Ethanol Fermenter Design

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MuPor industries has designed and patented a novel rapid fermentation bead system that needs to be tested and proven for industrial applications. These beads have shown to be effective for bench-top scale fermentation and microbrewery purposes, but their full potential will likely require a specially designed fermenter tailored to the design of the beads.

Problem Definition

Project Goal

To have a fully functional 150-300 gallon ethanol fermenter tailored specifically for the use of the BioEx beads and being capable of operating industrially.

Major Parameters

- Temperature
- Sugar concentration
- Mass of beads per sugar solution
- Alcohol content

Current Design Specifications

Liquid Volume	**175 gallons**
Process	**Batch**
Operating Temperature	**70-100° F Optimal (95°)**
Fermentation Time	**~2 hours**
Initial Sugar Concentration	**16% (yields 9.4% ethanol by volume)**
Bead Loading	**300 grams (Dry) Per Liter**

Kinetics: Parameters for modeling of beads (Jain, 2012)

Symbol	Value	Unit	Description
Co	1000	mol/m^3	Initial concentration
D	6.9×10^{-11}	m^2/s	Diffusivity of glucose in bead
Vmax	0.00041667	$mol/m^3\text{-}s$	Michaelis-Menten constant
Ks	150	mol/m^3	Michaelis constant
Dia	3×10^{-3}	m	Diameter of bead
ExpD	4×10^{-3}	m	Diameter of beads used in experiment
Nb	600		No of beads used in experiments

Kinetics: Expressions for modeling of beads (Jain,2012)

Symbol	Expression	Unit	Description
N_{nb}	N_b x $(Dia/ExpD)^3$	m^2/s	Diffusivity of glucose in bead
V_{maxn}	V_{max}/N_{nb}	mol/m^3-s	Michaelis-Menten constant
K_{sn}	K_s/N_{nb}	mol/m^3	Michaelis Constant
Rx	V_{maxn} x $C/(K_{sn} + C)$	mol/m^3-s	Reaction rate

Bead Specifications

Wet to dry ratio	**~3:1**
Expansion	**5.23 x dehydrated volume 33% expansion when actively fermenting**
Loading	**300g dry per Liter of solution**
Displacement	**1.22 liters per liter of solution at full eating capacity**
Change in Displacement	

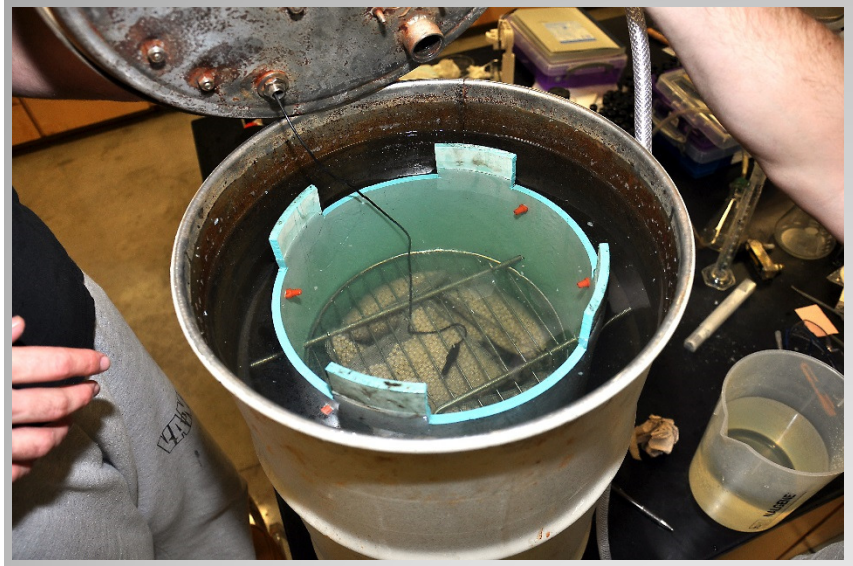
Bags

Loading per bag	1.5 kg wet beads 500g dry beads

Prototype 1

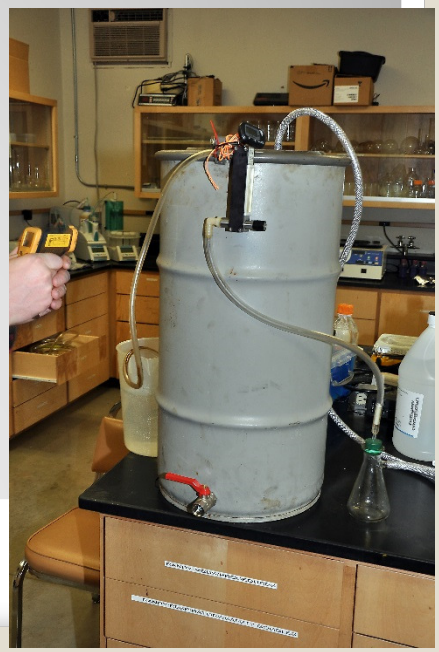
- Beads migrated across the layers
- Head space (1.2 gallon loss)
- Loading and unloading overly complicated
- Reaction is exothermic ~ 6400 btu of heat per barrel reaction
- Dead zone at the bottom of the reaction vessel ~10 degree temperature change
- Had some initial problems with the set up of our reactor and were not able to get sufficient data collected

Prototype 2

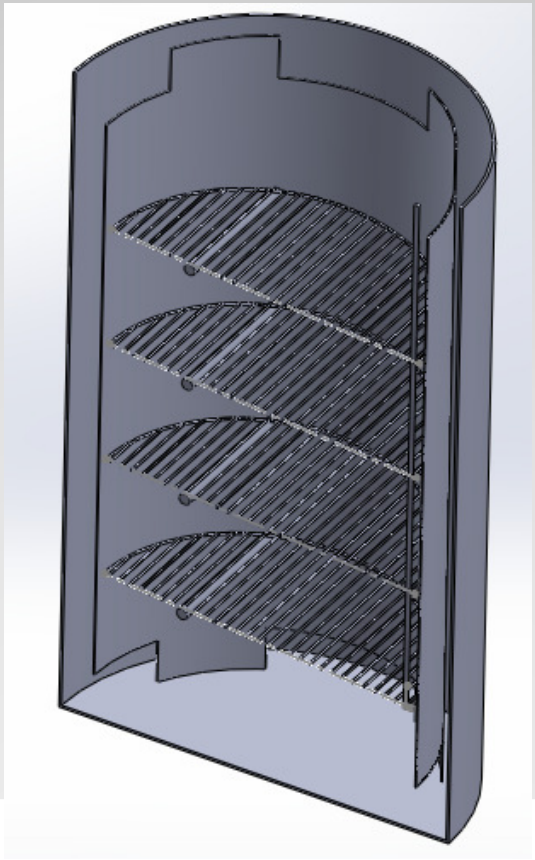


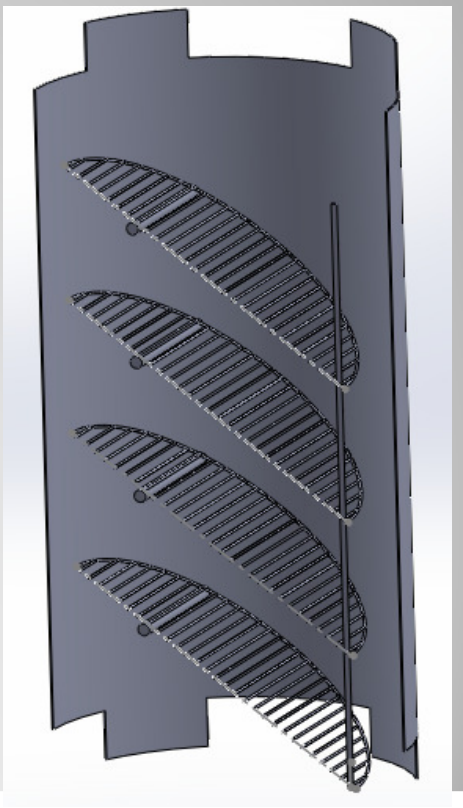
- Designed to promote flow
- Keep temperature constant throughout the reactor
- Beads bagged to promote easy loading and unloading
- Single layer loaded

- 60 grams of dry beads
- Expansion of active hydrated beads becomes a problem

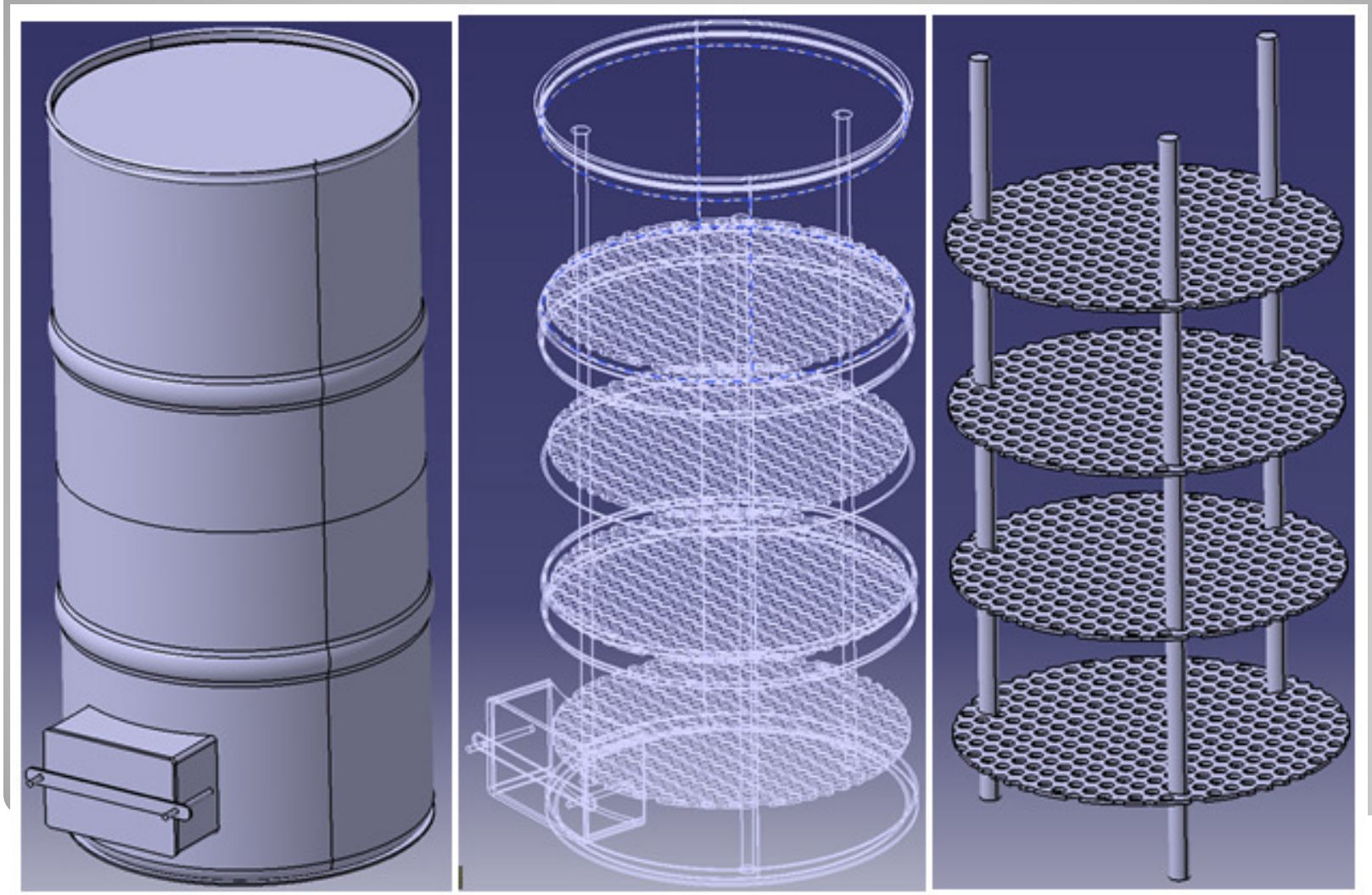


Prototype 2





Final Prototype

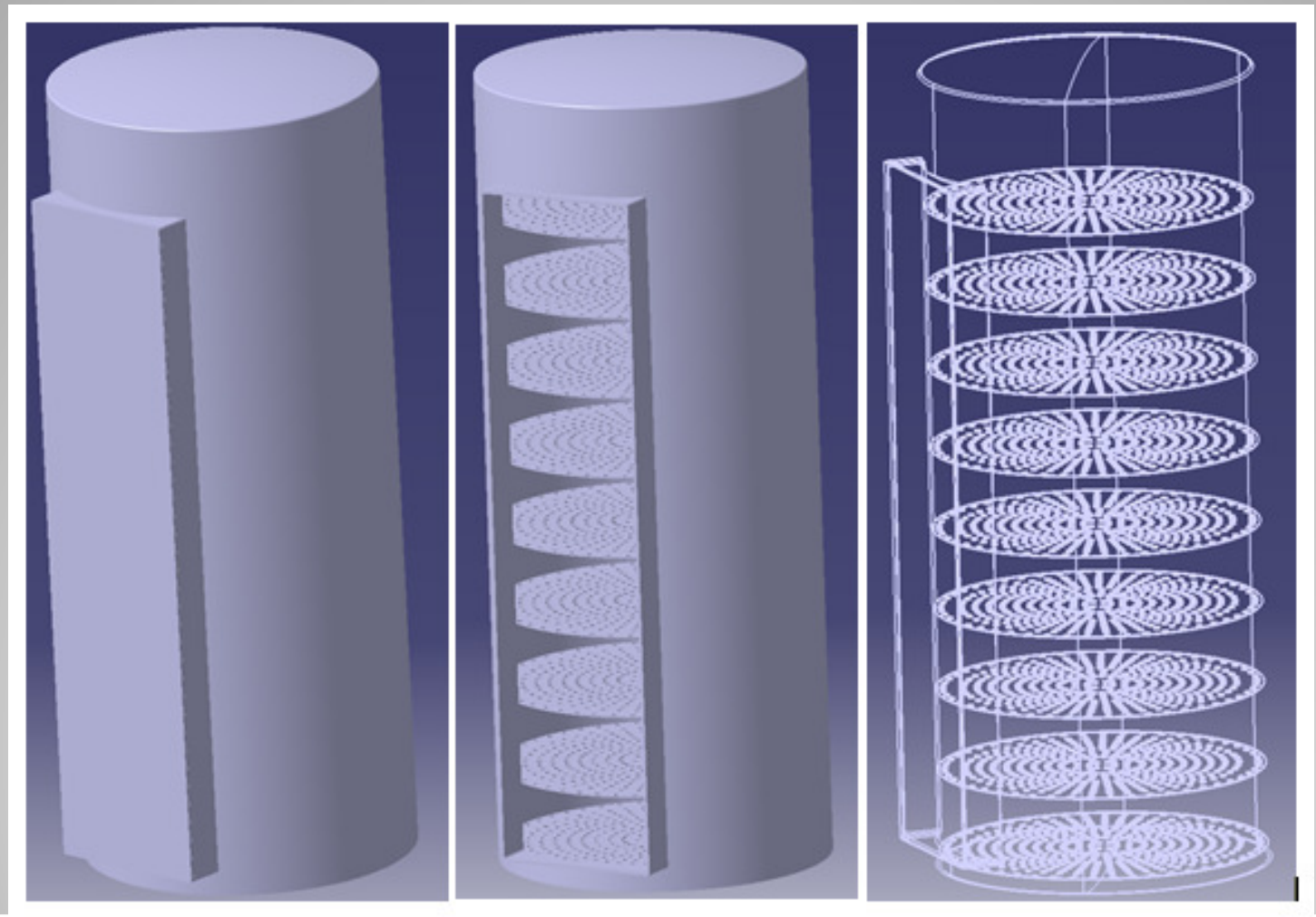


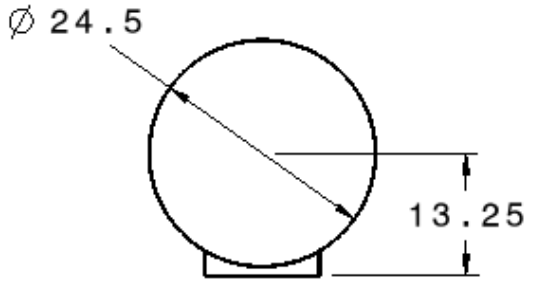
Prototype	
Volume	63.04 L 16.67 gal
Dimensions	14 in base in height
Racks	Drop in system Made from expanded metal

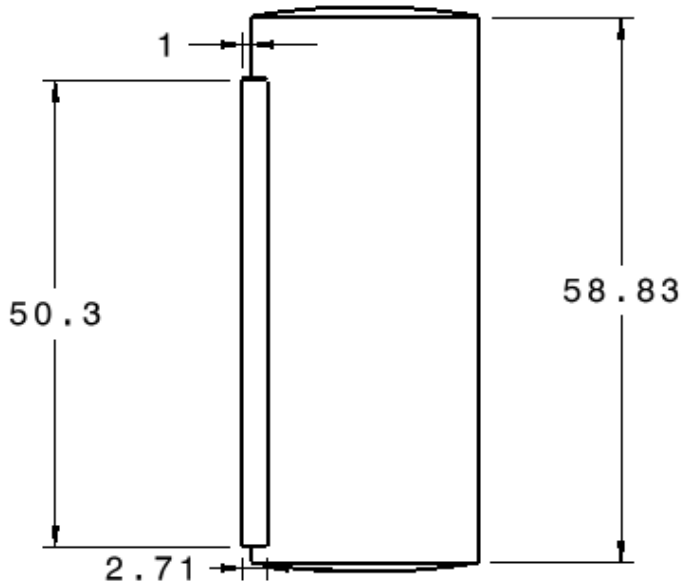
Final Design	
Volume	L 174.21 gal
Dimensions	24.5 in base 59 in height
Racks	Welded in system Made from expanded Aluminum

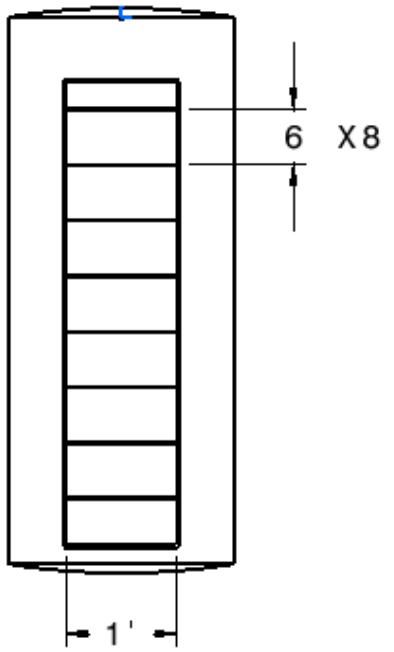
Scaling up from Prototype to Final Design

Final Design









DENENSIONS ARE IN INCHES THIRD ANGLE PROJECTIONS	DESCRIPTION:		*Final Design*
LINEAR TOLERANCES: X. ± 0.25 X.X ± 0.1 X.XX ± 0.01 X.XXX ± 0.002 ANGULAR TOLERANCES: X. ± 2 X.X ± 1 X.XX ± 0 30'	DRAWN BY: ISAAC WILSON REVIEWED BY:	DATE: 2/25/2014 DATE:	UNIVERSITY OF IDAHO ME DEPARTMENT
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UNIVERSITY OF IDAHO STANDARD TEMPLATE: FALL 2013		CAD APPLICATION: CATIA V5 RELEASE 23	

Cost

- $500 per day of labor
- ~2 days of labor

Project Timeline:

- Middle of spring semester (1 Mar-15 Apr)
  - Test scale model
  - Decide on manufacturing for final construction
- End of spring semester (16 Apr-2 May)
  - Build finish product
  - Run finished product (design validation)

Questions?

References:

Jain, T. (2012). *Ethanol from lignocellulosic biomass using*. (Doctoral dissertation), Available from Worldcat. (UMI Number: 3536887).