



ALLIANCE™

(<https://debug.globalseafood.org>).



Aquafeeds

Shrimp feeds depend on proper ingredient grinding

29 July 2016

By Eugenio Bortone, Ph.D., PAS, Dpl. ACAN and Todd Kipfer

Using correct particle size a critical step for best aquafeeds



Proper grinding of ingredients is a critical step in the manufacturing of aquafeeds with the proper quality and necessary characteristics for good performance at the farm. Photo by Darryl Jory.

Aquafeeds for fish, shrimp and other aquacultured species must be reduced to and have a particle size small enough to meet the digestibility and manufacturing characteristics of the target feed. To determine what particle size is appropriate for the ground meal containing all ingredients that will be pelletized or extruded into the final aquafeed product, it is important to consider the stage of life/growth and size of the target animal, and the process to be utilized to manufacture the specific aquafeed.

Perspectives from nutrition and processing

From the stand point of nutrition, the smaller the particle size the more surface area is available for the consuming animal's digestive enzymes, thus the better the feed digestibility. Therefore, the particle size needs to be small enough to meet the target species the feed has been formulated and manufactured for. Particle size also plays an important role in the various post-processing steps.

First, smaller particles, providing more surface area, will cook faster when subjected to the steam in the preconditioner. This is related to the heat transfer as steam condenses onto the particles. Second, the sizes of the particles need to be small enough to avoid the pelleting mill or extruder to have to do more work grinding them down. The latter can happen if the particles are too large that they cannot go through the inlet of the orifice that forms the pellet in the die. The rollers and the die will act as grinders to be able to push through particles. This can result in higher than desired energy consumption, poor pellet quality due to large pieces that can cause break points and fines, and poor water stability. Smaller, uniform particles can compact better as they are extruded through the die.

A similar situation could occur with the extruder because more energy will be required to break down the large particles and some, depending on the screw configuration, will not melt at all resulting in die blockage that can reduce the capacity of the extruder and affect the overall quality of the product.

Distribution of particle size

As important as particle size reduction is, it is also important that the particle size distribution be as narrow (uniform) as possible. In a pre-grinding system where ingredients are ground separately, it is more difficult to obtain a final mix in a narrow range of particles. In contrast, in post-grinding where the pre-mixed ingredients are ground together, the particle size distribution is narrower and thus more uniform.

This uniformity in particle size is very important because it improves the feed manufacturing process as it progresses downstream. For example, in the pelleting process the preconditioned mash with a larger particle size distribution will have less starch gelatinization, because it takes more energy and more time to make the starch gelatinize for a large particle than for a small one.

Durability of aquafeeds

For shrimp aquafeeds, the best results are obtained when the mixing of feed mash is of high quality. Extruder systems usually work better when the raw materials have a particle size distribution of 95 percent when passing through U.S 60 mesh (250 microns), and in some cases 95 percent minus U.S 80 mesh (177 microns).

Both mixing and grinding processes are critical to the finished pellet operation. Typically, the point where additional grind size attention becomes critical is when making 1.5mm or smaller diameter feeds and down to 0.8 mm. At this point, most feed manufacturers will have to use an Air Swept Pulverizer or double grind the mix. A 0.8 mm shrimp feed would require the raw materials to pass through 60 mesh (250 microns) but it depends on the final product size requirements. Extruder manufacturers use a rule of thumb that states that the largest particle should be no larger than one-third the die size. Using this rule and coupled with the extruder die will determine particle size requirements, and ultimately whether a Fine Grinding Hammer Mill or Ultra Fine Grinding Air Swept Pulverizer is required for feed production.



Selecting and properly using the right grinding equipment is another important step for the manufacture of quality aquafeeds. Photo by Darryl Jory.

Requirements for pellet density

Shrimp feed pellets have other requirements besides nutritional needs. Pellet density plays a significant role regarding whether the feed product will sink immediately (as desired) and/or lose integrity (break apart). Finer particles tend to form a tighter bond or pack, and result in a better density product. With each pellet or particle having more surface area per unit weight, the result is a stronger, more densely packed pellet that reduces the tendency to soak up water and then break apart. Further, loosely packed particles that quickly break apart will negatively impact pond water quality and effluents, in addition to reducing nutrient uptake by the shrimp.

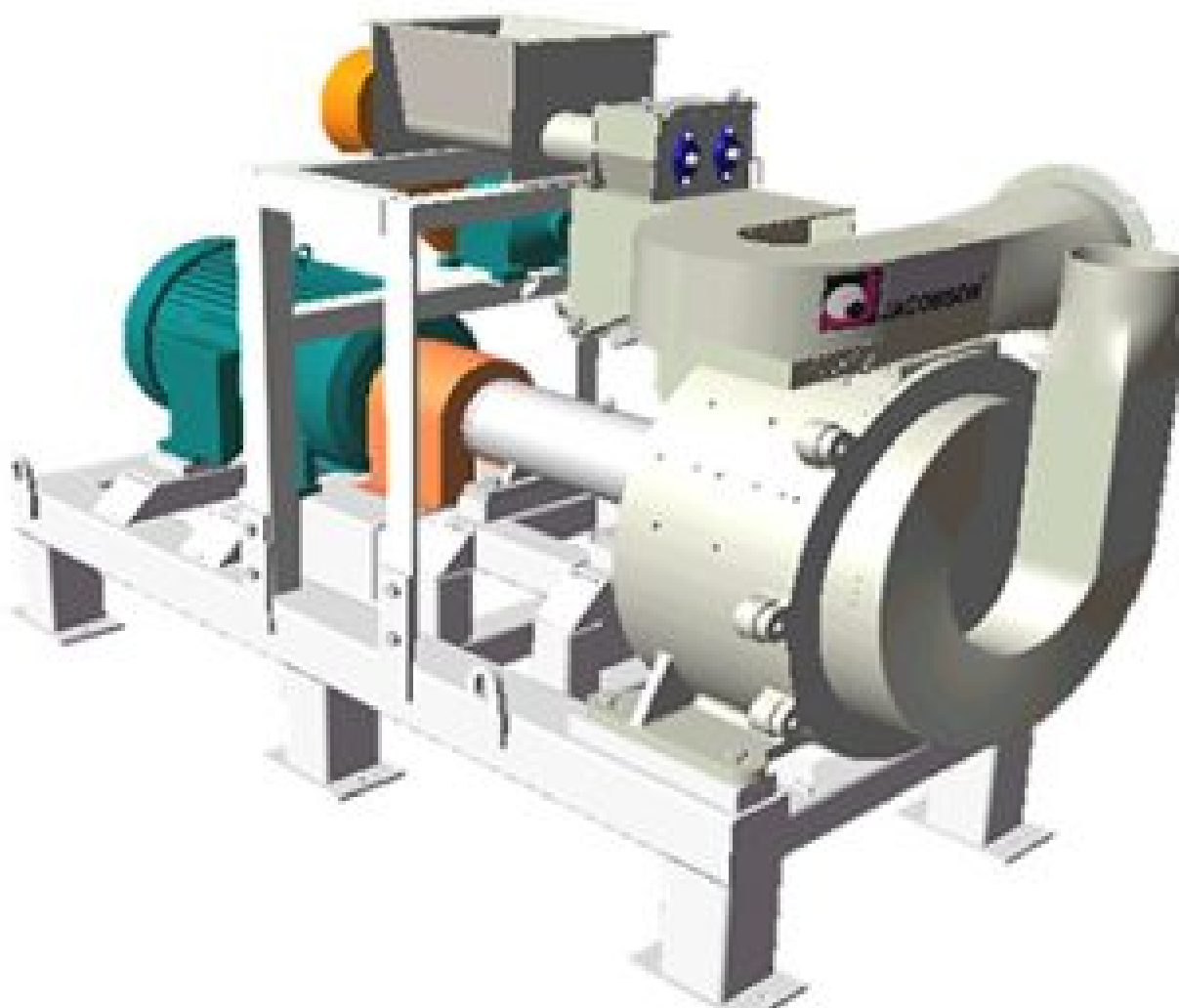
The pre-grind process

Prior to finish the ingredient grinding step, a process called pre-grinding is often carried out. It usually involves a Full Circle Hammer Mill to individually grind whole grains such as wheat, rice, corn and others. This is typically done using screen sizes of 8/64" – 9/64" (3.0 mm– 3.5 mm). Following this

process, all the major ingredients are weighed and are then transferred to the mixer. Following the mixing of the major ingredients, micro ingredients such as vitamins are added for an additional mixing cycle. The ration, once completely mixed, is prepared for fine or ultra fine grinding depending on the customer's desired particle size requirements.

Considering fine grind hammer mill or ultra fine pulverizer

A critical decision that frequently arises is what piece of equipment to use to reduce ingredient sizes to the desired range. Several factors must be considered to choose the right equipment that can meet your needs. Formulas high in protein and fat, yet lower in fiber, work very well on an Air Swept Pulverizer, while diets/formulas high in fiber and lower in protein and oil perform very well on a Fine Grind Hammer Mill (FGH). Both of these equipment types require air assist.



Feed formulas high in protein and fat, yet lower in fiber, work well on air-swept pulverizers. Illustration courtesy of Carter Day International.

In most practical applications, ambient air is the simplest and most affordable coolant method available. Dilute-phase pneumatic conveying serves two main purposes: first, it carries the ground product from the grinder to the product collector, and second it cools the material inside the unit grinding chamber using ambient air. This method is mainly used for ASPs prior to pelleting or extruding shrimp and other aquafeeds that are smaller than 2.5 mm. This method is also used on Fine Grind Hammer Mills (FGH) along with variations of this arrangement. For either unit, the air/cooling system is critical to proper system operation.

Pulverizers do not have screens like hammer mills, also known as high speed impact mills. They operate with materials metered into the air stream at the ASP inlet. The material is impacted by carbide-tipped hammers that are connected to the beater plates. The impact reduces the size of the larger particle and distributes the material around the interior of the grinding chamber. As impact continues against the corrugated liner ridges, particles are further reduced in size. The ground material is then pulled through the ASP and into the product collector. The tip speed of the beater tips can be as high as 31,000 feet per minute, thus producing fine grinds. ASPs have lower capacity capability than FGHs; however, they are capable of producing a finer grind of 95 percent minus 60 mesh (250 micron) at rates of 10-15 kg/hp./hr.

In pulverizers, carbide-tipped hammers connected to beater plates reduce particle size and produce fine grinds. Illustration courtesy of Carter Day International.

Hammer mills

Like ASPs, fine grinder hammer mills also impact the metered ingredient that is mixed in with the air stream. Material is impacted with hardened and hard-faced hammers and thrown against cutting plates for the initial particle breakage. The material bounces off the cutting plates and is impacted by the swing hammers again. The material is now approaching the screen at the interior velocity of the grinding chamber and it reaches the screen at an acute angle, thus providing further size reduction.

FGHs are capable grinding product to 90-95 percent minus 40 mesh (420 microns), and the performance will depend on the formula used (fat, fiber and protein content). Hammer mills tend to work well on fiber-type diets and not as well on ASPs when high fat is present, because of various screen blinding issues.

Perspectives

There are many factors to consider when selecting equipment for aquafeed manufacturing, whether it is for grinding, mixing, pelleting or various other processes. Consideration should be given to the quality of the equipment, initial investment cost, the efficiency and operating costs, its reliability, serviceability and other important factors. Prospective clients should request lab testing to verify particle size distribution and capacity on one or more formulas. Consider that an experienced, reliable supplier that has been in the business for a long time and supports its equipment installations is a valuable, long-term partner for your aquafeed processing needs.

Authors



EUGENIO BORTONE, PH.D., PAS, DPL. ACAN

Sapientia Technology
Frisco, Texas USA

drbortone@gmail.com (<mailto:drbortone@gmail.com>)



TODD KIPFER

Carter Day International, Inc.
500 73rd Avenue N.E.
Minneapolis, Minnesota

Copyright © 2023 Global Seafood Alliance

All rights reserved.

