NC-213 PROGRESS REPORT FOR 2024

Title
Performance Evaluation and Optimization of Thermal Processing During Feed Mash Manufacturing

Investigators
Maier, D.E., Professor, Agricultural & Biosystems Engineering
Lambros, A., Graduate Research Assistant, Agricultural and Biosystems Engineering
Rosentrater, K.A., Professor, Agricultural & Biosystems Engineering
Brehm-Stecher, B., Associate Professor, Food Science and Human Nutrition
IOWA STATE UNIVERSITY

Outputs/Research Updates
The animal feed industry is a multi-billion-dollar industry contributing significantly to the United States agricultural sector and global economy. As of 2023, the U.S. produced 284 million tons of feed consumed by livestock, poultry, aquaculture, and pets, generating an estimated $267.1 billion in sales. However, feed costs may constitute up to 70% of the production costs and account for 18.5% of the estimated $452.7 billion in total U.S. farm production expenditures in 2022. Additionally, the feed industry needs to meet the demands of rising energy costs, safe and biosecure feeds, pressure for more sustainable food production systems, and the growing need for more accurate and efficient technology. Thermal processing is ideal for introducing advanced technology and machine learning due to the numerous variables that affect performance. More data must be collected before advanced algorithms can be integrated into thermal processing systems. The Iowa State University Kent Feed Mill and Grain Science Complex is being utilized for researching thermal processing in-depth. Understanding current system losses throughout the steam harness is essential for assessing possible improvements and opportunities for advanced automation. This study focuses on understanding current system losses and identifying opportunities for advanced automation and optimization, with the following specific objectives:

1. Quantify steam losses and efficiency in the ISU feed mill steam harness.
2. Collect data on feed mash moisture and temperature properties to support future thermal process modeling and optimization.
3. Develop recommendations for system design improvements to enhance energy efficiency and feed quality.

Outcpmes/Impacts/Deliverables and updates of studies continued in 2024
This study focused on collecting steam and feed mash data to quantify steam and energy utilization and develop recommendations for more efficient thermal processing and opportunities for advanced automation. To measure steam losses and efficiency in the ISU feed mill steam harness, the steam system was retrofitted with sensors and flow control devices to measure steam quality and losses. Steam entering the harness was measured with a Yokogawa VY050 VY Series Vortex Meter. Steam condensate lost during processing was measured using a process control loop along the condensate lines, consisting of two limit switches (Magnetrol Echotel Ultrasonic Level Switch), a liquid flowmeter (AquaTrans Ultrasonic Liquid Flowmeter), an automatic ball valve (Sesto M32 Series), and a manual relief valve (Sesto M32 Series). Temperature and moisture data from mash samples between June through November 2024 were

collected. Dry mash temperatures and moisture contents varied between 64.8-92.8°F (18.2-33.8 °C), with an average of 84.4°F (29.1°C), while the moisture content ranged between 8.50-13.2%, with an average of 10.9%. Conditioned feed mash properties increased to an average temperature of 176°F, ranging from 152-194°F (66.7-90.2°C), and moisture content of 14.3% (ranging from 9.83-17.7%). The hygienizer maintained similar values to the conditioner, ranging from 152-189°F (66.7-87.2°C), with an average of 175°F (79.4°C), for temperatures, and moisture content ranging from 9.00-17.7%, with an average of 13.8%. Due to the consistent temperature decrease between the conditioner and hygienizer, installing a rotary airlock at the hygienizer discharge into the cooler is recommended. This would prevent suction airflow between hydrothermal processing and cooling, improving heat and moisture transfer during conditioning and hygienizing. Additionally, the data collected from the steam equipment and feed mash can be used for energy and moisture balance calculations to determine steam and energy utilization. In addition to temperature and moisture data, the product flowrate, steam inlet flowrate, and steam enthalpy were recorded during sampling, averaging 4.42 tons/h, 777 lb/h, and 1176 BTU/lb, respectively. This resulted in an average steam utilization of 71.6%±3.92 and energy utilization of 102% ± 0.486. These results reflect the current industry standard for steam utilization and demonstrates minimal energy losses throughout the system. This research provides a foundation for integrating advanced automation into thermal processing, contributing to a more sustainable and efficient feed manufacturing industry.

Publications

Oral/Poster Presentations

- Lambros, A. and Maier, D.E. Assessment and Modeling of Thermal Processes for Improved Process Optimization in Animal Feed Manufacturing. ASABE 2024 Annual International Meeting, Anaheim, CA, July 28-31, 2024. (Lambros: presenter)

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