PURDUE UNIVERSITY

CAPSTONE/DESIGN EXPERIENCE 2017

# Fluidized Bed Roasting of Malt

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Agricultural & Biological ENGINEERING

## Objective/ Background:

To design a barley malting system for Sugar Creek Malting Company for less than $10,000. This design allows for a more uniform high quality roasted product while decreasing the cost from a traditional drum roaster.

**Table 1:** Stakeholder Requests and Final Deliverables

| Constraint | Stakeholder Request | Deliverables |
|---|---|---|
| **Temperature** | 200 F - 600 F | 70 F – 392 F |
| **Throughput** | 12 – 15 bushels | Lab scale (0.01 bushels) |
| **Cost** | < $10,000 | $10,170 |
| **Equipment** | Drum roaster and cooling tray | Conversion oven, fluidized bed for roasting, fluidized bed for cooling |

Currently, the only competitor for such a design is a coffee company. If this design were to fail, the Sugar Creek Malting Company could purchase a drum roaster and cooling tray at a higher cost.

## Global and Societal Impact:

- Organic Waste/Year: 5,394 kg
- Emissions/Year: 16,624 kg
- Total Waste/Year: 22,018 kg
- Filtered out materials can be composted
- Scrubber on air vented to atmosphere
- Test water for CWA standards before releasing it to streams
- Use heat exchangers to cut down on energy consumption
- Creates jobs for students
- Never been used in the malt industry before

## Final Design:

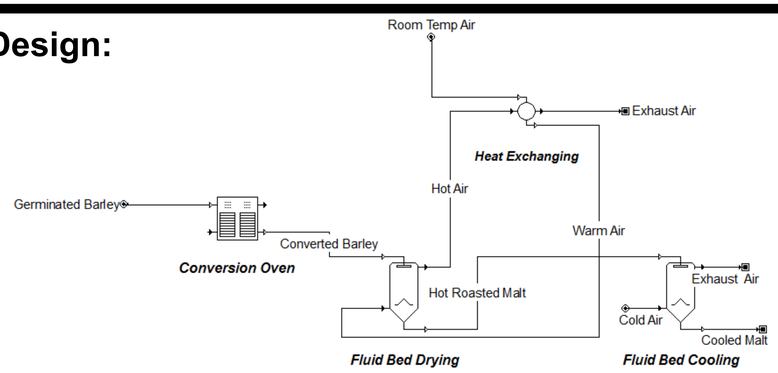


**Figure 1:** Final Flow Diagram

**Table 2:** Mass Balances and Moisture Content from Roasting

| | Pre-Conversion | Post-Conversion/Pre-Roasting | Post-Roasting |
|---|---|---|---|
| **Mass (g)** | 400.1 | 392.9 | 225.8 |
| **Moisture Content (%)** | 0.4646 | 0.4612 | 0.0567 |

**Figure 2:** Barley Roasting in Bed

**Figure 3:** Fluidized Bed System

**Figure 4:** Pre v Post Roasting

## Economic Analysis:

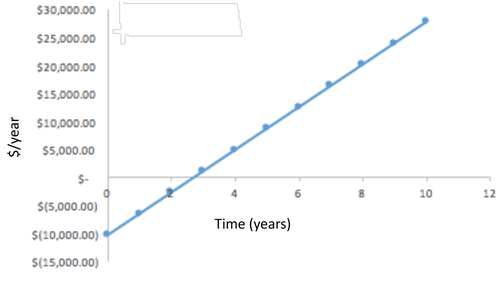


**Figure 5:** Breakeven Point

- Price of roasted malt: $4.25/lb
- Annual insurance: $1,200
- Annual rent: $12,000
- Wages: $50,000
- Estimated sales: 30,000 units/yr
- Production cost: $1.01/lb
- Breakeven point: 2.68 years

## Design Process:

**Table 3:** Morphological Analysis of Alternatives

| Morphological Analysis | | | | | | |
|---|---|---|---|---|---|---|
| Product: Fluidized Bed Malt Roaster | Organizatson Name : ABE 558 Senior Desugn Group 4 | | | | | |
| Function | Concept 1 | Concept 2 | Concept 3 | Concept 4 | Concept 5 | Concept 6 |
| **Type of Fluidized Bed** | Batch | Well-Mixed, Continuous | Plug-Flow | Multistage/ Multiprocess | Spouted Bed | Agitated |
| **Type of Barley Used** | Pearl barley | Rolled barley | Hulled barley | Scotch barley | Barley grits | Barley flakes |
| **Cooling** | Fluidized Bed | Open Air Tray | Refrigeration | Vacuum | | |
| **Heat Source** | Natural Gas | Electric | Steam | Propane | Solar | Geothermal |
| **Type of Heat Exchanger** | Shell & Tube | Spiral Plate | Plate and Frame | Plate fin | Rotary | Double Pipe |

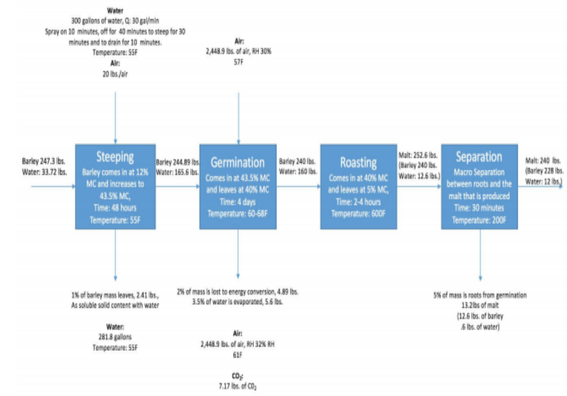


**Figure 6 :** First Iteration of Design

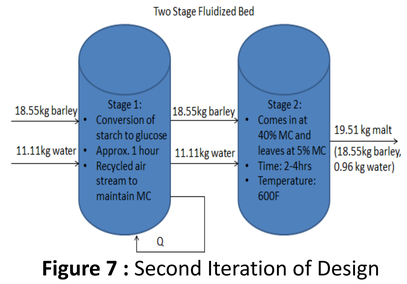


**Figure 7 :** Second Iteration of Design

## Recommendations:

- Scale up of process to batch size of 15 bushels
- Smaller diameter pipes in fluidized bed to prevent the build up of water
- Test with different kinds of barley
- Try to achieve different kinds of malt

Sponsor:
Sugar Creek Malting Company

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