The Art of Oilseed Meal Grinding [1]

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Abstract

Meal grinding must be set up to give a definite and desired product. The original concept of solvent extracted soybean meal grinding was to use the two-stage grinding system. However, the advent of front end hull removal equipment resulted in the development of the single stage grinding system, utilizing the grinders with just one sifter. This system lends itself well to grinding on stream. Meal grinding installations must be carefully planned to accommodate all parameters, such as desired consistency of finished product, dust control, conveyance systems, placement of all equipment in meal grinding system, and provisions for hot-meal, or wet-meal grinding requirements.

The operation of meal grinding, whether it be for soybean or other oil-bearing seeds, is best looked at in two main areas, the mechanics of the grinding device, and the placing of the mill in the processing system.

Changes in the preparation of meal prior to the grinding process have caused changes in the effectiveness of meal grinding. Perhaps the biggest and most significant change was the change from the expeller cake process to the solvent extraction process. Also, in later years, the advent of front end dehulling equipment greatly facilitated the processing of meal through the grinding process.

The problem, therefore, becomes one of selecting the proper type of pulverizer to meet the objectives and specifications of a finished product of the oilseed meal industry. Although in terms of final granulation the specifications may vary somewhat, they really are very close. One major feed company has the following specifications for their finished meal grinding: Everything through a 10 mesh screen, with 50% maximum through a 24 mesh screen. Another company gave an older original specification of approximately 11% moisture meal of 0% on 10 mesh, 10%–20% on 20 mesh, 40%–60% on 60 mesh, 25%–40% on 100 mesh, 2% maximum through 100 mesh. The companies have since revised the figures because these seemed to be just too fine. In general it can be safely assumed that the finished meal specification for most applications calls for no more than 1% on a 10 mesh screen and no more than 1% through an 80 mesh screen.

Because of this specification, the selection of a mill which will not grind the friable meal too fine is important. The first important parameter to achieve this condition is to arrive at the proper relationship between horsepower and screen area. The nature of grinding a product like solvent extracted soybean meal is such that a mill with a large screen area is highly desirable. One cannot simply add more horsepower to an existing small screen mill to achieve a good high volume meal grinder, because as the driving force (horsepower applied) is increased, while holding to a fixed screen area, the resultant grind will be finer. Obviously in meal grinding this is not desirable. The particular mill which is grinding most of the soybean meal processed in the United States today has not one, but two screens in it, giving a total of 1,710 in.^{2} of screen area, with a driving force of 100 horsepower or a ratio of over 17 in.^{2} of screen area per horsepower applied.

A second important consideration is to get the product being ground out of the mill, after it has been reduced to the proper granulation, as fast as possible. Of course, a large screen area will help to do this. In addition to a the mill is also of help. A pulverizer, which is really screen area, however, proper use of the air passing through nothing more than a rotor with swinging hammers turning inside a mill case or an enclosure, can be considered as a fan. The air created by the turning of the rotor at 1800 rpm, particularly in a large diameter mill, is definitely a reality and, properly used, can be an asset to the grinding of meal.

The air naturally enters at the eye of the mill through both sides, under the suction caused by the turning of the rotor, and exits at the bottom of the discharge. If this system were to be choked or starved for air in any way, the capacity and resultant granulation would be adversely affected. In other words, it is a good policy to let the mill "breathe," and if the discharge goes into a mechanical conveying system, it is sufficient to balance the air system with a small dust collecting system sized to accommodate the air generated by the mill itself. This is normally done by taking suction from a plenum chamber built on top of the conveyor further on down the line, with the return of separated particles from the collector to the system. In setting up the air relief system in this manner, you should have about ¼ in. water pressure (negative) at the discharge of the mill. Referring again to the 100 HP mill mentioned previously, the air relief on this mill amounts to approximately 2100 cfm.

In an effort to closely control granulation, a third consideration is important. Gradual reduction, rather than instant reduction, will greatly reduce fines. Our meal grinder uses the Triple Reduction process, rather than the instantaneous confrontation of the product into the hammer section of the mill. The advent of side feeding also has the advantage of spreading out the product being ground, so as to put the meal across the total screen area for final reduction in the most effective manner possible. Consider for a moment a woman preparing mashed potatoes. She first cuts up the potato in smaller pieces before cooking and final mashing. She does not attempt to mash the whole potato. This gradual reduction, or Triple Reduction has also gained much prominence in the distilling industry, where controlled granulation without excessive fines on corn, rye and malt products is very important.

The meal-grinding stage in a meal production plant comes usually after the extractor, the desolventizer-toaster, the dryer (if possible), and the meal cooler (if possible). If the dryer is not installed or is placed after the grinding system, the condition is known as "wet meal grinding." If the meal is ground on stream without the benefit of a cooler, the process is known as hot meal grinding. The meal usually has about 18–20% moisture from the desolventizer-toaster and it is desirable to get the moisture level down before grinding.

In the early days of solvent extraction soybean operations the most common soybean milling setup was what was known as the two-stage grinding system. In this system the processed meal from the D.T. tank is first sifted through approximately a No. 12 screen. Some of the meal (sometimes as much as 30%) from the D.T. tank is minus 12 mesh and will pass through the screen into the system without going to the mill. The overs from the first sifter are then ground in as many mills as necessary to keep up with plant production requirements.

If the product is friable and without hulls it is possible to operate the first mills at 1200 rpm to reduce the impacting force, and by so doing, reduce the potential of making fines.

The material then passes from the first stage mills, to a second sifter, and into the finished meal conveying system. The overs from the second sifter, which in the early days before front end dehulling consisted of mostly hulls, are then passed through a second stage mill, this time a 1800 rpm mill to insure that all of the material will be reduced to proper size.

The most common system of meal grinding today is

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known as the single stage grinding system. The advent of front end dehulling equipment makes this system even more popular. In the single stage system, the incoming meal is first passed over a sifter, and the material that is already down to size passes into the conveying stream. The overs from the sifter then are passed to as many mills as necessary to keep up with plant production requirements. After grinding, the finished material is returned to the original sifter and the overs are passed through the mills once again. Usually the amount of overs returned to the mills for grinding a second time, rarely exceeds 20%. These mills are usually 1800 rpm pulverizers in this system.

Most of the pulverizers supplied to the industry today are either replacements or additions to existing systems, rather than newly constructed plants or facilities. As such, it is more likely to find modifications and additions to either the single or two-stage grinding systems, rather than the simple flow patterns suggested here. However, when new facilities are planned today, they probably will include the extractor, desolventizer-toaster, dryer and cooler, and then the single stage on-stream grinding set up, as outlined.

Grinding systems in soybean plants today are usually operated on a 24 hr/day basis and the capacity of the pulverizing equipment usually allows for a very comfortable grinding rate. Grinding facilities should not operate at 100% full load capacity, so that ammeter readings would not have to be constantly watched to prevent overloading. It is far better to assume a given capacity based on 70% to 80% full load readings. By so doing the equipment can be permitted to run continuously without problem. Typical of some of these safe, very conservative grinding rates giving an acceptable finished product are as follows: Solvent extracted soybean meal, 300–400/hp/hr; solvent extracted cottonseed meal, 275 lb/hp/hr; solvent extracted linseed meal, 300 lb/hp/hr.

The processing of soybeans by pulverizers, particularly through the scientific particle reduction phase, has given our company an opportunity to contribute to this phenomenal success story. We are happy to have been able to contribute our part to this most dynamic oilseed processing industry.

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Quantitative relationship between amount of dietary fat and severity of alcoholic fatty liver. C. S. Lieber and L. M. DeCarli (Section of Liver Dis. and Nutr., Bronx Veterans Admin. Hosp., New York, N.Y.). *Am. J. Clin. Nutr.* **23**, 474–8 (1970). To assess the quantitative relationship between fat content of the diet and lipid accumulation in the liver after alcohol ingestion, rats were given various isocaloric liquid diets, containing 18% of total calories as protein and 36% as ethanol or isocaloric carbohydrate. The remainder of the calories consisted of varying amounts of fat (2, 5, 10, 15, 25, 35 or 43% of total calories) and corresponding amounts of carbohydrate. Dietary fat consisted of ethyl linoleate (2% of total calories), to avoid essential fatty acid deficiency, and an olive-corn oil mixture. After 24 days of ethanol and 43% of calories at fat, hepatic triglycerides increased seven- to eightfold. With 35% of calories as fat, the increase was five-fold and with 25%, only two- to threefold. No significant decrease in hepatic lipid accumulation was achieved by further reduction in the dietary fat; a diet with 25% of calories as fat (about half that of the average United States diet) appears, therefore, to be optimal for minimizing the steatogenic effects of ethanol. An excess of dietary protein did not affect the ethanol-induced steatosis, and even a combination of a high protein-low fat diet did not achieve full protection against the ethanol-induced hepatic deposition of lipids in the liver. The ethanol effect persisted unchanged for periods up to 3–5 months.

Hepatic lipid metabolism in hypophysectomized and growth hormone-treated hypophysectomized rats. J. P. Liberti, R. S. Navon, E. S. Longman and P. F. Jezyk (Dept. of Biochem., Medical College of Virginia, Health Sci. Div., Virginia Commonwealth Univ., Richmond, Va. 23219). *Proc. Soc. Exp. Biol. Med.* **133**, 1346–50 (1970). Changes which occur in hepatic lipid metabolism of hypophysectomized and bovine growth hormone-treated hypophysectomized rats were studied. Synthesis of lipids, as measured by the ability of tissue slices to incorporate ^{3}H-glycerol into lipids, decreased rapidly following hypophysectomy. Three weeks after hypophysectomy, glycerol incorporation was approximately 40% of that in normal rats and remained depressed over the experimental period. Synthesis of acidic lipids was not appreciably affected by hypophysectomy but labeling of all other classes of lipids, particularly triglycerides, was diminished.

Lipase in pancreas and intestinal contents of chickens fed heated and raw soybean diets. S. Lepkovsky and F. Furuta (Dept. of Poultry Husbandry, Univ. of Calif., Berkeley, Calif. 94720). *Poultry Sci.* **49**, 192–98 (1970). Lipase activity was measured in: pancreases of intact chickens and in pancreases of chickens with ileostomies; intestinal contents from intestines of intact and operated chickens; intestinal contents voided through an ileostomy; and cecal contents from intact chickens. After one feeding of raw soybean diet, the level of lipolytic activity in the pancreases of the chickens was reduced to about one-half of that found at fasting, and was in marked contrast to the small decreases of lipolytic activity in the pancreases of chickens fed heated soybean diet.

Aortic rupture, body weight, and blood pressure in the turkey as influenced by strain, dietary fat, beta-aminopropionotrile fumarate and diethylstilbestrol. L. M. Krista, P. E. Waibel, J. H. Sautter and R. N. Shoffner (Depts. Animal Sci. and Vet. Pathol., Univ. of Minn., St. Paul, Minn. 55101). *Poultry Sci.* **48**, 1954–60 (1969). Three strains of Broad White male turkeys were utilized to determine the effects of dietary fat, beta-aminopropionitrile (BAPN), and diethylstilbestrol (DES) on blood pressure (BP), incidence of aortic rupture (AR), and body weight (BW). While 10% of animal fat increased BW significantly it did not alter blood pressure or provoke aortic rupture in an experiment of low natural incidence. BAPN at 0.01% did not influence these measures but at 0.015% decreased BW slightly, increased incidence of AR, and did not affect BP. DES did not alter BW but it resulted in reduced BP and greater incidence of AR. Three strains of turkeys were used. Two strains showing greater body weight gains and higher blood pressure also were afflicted to a greater extent by aortic rupture as compared to the third strain. One of the higher incidence strains showed a greater susceptibility to aortic rupture as induced by DES. With one generation of selection for higher and lower blood pressures, the incidence of natural aortic rupture was approximately twice as high in the high lines of all three strains.