abstract: *While pelletizing limestone has become a standard practice due to the numerous advantages it offers, the process demands careful engineering to guarantee a consistently reliable and continuous operation, maximizing on-size yield. Several material characteristics play a crucial role in this endeavor. These include factors such as particle size distribution, moisture content, bulk density, and chemical composition. Each of these characteristics must be meticulously managed to produce a high-quality final product and optimize the efficiency of the pelletizing process. Understanding and addressing these variables is essential for achieving the desired outcomes and maintaining operational effectiveness.*

Key words: LIMESTONE, PELLETIZING, MATERIAL CHARACTERISTIC

INTRODUCTION

THE LIMESTONE PELLETIZING PROCESS

The most common configuration for a limestone pelletizing plant features a combination of a pin mixer and a disc pelletizer. This approach not only maximizes on-size yield but also results in a highly refined product with improved physical and chemical characteristics. [1]

The pin mixer-disc pelletizer setup operates on the principles of wet granulation, or agitation agglomeration, which involves the use of a liquid binder combined with a tumbling motion to transform powders and fines into spherical granules. This process is akin to rolling a snowball, where smaller particles adhere to one another, gradually forming larger, more uniform pellets. [1,2]

Although some producers may choose to utilize a disc pelletizer alone, many have found that the benefits of adding a pin mixer to the process far outweigh the costs. The pin mixer enhances the initial agglomeration phase by promoting better particle cohesion and moisture distribution, which leads to a more consistent product. This efficiency can significantly increase throughput and product quality, allowing producers to meet market demands more effectively.

Additionally, the combined setup can help reduce waste by minimizing the amount of oversize or undersize material generated during production. The investment in a pin mixer often pays for itself through these efficiencies and the enhanced performance of the final product. A simplified flow diagram illustrating the pin mixer-disc pelletizer setup is provided here for further clarity. [2]

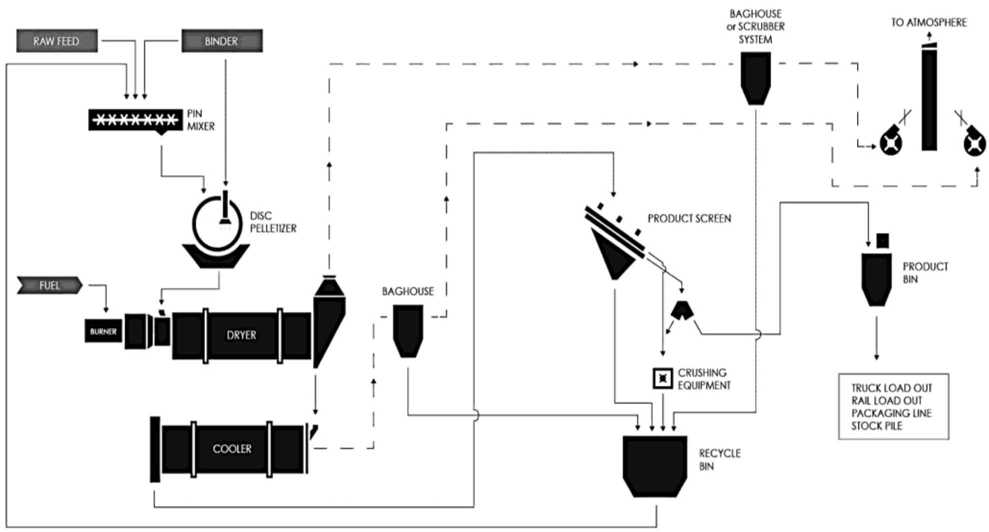

Figure 1, A simplified process flow diagram (PFD) for a typical limestone pelletizing process using a pin mixer-disc pelletizer combination generally includes the following steps

- Raw Material Feed: Limestone is sourced from a quarry and transported to the facility.
- Crushing and Grinding: The limestone is crushed and ground to achieve the desired particle size distribution.
- Moisture Adjustment: Moisture content is adjusted through pre-drying or backmixing with dried material.
- Pin Mixer: The limestone is mixed in a pin mixer, where moisture is added to facilitate initial agglomeration.
- Disc Pelletizer: The mixture is then fed into a disc pelletizer, where it is further agglomerated into pellets through controlled motion.
- Drying: The newly formed pellets may undergo a drying process to reduce moisture content and enhance strength.
- Cooling: The pellets are cooled to stabilize their structure.

- Screening: The cooled pellets are screened to separate on-size pellets from overs and unders.
- Packaging: The final product is packaged for distribution.

MATERIAL CHARACTERISTICS THAT INFLUENCE THE LIMESTONE PELLETIZING PROCESS

Successful pellet formation and growth primarily hinge on achieving the right combination of parameters, which can vary significantly for each material. The following characteristics serve as the foundation for any pelletizing operation, regardless of the type of material being processed. [3]

PARTICLE SIZE DISTRIBUTION

Particle size distribution (PSD) plays a crucial role in agglomeration. The distribution of particle sizes must be sufficiently narrow to promote a uniform product while also diverse enough to provide a range that allows smaller particles to fill the gaps between larger ones. The ideal PSD for effective agglomeration varies by material; for limestone, the optimal PSD typically falls within minus 250 microns.

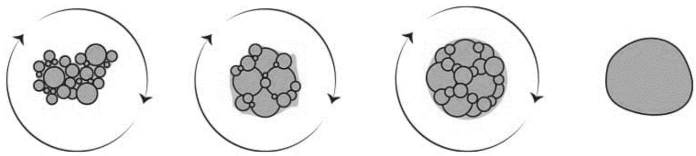

Figure 2, This illustration shows how the right PSD allows smaller particles to fill in the spaces between larger particles during pellet formation

Obtaining the optimal particle size distribution for pellet formation often necessitates some form of pretreatment, such as crushing or grinding, especially when the material is sourced directly from a quarry. This pretreatment is important because variations can occur not only between different sources but also within the same deposit. By implementing pretreatment, producers can ensure a uniform feedstock, leading to consistent processing and predictable product quality. [4]

Figure 3, Powdered limestone before (left) and after (right)

PARTICLE SHAPE

Like particle size distribution, particle shape significantly impacts the pelletizing process, particularly in how particles fit together on a micro level and the strength of the resulting agglomerates. Granules with irregular shapes that create many void spaces will be weak, while more rounded particles fit together more effectively, resulting in stronger agglomerates. [4]

It’s not surprising that particle shape works in tandem with particle size distribution to determine how well particles interconnect. The shape of limestone particles can vary based on several factors, including natural formation and pretreatment methods.

MOISTURE CONTENT

Moisture content plays a crucial role in the pelletizing process; insufficient moisture prevents particles from coalescing effectively, while excessive moisture can cause the material to become a cake or slurry. Each material has a specific "window" of moisture content that allows for optimal agglomeration. For limestone, this optimal moisture range typically falls between 5% and 15%.

Similar to particle size distribution, achieving the precise moisture content often necessitates some form of pretreatment. This may involve a pre-drying step or backmixing, a technique where dried material is blended with the raw feedstock—usually using a pugmill mixer—to lower the overall moisture content of the mixture.

BULK DENSITY

Limestone generally has a bulk density ranging from 60 to 80 PCF, although this can vary. Considering bulk density is crucial because, in general, a lower bulk density of the feedstock leads to reduced throughput in the system. Most limestone producers aim to achieve a product with a specific bulk density that aligns with fertilizer products. The further the feedstock deviates from this target, the longer it takes to reach the desired density.

This is one reason why producers using a disc pelletizer often choose to include a pin mixer in their process. The mixer increases density rapidly through motion, which in turn enhances overall production.

LIMESTONE COMPOSITION

As mentioned earlier, limestone can vary greatly in its natural physical properties. Similarly, its chemical composition can differ significantly not only between sources but even within the same deposit, creating a complex matrix of potential compositions and characteristics. These varying constituents and their concentrations can make the pelletizing process highly unpredictable. This is why process development work remains essential when designing a limestone pelletizing line, despite the well-established nature of the technique.

Two of the most commonly found constituents that impact the pelletizing process are clay and silica. Clay is particularly notable because it can aid the agglomeration process. As a natural binding agent, clay in limestone can reduce the need for an additional binder, depending on its type and concentration. However, if the clay content is too high, it can hinder or even prevent agglomeration, causing the material to behave like a slurry or cake.

RECYCLE

Recycle refers to the amount of over- and under-sized product generated during the process. While recycle itself is not a characteristic of limestone, it is influenced by limestone's properties, making it worth noting. Certain types of limestone, due to their specific physical and chemical traits, are easier to manage during agglomeration. This allows operators to control pellet formation and growth by adjusting process variables, leading to a higher on-size yield and reduced recycle. [5]

Conversely, limestone that is more challenging to manage results in a higher recycle rate. Some level of recycle is often beneficial, as it provides a buffer during process disturbances and facilitates easier startups. However, excessive recycle can be inefficient, as it leads to the reprocessing of large amounts of material.

LIMESTONE CHALLENGES

Along with the standard parameters that affect the pelletizing process, limestone possesses several material characteristics that can pose challenges for those aiming to convert it into a granular product. Its potential for wide variation, abrasive nature, and tendency to clump or cause buildup emphasize the importance of conducting early testing.

Figure 4, Limestone's tendency to clump can complicate the pelletizing process, as any imbalance may lead to the formation of clumped pellets, often referred to as "raspberries," as illustrated here

CHARACTERISTICS OF PELLETIZED LIMESTONE

By controlling the characteristics mentioned earlier, along with production conditions, limestone producers can fine-tune their pelletizing process to create a product that meets exact specifications. [6,7] Depending on requirements for handling, performance, and appearance, producers often aim to achieve a combination of the following qualities:

- Bulk density (apparent and tapped)
- Surface area to volume
- Compression
- Crush strength
- Flowability
- Green/Wet strength
- Porosity
- Attrition
- Particle size distribution (PSD)
- Moisture content
- Solubility

In fact, it is this capability of particle engineering that has led to the growing market share of pelletized limestone in the soil amendment industry and beyond. Producers can fine-tune particle characteristics to ensure their products meet market demands in the following ways:

- Product uniformity
- Minimal dust (attrition)
- Handling and performance characteristics
- Storage potential and shelf life
- Blending abilities
- Appearance

CONCLUSION

Limestone pelletizing provides many benefits, but the process is highly dependent on material characteristics that require careful attention. Factors such as particle size distribution, moisture content, bulk density, and chemical composition are crucial in producing a consistent, high-quality product. By fine-tuning these variables, producers can enhance operational efficiency and maximize the yield of correctly sized pellets. This highlights the importance of thorough testing and process development to address the complexities of limestone and ensure the pelletizing process aligns with both production and quality objectives.

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