Sustainable Production of Vegan Paintballs

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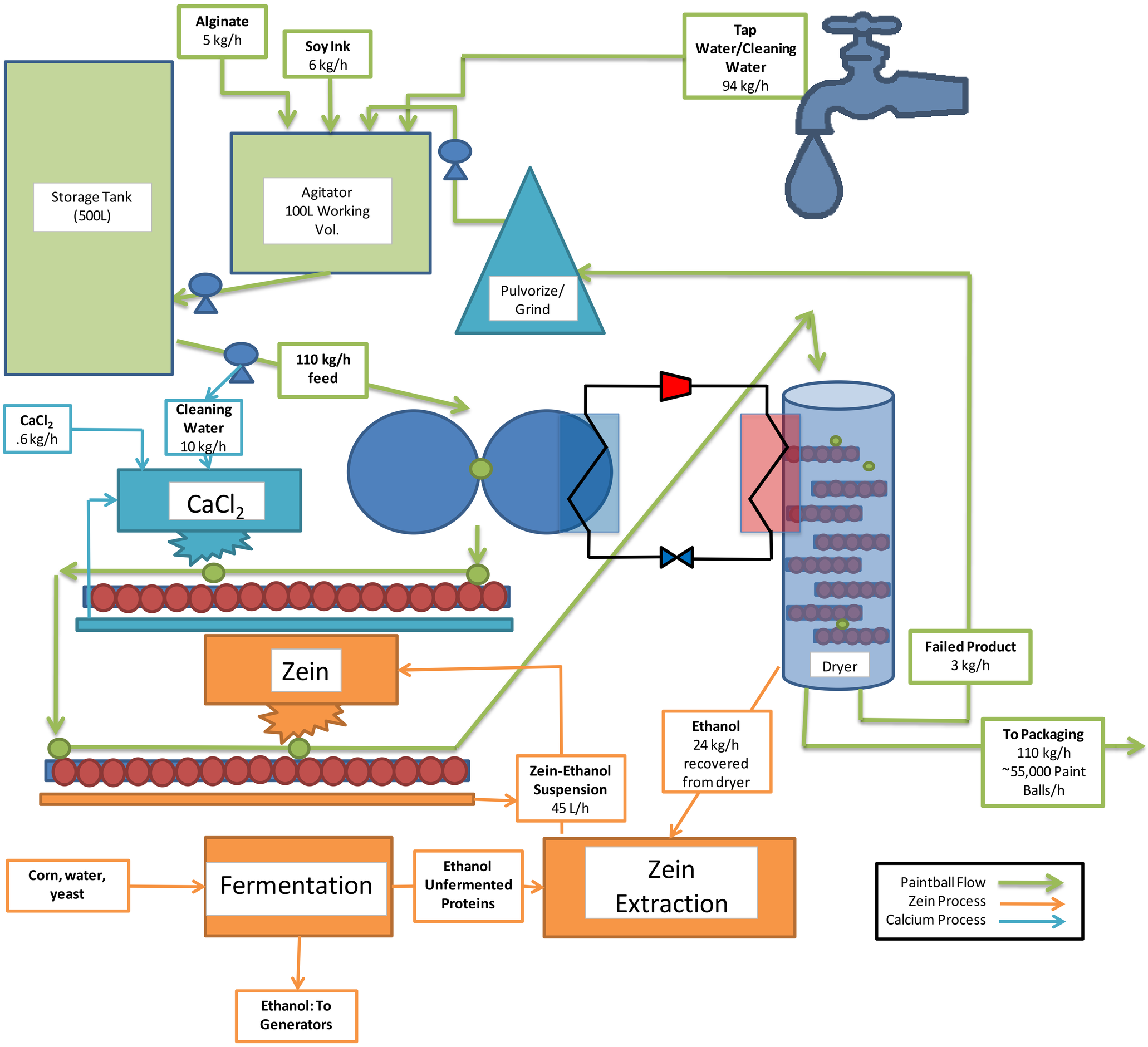
Objectives:

- Create a new method for manufacturing paintballs that does not include the use of animal products or any environmentally hazardous materials.
- Design a sustainable, zero discharge plant that will manufacture these paintballs
- The current practices used by the paintball industry in regards to energy and water consumption are not sustainable

Problem Statement

- The current paintball process uses gelatin for the outer shell, which is extracted from collagen found in animal bones and skin which prevents people with certain beliefs or lifestyles from using the product.
- The process of making paintballs with gelatin is a high energy heating process.
- The use of fossil fuels or other non-renewable sources of energy to manufacture products is not sustainable.
- Water is becoming a limited resource that must be conserved, recycled, or reused.

Process: Manufacturing, Cleaning, & Zero Discharge



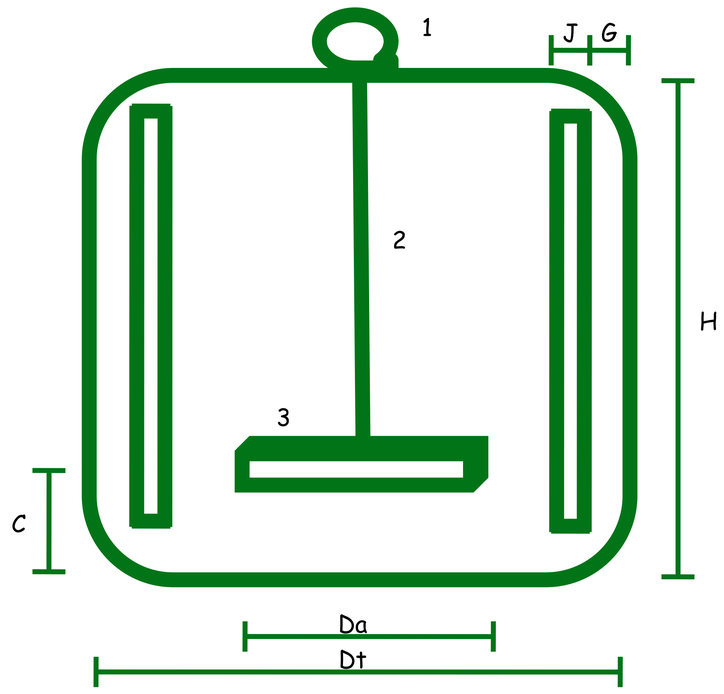
Cleaning

1. Regular CIP cleaning schedule is after production shift
2. 1st rinse: Use warm water rinse all the equipment, and recycle the water to the agitator.
3. 2nd chemical cleaner: use 20% wt/wt "solve all #1" from Elgene Chemical, which contains citrus acid and non-toxic, and acts as degreaser and cleaner to clean the inside of equipment. The solution will pump back to the calcium chloride tank.
4. 3rd rinse: use cold water rinse all the equipment, and recycle the water to the agitator.

Zero Discharge Energy Balance

Unit Operation	Energy Requirement (kW)	Energy Output (kW)
Agitation	65.545	0
Refrigeration	70.28	52.93 (33% eff heat exchanger)
Zein Extraction	231.8	0
Energy Needed From Corn Fermentation	**314.695**	

Equipment Design and Energy Requirement



Agitator Design:

- Working volume: 100L
  - ~30 L worth of impeller and shaft

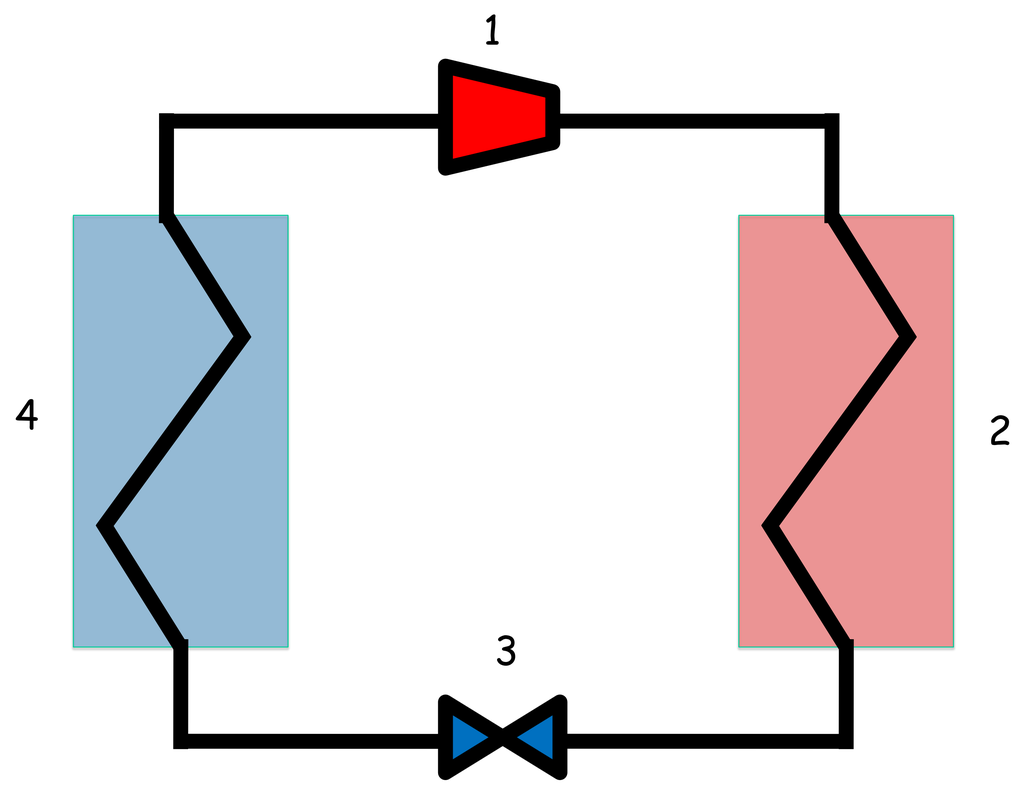
1. Motor Req: 90 brake HP
2. 300 RPM
3. Flat-6 blade open turbine with 4 baffles

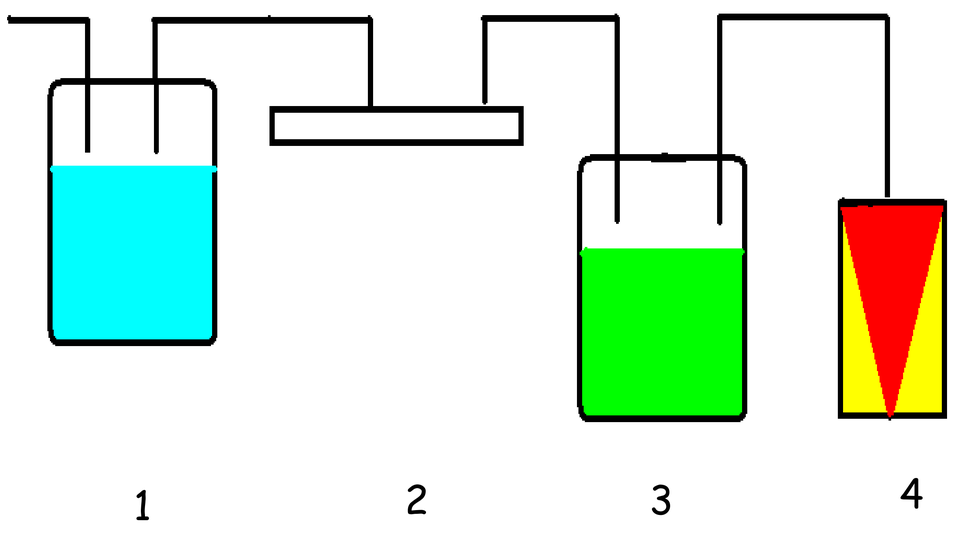
Dt = H = 0.55 meters
Da = 0.22 meters
C = 0.183 meters
J = 4.6 centimeters
G = 1 centimeter

Refrigeration Cycle:

1. Compression of ammonia
   - 93 kPa to 1.2 MPa
   - 238K to 313K
2. Condenser: heat is recovered here at 33% efficiency to operate the dryer and zein extraction
   - 313K to 303.94K
   - Isobaric de-superheating and condensing of fluid
3. Expansion valve
   - 1.2 MPa to 93 KPa
4. Evaporator: fluid vaporizes completely

- **Compressor Req: 95 brake HP**
- **Ammonia Mass Flow Rate: 0.137 kg/s**
- **Energy Recovered in Condenser: 52.93 kW**





Zein Extraction: Start from Dry Corn Gluten

1. Suspension in 50 C water in mixing tank 1 for 1 hour
2. Filter, transfer solid into mixing tank 2
3. Suspension in 50 C 70% wt/wt ethanol solution in mixing tank 2 for 1 hour
4. Centrifuge, keep the zein dissolved in liquid

Continuous rotating disk centrifuge

- 80 disks at 40 degrees
- Major disk radius: 0.5 meters
- Inner shaft radius: 0.1 meters
- 3500 RPM
- 310 brake HP at 80% efficiency
  - Approximated from kinetic energy req