Handling issues in modified DDGS

Bulk transportation of the feedstuff is challenging due to caking, flow problems

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Bulk solids handling in food and biomass processing industries is often associated with handling and transportation problems due to moisture absorption, caking, microbial growth, and overall product quality degradation.

Dried distillers grains with solubles — a vital co-product of the corn ethanol industry that is commonly known as DDGS — is certainly not exempt from these problems. Corn-based ethanol production in the U.S. was 13.3 billion gallons in 2012, yielding a DDGS production of 34.4 million tonnes. This production is based on the output from about 204 operating ethanol plants, mostly located in the central and midwestern U.S. (Figure 1).

Demand for DDGS in international markets is increasing exponentially with about 9.7 million tonnes DDGS exported overseas in 2013, up by 31% compare to 2012 export. Top destinations include China (46% of the total export), Mexico and Canada.

Transportation woes

DDGS has been favored as a livestock feed for cattle, swine and poultry because of its high protein content (approximately 34%), fat content (approximately 11%), and vital amino acids needed for healthy growth of animals. Further, research at South Dakota State University has shown that DDGS could be used for aquaculture feed.

However, DDGS bulk transportation and handling is a challenge because of its caking and flow problems. Fluctuations in ambient temperature and humidity, moisture, particle size and consolidation pressure are the key factors that lead to DDGS caking. The presence of temperature gradients during cooling can lead to high stickiness between DDGS and can facilitate moisture transfer between particles. Moisture migration and drying/wetting cycles lead to formation of solid and liquid bridges between particles.

Transportation and handling of DDGS is the third most expensive process in ethanol plants after raw materials and production costs. DDGS caking during transportation leads to added cost of breaking the caked mass, damage to the vessel and worker safety issues.

Generally speaking, for DDGS transportation over short distances (less than 250 miles) trucks are preferred (costing $0.115/tonne/mile for the average trip length of 80 miles, with each additional mile adding 10¢ per tonne to the cost). For transporting longer distances, railcars (costing $0.052/tonne/mile for a typical trip distance of 800 miles one way), and barge (costing $0.018/tonne/mile for a typical trip of 1,400 miles one way) are used. These figures are according to F.J. Dooley and B.J. Martens in the 2008 section, “Transportation and Logistics in Distillers Grain Markets,” in the Using Distillers Grains in the U.S. and International Livestock and Poultry Industries book.

Based on these estimations and assuming that about 10% of DDGS is retained or left over in each railcar due to insufficient flow caused by caking, about 52¢ is lost per railcar/mile (assuming 100 tonnes of DDGS is loaded in one jumbo railcar).

Hence, for a typical train load with about 62 railcars there is $32.24/mile, i.e., $25,792 loss for the entire one-way trip. For a 100-million-gallon-ethanol plant, it is estimated that it will take about 62 railcars per week to ship DDGS.

Additionally, expenses are incurred in labor, safety, cleaning of the agglomerated DDGS mass, and repairs caused by damages by sledge hammers on railcars. Sometimes railcars are leased out to an ethanol plant based on a yearly lease system. A five-year lease rate on jumbo railcar ranges from $450 to $630 per month. However, it should be noted that these prices are based on 2008 rates and prices vary based on current supply and demand scenarios in the industry.

Evolution to Modified DDGS

Extraction of corn oil (Figure 2) from DDGS, in the dry grind corn to ethanol process, has become a viable option for the industry. Currently, about 105 ethanol plants (50% of the total dry grind corn ethanol plants in the U.S.) are extracting oil.

Thin stillage and whole stillage are the major co-product streams in a dry grind processing facility. Thin stillage is further centrifuged to yield condensed distillers solubles (CDS) or syrup, which is then mixed with whole stillage and dried in rotary drum dryers to produce DDGS.

Corn oil is being extracted in two ways — from thin stillage before it is concentrated to CDS or from whole stillage. About 30% of the corn oil is removed from thin stillage and 60% from whole stillage process lines in this back-end process.

This extraction of corn oil before DDGS production has led to the birth of a new generation DDGS known as modified DDGS (Figure 3, page 27). Now the larger question is why the industry is leaning toward modified DDGS?

Corn oil production adds profit for ethanol plants and currently is sold at a price of around 45¢/lb. It is estimated that for a typical 100-million-gallon plant, it will take a $3 million investment for the oil extraction process. However, if the plant extracts 20 million lb/year of oil, the annual revenue will be around $9 million, i.e., the investment is recovered in approximately four months. This is according to Jerry Shurson and Brian Kerr, and their presentation, “Reduced oil DDGS — It’s not the fat, it’s the fiber,” from the Nutriquest DDGS Symposium, Des Moines, Iowa, U.S., in March 2012.

The quick initial investment recovery period and added profits make the oil extraction process an extremely viable option for the dry-grind ethanol industry. Some plants have tried implementing a front-end fractionation process to separate endosperm from non-fermentable fractions like germ and bran, producing high protein DDGS. But, due to poor long-term economic sustainability of these technologies front-end extraction methods were limited to very few ethanol plants in the U.S.

Modified DDGS have lower fat content (approximately 4% to 6%, db) compared to regular DDGS (approximately 8% to 10%, db). Recent studies at the University of Nebraska, South Dakota State University, and Auburn University indicated that diets with modified DDGS (sometimes referred to as reduced oil DDGS) reduced the growth rate and feed conversion ratio for beef cattle, but for dairy cattle feeding modified DDGS did not show any decrease in milk production.

Actually, animal feed with reduced oil DDGS improved lactation performance of dairy cows without any negative effects. However, conclusive studies on modified DDGS effects on swine, poultry and aquaculture diets are yet to be completed.

The U.S. Environmental Protection Agency (EPA) proposed lowering the mandated volume of ethanol blending in gasoline in 2014. This will cut ethanol production in the U.S. from 14.4 billion gallons to 13.01 billion and total renewable fuel production from 18.15 billion gallons to 15.21 billion gallons.

This proposed reduction in ethanol production might not affect the modified DDGS production and output, since most of the established dry grind corn-to-ethanol conversion facilities have standardized the process due to favorable economics. The fact that most of the ethanol plants are clustered in the Midwest region of the U.S. means transportation and handling of DDGS is crucial for overall sustainability of this industry. Unfortunately, we do not have adequate knowledge to address all aspects of modified DDGS including flowability and caking issues.

The road ahead

Kansas State University (Manhattan, Kansas, U.S.), USDA-ARS (Manhattan, Kansas, U.S.), and North Dakota State University (Fargo, North Dakota, U.S.) are working together to investigate the flowability and caking issues in modified DDGS using simulated storage and handling conditions.

Results of this project are aimed to benefit the ethanol industry and other areas where modified DDGS are being handled. Also, this will add value to the academic sector dealing with modified DDGS and co-products utilization research.

From this collaborative effort, the research team expects major outcomes such as scientific models to help corn ethanol industry managers predict flow characteristics of modified DDGS. Guidelines and recommendations on effective handling strategies will be communicated to the corn ethanol industries, feed industries and other DDGS handling storage facilities.

Results of this project are not limited to only ethanol industries, but will also benefit and create awareness for stakeholders in related bulk powder or grain handling industries with reported issues of particle stickiness. Also, this will add valuable information to the overall repertoire of DDGS flowability and handling studies.

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