Department of Biosystems and Agricultural Engineering
MICHIGAN STATE UNIVERSITY

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Biosystems Design Projects

Improving Existing Oat Transport System into Food Service Mixer (Under NDA)

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Background

Chelsea Milling Company (CMC) uses a screw auger for application of several ingredients, including oats, from a supersack hopper into a major scale on their food service line. Oat ingredients are only used in CMC's oatmeal cookie mix so there are doors on the screw auger to ensure oats are 100% removed from the system to preserve the quality of their other products. However, these doors have caused leakage of other ingredients run on the same auger. Figure 1 shows the food service process flow.

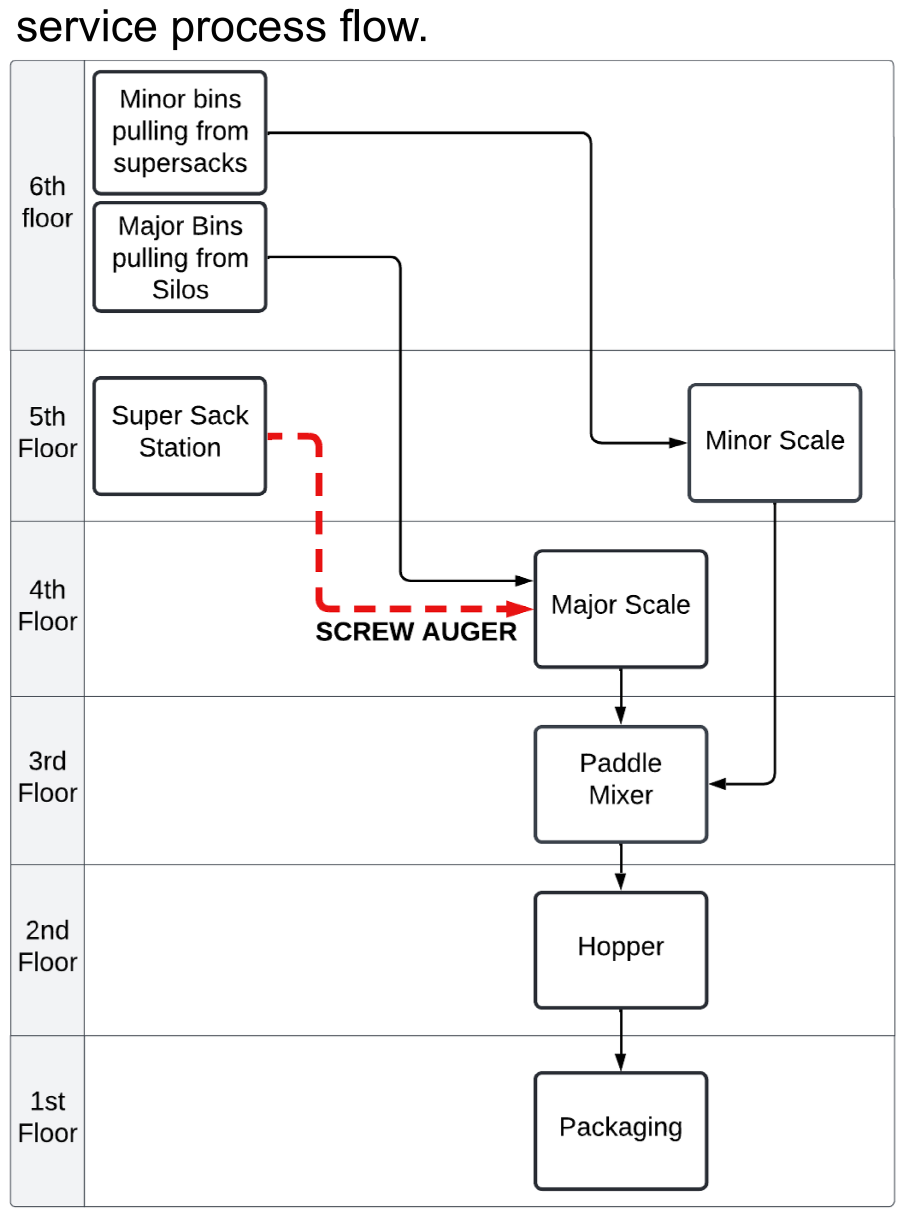

Figure 1: Process Flow of CMC Foodservice, red line shows screw auger in question

This project aims to design a more efficient system to introduce oats to CMC's oatmeal cookie mix, between the supersack unloader and the mixer of their food service line. A solution must allow full cleanability of the unit and transport non-oat ingredients with minimal loss. Finding a solution is imperative to limit product revenue loss, while maintaining cleanability and subsequentially maintaining quality of product.

Objectives

Objectives are hopeful outcomes of a solution; however, designs do not need to uphold these to be considered. A solution may not fulfill all objectives. Our team worked with CMC to develop three main objectives for this project.

- Reduce loss of ingredients in transport to 0%.
- Increase current oat application rate by 100%.
- Reduce current sanitation time of the unit by 10%.

Constraints

Our team worked with CMC to develop these constraints for our project. The final design must meet each of these to be considered viable.

- Maintain current batch cycle timing of [redacted].
- Maintain oat application rate of [redacted].
- Accommodate other ingredients.
- Maintain visual oat integrity.
- Worth within current [redacted] floor space and [redacted] elevation, while maintaining access to existing equipment and walkways.
- Maintain current sanitation time of [redacted].
- Follow FDA and OSHA standards.

Design Alternatives

Our team evaluated 8 different design alternatives for this problem. 7 were alternatives we developed and one was proposed by CMC's team working on this problem. Some designs were solutions for all supersack ingredients such as:

- Pneumatic conveyor
- Tubular chain conveyor

Some designs introduced an oats-only application to the major scale such as:

- Use of major bin with existing silo
- Use of major bin with new silo
- Divert with 2 screw auger system
- CMC's design: oats-only pipe

Some designs introduced an oats-only application directly into the mixer via 4th floor shortening chute such as:

- New supersack unloader with bucket conveyor
- Current supersack unloader to new hopper scale via bucket conveyor

A decision matrix was used to evaluate each design alternative to determine the most effective design solution. Each design was ranked on a scale of 1-10 for 6 criteria. A score of a 10 means the design performs well, and a score of 1 means the design doesn't satisfy that criterion. Table 1 shows the criteria and weight of importance.

Table 1: Weighted decision matrix criteria

Criteria	Weights (%)
Cleanability	23
Equipment reliability and maintenance	19
Ease of operation	19
Space required for equipment	17
Cost	14
Project lead time	8

Selected Design

Our final selection for our design to the CMC team is a two-screw auger system. This design places a divert at the output of the supersack unload. This will divert oats to the current screw auger and the finer ingredients into a new hingeless screw auger via a manual gravity diverter valve. This will allow transport of these ingredients with no loss or concern for residual oats. These two paths will converge together before application into the major scale. Figure 2 shows this process flow.

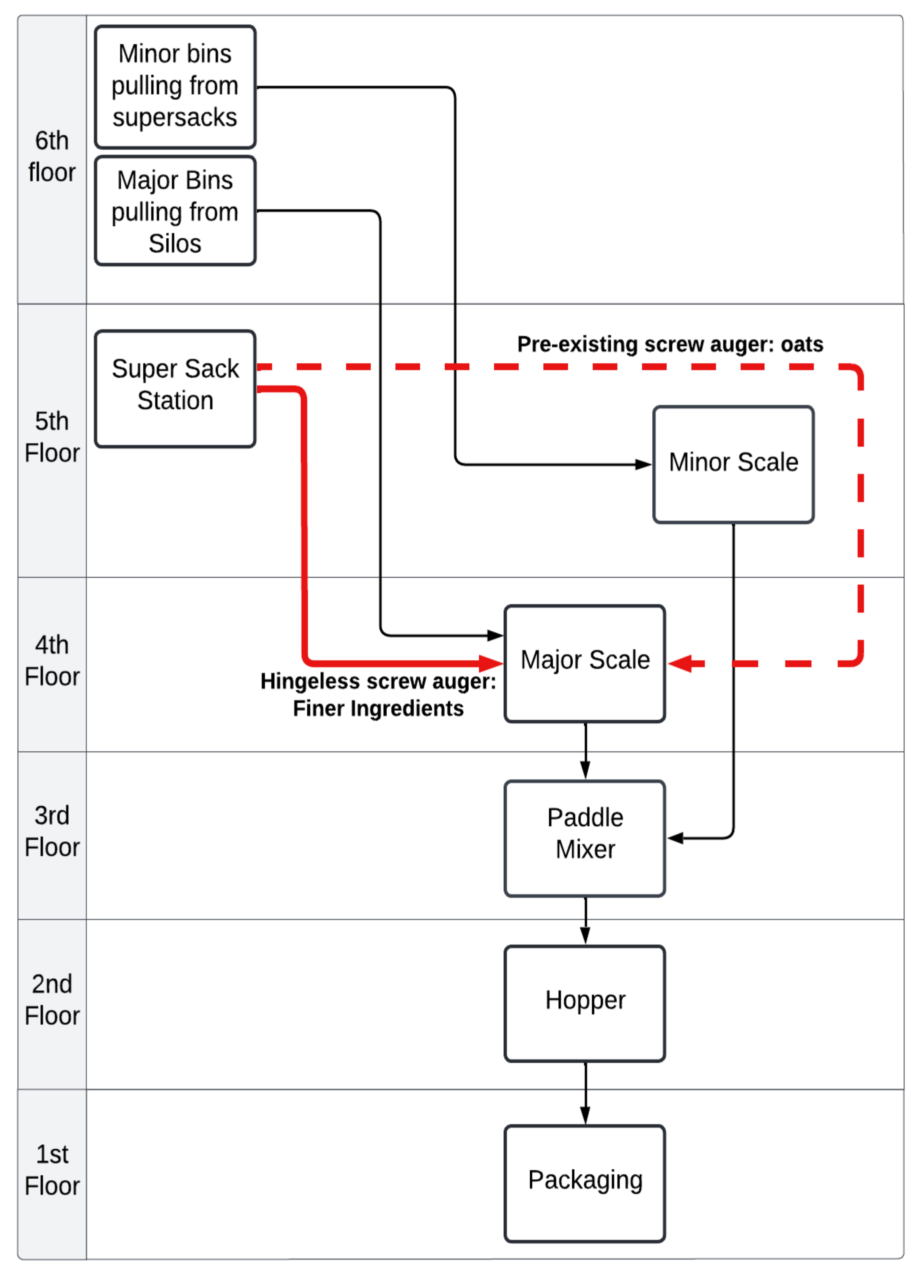

Figure 2: Process Flow of CMC Foodservice selected design with the dash line indicating the pre-existing auger where oats will run, and the solid line indicating the new hingeless screw auger for all other supersack ingredients.

The new screw auger will be the same dimensions as the current auger. It will be made of 304 stainless steel. There will be no hinges or doors on the bottom, which prevents leakage. There is a dust-tight cover on top for maintenance access. The screw flighting is continuous, which prevents ingredient build-up. Figures 3a and 3b show CAD drawings of the new hingeless screw auger.

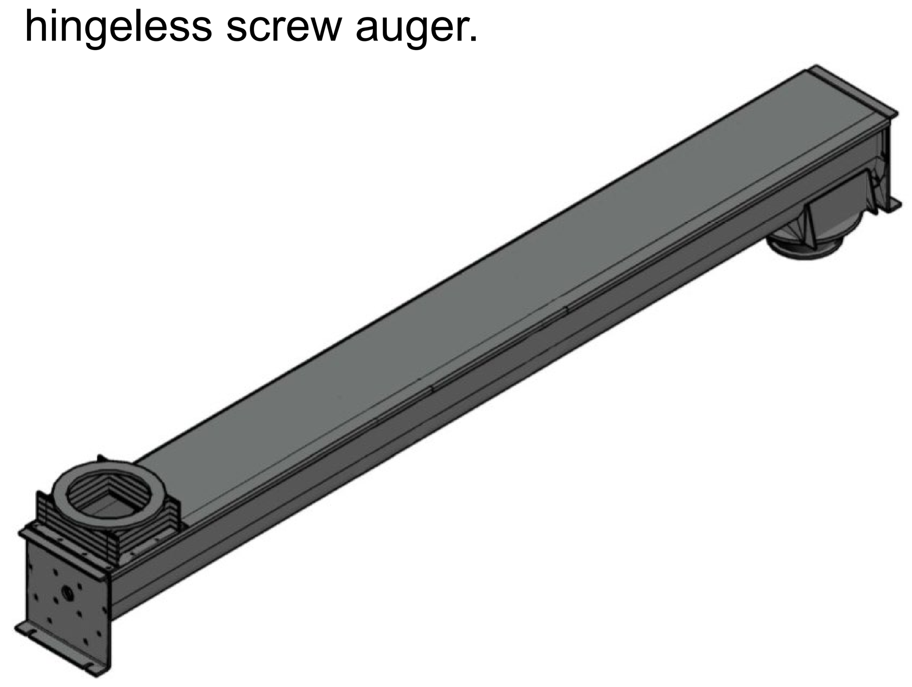

Figure 3a: 3D drawing of new hingeless screw auger

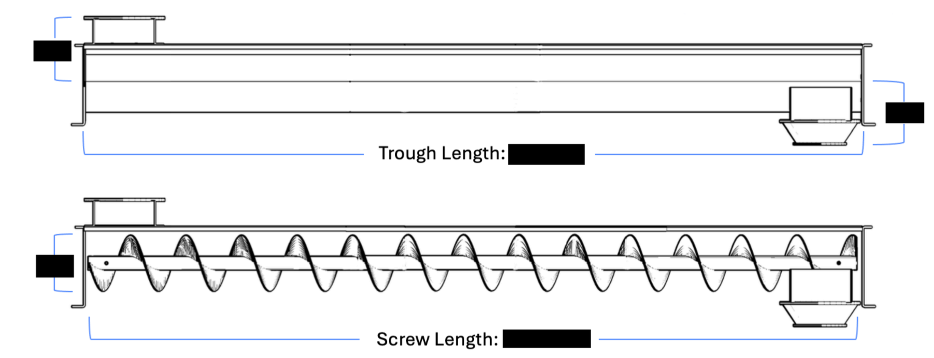

Figure 3b: 2D drawings of new hingeless screw auger

The diverter for this design is a manually controlled 2-way gravity diverter made with 304 stainless steel, a wiper seal and food grade rubber. This will divert oats to the current auger and all other supersack ingredients to the new hingeless screw auger. The diverter will also have panels to access the inside for full cleanability. Figure 4 shows CAD drawings of the diverter provided by Carolina Conveying.

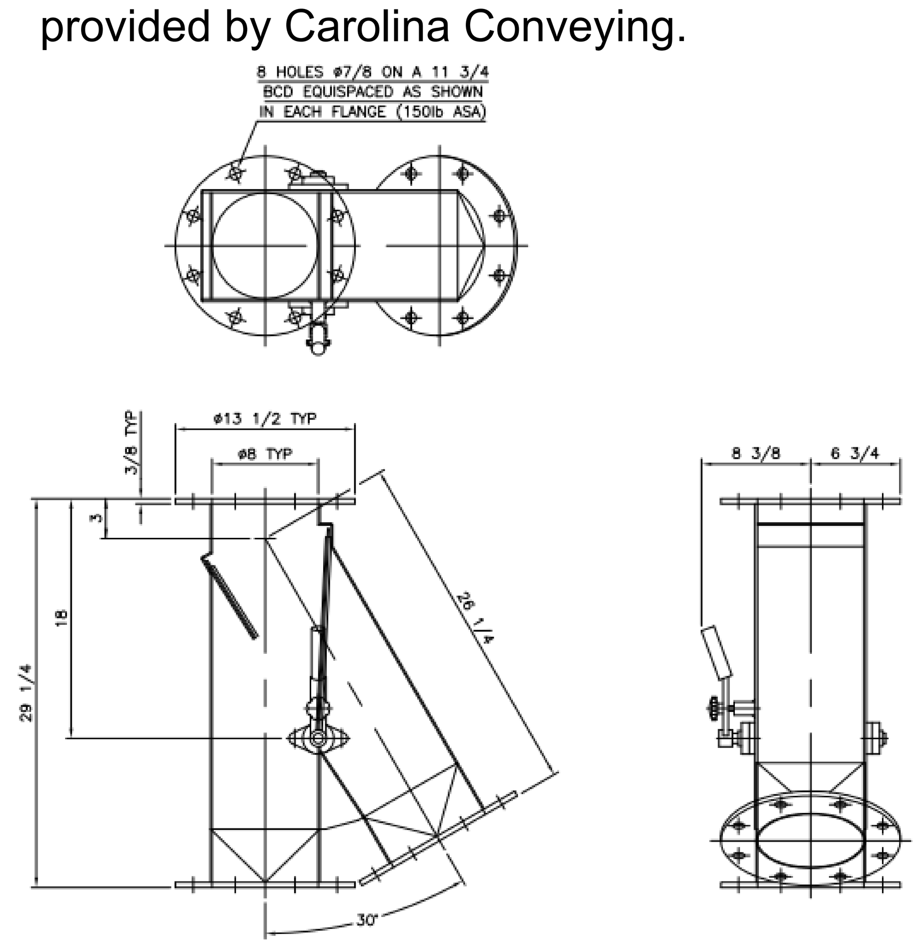

Figure 4: CAD drawings of diverter

Design Parameters

We calculated theoretical flowrate of each supersack ingredient as well as efficiency. Table 2 shows efficiency of each ingredient.

Table 2: Volumetric efficiency of each supersack ingredient

Ingredient	Volumetric efficiency (%)
Oats	21.1
Whole Wheat Flour	96.7
Whole White Flour	69.8
Dextrose	67.9
Powered Sugar	91.3

Inefficiency of oats is due to the supersack unloading system, not the screw auger. The application of the oats will not increase and will be ran at the same rate as they are currently are on the current auger.

The other 4 supersack ingredients will be run on the new hingeless screw auger, which reduces the loss of ingredients by 100% to a 0% loss.

Cleaning time will be reduced by 10% by running oats and other supersack ingredients on different lines.

Economics

Our team calculated an economical analysis for our chosen design including capital cost, resale or salvage value, maintenance cost, and energy cost. Table 3 shows itemized capitol cost.

Table 3: Itemized capitol cost of 2-screw auger system

Item	Cost ($)
Hingeless Screw Auger	$30,000[1]
Diverter (2)	$7,600[2]
Mechanical Installation	$80,000[3]
Electrical Components	$15,000[3]
Electrical Installation	$10,000[3]
Automation	$15,000[3]
Total:	$165,500[1]

1. Includes 5% contingency

Table 4 shows the resale or salvage value for the equipment.

Table 4: resale/salvage value of 2-screw auger system

Item	Cost ($)
Screw Auger Resale Value	$8,500
Diverter Resale Value (2)	$5,200
Resale Value Total:	$13,700
Screw Auger Salvage Value	$435
Diverter Salvage Value (2)	$483
Salvage Value Total:	$918

Maintenance is estimated to be 5% of the initial capital cost. This is estimated to be $8,275 total or $1,182 per year.

We also calculated monthly energy cost of our design. This was done by calculating power, energy, and rates to convey 1000 lb of each ingredient.[4] Table 5 shows calculations for total monthly energy cost for conveying oats.

Table 5: Calculations for total monthly energy cost for conveying oats

Total weight of oats conveyed per month (lb)	[redacted]
Base monthly rate ($)[5]	[redacted]
Energy cost for total weight ($)	[redacted]
Total monthly energy cost ($)	[redacted]

This design reduces labor costs by shortening cleaning times. It also reduces ingredient loss by 100% during transport, which lowers material costs.

Select References

[1] (L. Weeden, Personal Communication, February 25, 2025).
[2] (P. Golden, Personal Communication, February 25, 2025).
[3] (S. Crawford, Personal Communication, March 20, 2025).
[4] (Liu, 2024). [Lecture notes on conveying of agriculture material].
[5] City of Chelsea Michigan. (n.d.). Utility rates and city services fee schedule. *Utility Rates.* https://city- chelsea.org/services/utilities/rates.php