Department of Biosystems and Agricultural Engineering
MICHIGAN STATE UNIVERSITY

BE 487 - Spring 2024
Biosystems Design Projects

Purge Reduction in Continuous Flow Corned Beef Production (Under NDA)

Josephine Dukaj, Victoria Loomis, Sydney Richter, Bilal Sabri

Client: E.W. Grobbel Sons, Inc. Faculty Advisor: Dr. Kirk Dolan

ewGROBBEL
FOOD FOR GENERATIONS

Background

Grobbel is a meat processing company located in Detroit, MI, that specializes in corned beef processing. Grobbel has asked our senior design team to optimize their institutional continuous process, by minimizing purge in the packaged products.

Purge is the reddish-colored liquid that accumulates at the bottom of the packaged meat product and is commonly mistaken by consumers for blood. Purge can be unappealing to the consumer and decrease customer perception of the product.

Purge is a byproduct of the brine injected into beef and natural post-mortem muscle changes. Brine is a solution that infuses proteins, salts, and sugars into the beef to improve the flavor and tenderness of the meat. The proteins in the meat are unable to hold onto all the brine injected during processing and cutting. Therefore, purge is moisture that gradually seeps out of the brisket, as the brisket cells loosen when the product sits out. (U.S. Department of Agriculture [USDA], 2013).

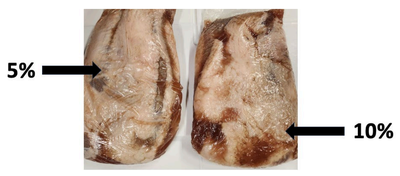

Figure 1 – Ideal and unideal purge amounts in packaged corned beef

Grobbel currently has three different production lines, including a batch process and two continuous processes. The continuous processes are experiencing higher, unideal levels of purge in the final product. The production line Grobbel has asked us to work on is the institutional continuous line, which includes an injector, which injects the meat with a brine solution. Followed by a vibratory conveyor, small rotational bins, and a press conveyor.

Figure 2 – Institutional continuous process including all elements in production line

Objective

- Modify current system to reduce purge to less than 5% in packaged corn beef products

Constraints

- Nitrate cure levels must be between Grobbel's formulation of 120-200 ppm
- The initial injection must be a minimum of 42% and max 65% nitrates in brine
- The final product cannot have greater than 35% gain in weight
- Flow rate must be maintained at current IC process throughput of 5,000 lb/hr

Design Alternatives

Perforated Vacuum Conveyor

Beneath the press conveyor, the addition of a vacuum element would could be useful in removing excess purge (Umrath, 1998). The vacuum device would include a perforated conveyor belt, with vacuum pumps directly beneath it. The vacuum suction beneath the corned beef products would apply pressure and collect an additional amount of purge from the product.

Massaging Device

The addition of a massaging device to the production process will incorporate physical movement and friction to the brisket. This manipulation increases the water holding capacity of the meat and reduces purge in the final product (Knipe, 2014). The team would incorporate a massager with vertical reversible direction paddles after the injection step in the IC process.

Modification to current press conveyor

The current press conveyor contains one plastic roller, that applies pressure to the meat at the end of the IC process. One solution is to modify the length of the press conveyor. This modification will alter the the amount of time and pressure the meat undergoes in the press conveyor. The team will equate the time and pressure settings of the new press conveyor, to the time and pressure meat previously sat in the small bins. This design will eliminate the need for the small rotational bins, making the process fully continuous. As well as eliminate the need for the vibratory conveyor.

Decision Matrix

Table 1 – Decision matrix

Criteria	Weight	Perforated Vacuum Conveyor	Massaging Device	Modification to Press Conveyor
Effectiveness	35	6 (210)	7 (245)	7 (245)
Practicality	25	6 (150)	8 (200)	10 (250)
Cost	15	6 (90)	5 (75)	10 (150)
Safety	10	10 (100)	8 (80)	9 (90)
Cleanability	10	8 (80)	6 (60)	7 (70)
Maintenance	5	9 (45)	8 (40)	9 (45)
Total	**100**	**675**	**700**	**850**

Selected Design

Modification to press conveyor

The current process consists of a 6 ft long vibratory conveyor and a 4 ft long press conveyor, with one 6 in diameter roller. Prior to the press conveyer, the corned beef is removed from the production line, and stacked in vats for 3 min. The corned beef is placed back on the production line and run through the press conveyor. The goal of this design is to equate the pressure exerted on the meat in the vats to the pressure exerted on the meat by the press conveyor. To account for both the pressure and the time element, elongation of the press conveyor would result in consistent purge reduction in every product, as well as make the IC process fully continuous.

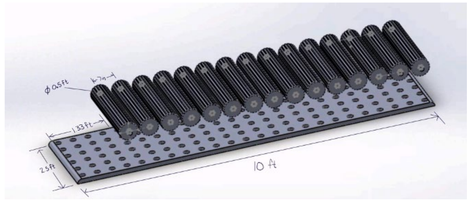

Figure 4 - Solidworks drawing of modified press system

Details of elongated press conveyor:

- Motor powered conveyor and rollers
- Perforated bottom conveyor
- Top conveyor with grooved rollers
- Length: 10 ft
- Width: 2.5 ft
- Number of rollers: 15
- Roller Diameter: 6 in
- Distance between each roller: 1 in
- Entrance gap: 1.33 ft

Entrance gap will allow time and space between injection and pressing.

Design Parameters

Conveyor flow rate:

When calculating the flow rate two parameters need to be met:

1. Maintain a flowrate of 5000 lb/hr
2. Allow the brisket to be under pressure for 3 minutes

The following factors and speed allowed us to meet these parameters:

- 3 briskets side by side
- Extension of press conveyor to 10 ft
- Flow rate of 3.34 ft/min

Roller weight selection:

When choosing a weight for the rollers, the goal is to match the pressure the briskets undergo at the bottom of the rotational bins. The bottom of the bins is where the greatest purge results are achieved.

In the rotational bins, there are generally 6 briskets stacked on another, weighing roughly 15lbs each. This means the bottom brisket has 75lbs of weight applied to it.

- 3 rollers per brisket
- 225 lb / 3 rollers
- 75 lb / roller

Motor power required:

The modified press conveyor has a significantly higher load being applied to it than the previous conveyor. There is a longer belt, as well as additional briskets and rollers, increasing the overall weight of the process.

An experiment was conducted using makeshift rollers, with 75lbs of weight on top of a brisket. A digital scale was used to pull the brisket out from under the rollers. Below is a diagram of how the motor power required for the modified press conveyor was achieved.

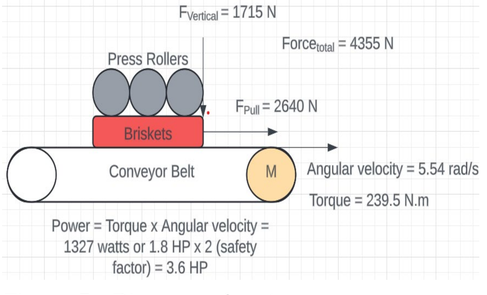

Figure 5 - Diagram of motor power calculations

- Measured pull force of 33 lb
- Final power requirement of 3.6 HP

Economic Analysis

Table 2 – Cost breakdown of system

Element	Cost
Conveyor CV1A	$32,000
Conveyor CV2B	$22,000
Installation Cost	$5,000
Total Cost	**$59,000**

System will save Grobbel $60,000 annually

- Reduces line labor by 2
- Salary ~$30,000 each worker per year (U.S. Bureau of Labor Statistics, 2023)

Another economic benefit of the design is the decrease of purge in the packaged product. A decrease in purge can lead to higher customer satisfaction, which can indirectly lead to economic gains for Grobbel. When considering the elimination of two worker wages and the increase in customer satisfaction, the payback period is short enough for Grobbel to justify implementing the design.

Summary

- Maintains continuous process line
- Maintains desired purge level
- Reduces labor requirement
- Simplifies 2 machines with 1 machine

Next steps:

- Testing of the system using meat injected with Grobbel's brine formulation
- Grobbel will implement the design by removing the current vibratory conveyor and press conveyor

References

Umrath, W. (1998). Fundamentals of vacuum technology. https://www.vacuubrand.com/us/page1082.html#:~:text=Liquids%20can%20be%20sucked%20into,to%20risk%20evaporation%20of%20solvents.

U.S. Bureau of Labor Statistics. (2023). Food Processing Equipment Workers. Occupational Outlook Handbook. U.S Bureau of Labor Statistics https://www.bls.gov/ooh/production/food-and-tobacco-processing-workers.htm

Knipe, C. (2014). Processing Equipment: Tumblers and Massagers. Encyclopedia of Meat Sciences (2), 143-146. https://doi.org/10.1016/B978-0-12-384731-7.00120-3

U.S. Department of Agriculture. (2013). Water in Meat & Poultry. Food Safety and Inspection Service. https://www.fsis.usda.gov/food-safety/safe-food-handling-and-preparation/food-safety basics/water-meat-poultry