CHEMICAL & BIOMOLECULAR ENGINEERING

Crisp Box

A container that keeps your leftovers fresh!

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Motivation/Impact

Motivation

Sealing food in rigid containers **traps moisture**, causing condensation and leaving food **soggy**.

- Reduces food quality and texture
- Discourages leftovers, increasing waste

Impact

- **Buildup:** Utilizes optimized geometry and a microporous membrane to prevent moisture buildup and deposition on leftovers
- **Shelf Life:** Extends palatable shelf-life, keeping leftovers out of the trash
- **Sustainability:** Incentivizes consumers to abandon single-use plastics and styrofoam

Product Specifications

Materials of Construction

- **Body/Outer Lid:** Tritan Copolyester (3mm thick)
- **Membrane:** Expanded Polyethylene (10uM thick)
- **Guard Plates:** Polypropylene (1.5mm thick)
- **Sealing Ring:** Silicone
- **Lid Clamps:** Polypropylene
- **Packaging:** Paperboard protective sleeve

Features

- Lowered "reservoir" ring between upper grate and outer lid for condensate collection
- Curved inner surface of outer lid to drive runoff toward reservoir
- Removable and hand-washable inner lid assembly protects the membrane

Regulation

- FDA classification: Food Contact Substance
  - Submit data and safety reports for premarket approval

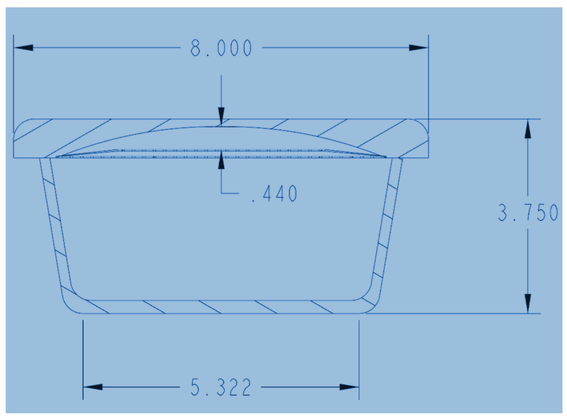

Figure 1. Schematic representation of Crisp Box. The main dimensions of a prototypical 56 oz Crisp Box are given in inches.

Manufacturing Process

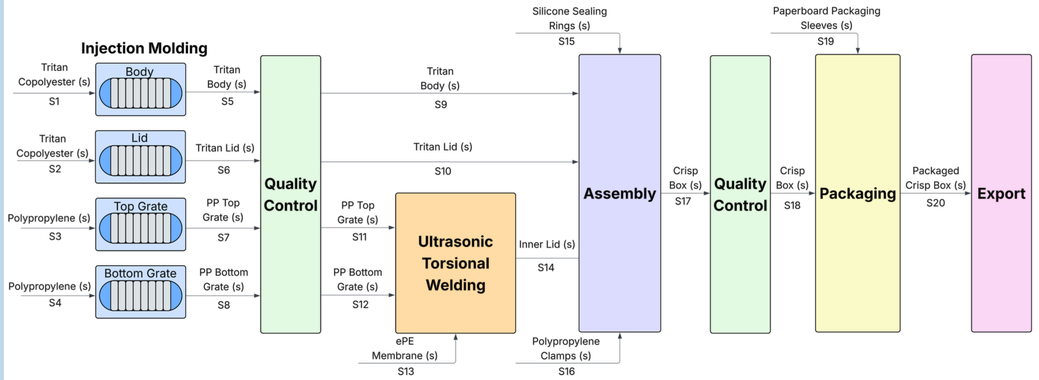

Figure 2. Overview of the manufacturing process for Crisp Box.

Goal: 1 million in Y1

- 4 injection molding machines (8 cavity molds each): 20 sec/cycle
- Ultrasonic torsional welding: 0.1 sec/weld
- Automated quality control: 0.5 sec/unit
- Assembly: 10 sec/unit per worker (4 assemblers)
- Manual packaging: 20-30 sleeves/minute per worker (1 packager)

→ 48.8 sec to produce 8 ready-to-ship Crisp Boxes

1,227,540 units per year

Market Need

Market Size

Reusable Food Storage Container Industry

- Market size: $250 billion
- 5.25% CAGR

Premium Kitchen Product Market

- 17.9% CAGR

Customer Segmentation

- **Primary**: Students, young professionals, families
- **Secondary**: Restaurant owners

Aligned Market Trends

Food Waste Awareness

- Reduces food waste by preserving food quality

Sustainability

- Reusable, durable container

Smart Kitchen Tools

- Moisture absorbing technology

Financial Analysis

Year	0.5	1	2	3	4
Revenue	10.00	20.00	30.00	40.00	50.00
Operations	1.38	2.77	3.13	3.49	3.85
Business	1.13	1.92	1.57	1.57	1.57
EBITA	7.48	15.32	25.31	34.95	44.59
Tax Payable	2.12	4.42	8.03	11.57	15.08
Net Cash Flow	5.36	10.90	17.28	23.38	29.51
Discounted CF	5.56	11.58	20.90	31.11	43.21
NPV (No TVM)	-9.90	-4.36	12.92	36.29	65.80
NPV (TVM)	-10.09	-4.99	9.29	26.85	47.00

Table 1. Cash Flow Table.

Price:

- $20/box

Breakeven:

- Year 2

Revenue (Y2):

- $30M/year

Profit Margin:

- 57.6%

Valuation (Y10):

- $200M

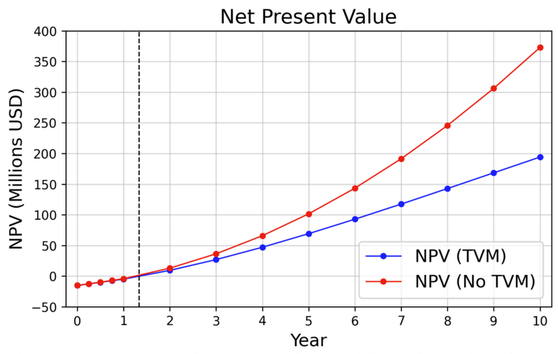

Figure 5. Net Present Value Curve With and Without Time Value of Money. Crisp Box breaks even after 16 months and reaches a valuation of approximately 200 million USD by Year 10.

Final Product Design

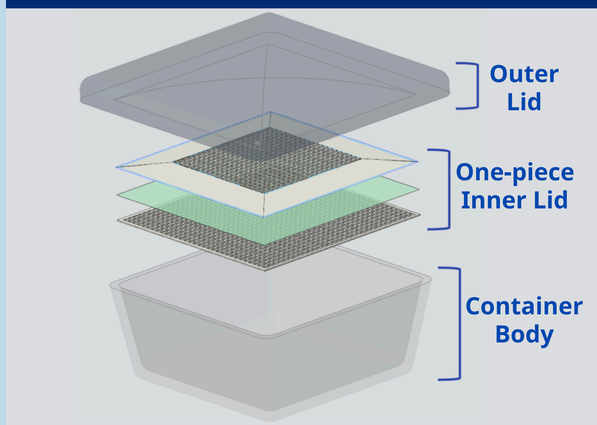

Figure 3. 3D schematic of Crisp Box.

Governing Equations

Heat Transfer in Food

$$\rho C_p V \frac{dT}{dt} = -hA(T - T_{ambient})$$

Vapor Pressure Equilibrium

$$P_{sat}(T) = 610.78 exp(\frac{17.27T}{T + 237.3})$$

Fick's Law

$$J = D_{eff} \frac{C_{in} - C_{out}}{L}$$

Effective Diffusivity

$$D_{eff} = D_{ref}(\frac{T}{T_{ref}})^{1.5} \frac{\varepsilon}{\tau}$$

Mass Flow Rate

$$\dot{m} = JAM_W$$

Condensation Condition

$$T_{lid} < T_{dew} \Rightarrow Condensation\ Occurs$$

$$T_{dew} = f(RH, T)$$

Furmidge Force Balance

$$\rho g V sin(\alpha) = k\gamma w(cos\theta_R - cos\theta_A)$$

ρ	Density
C_p	Specific heat capacity
V	Volume
T	Temperature
h	Convective heat transfer coefficient
P_{sat}	Saturation pressure
J	Molar flux
D	Diffusivity
C	Concentration
L	Path length
ε	Porosity
τ	Tortuosity
$\dot{m}$	Mass flow rate
A	Cross-sectional area
M_w	Molecular weight
RH	Relative humidity
g	Gravity
α	Local curvature angle
k	Geometric pre-factor
γ	Surface tension
w	Droplet characteristic width
θ_A/θ_R	Advancing/receding contact angle

Product Model

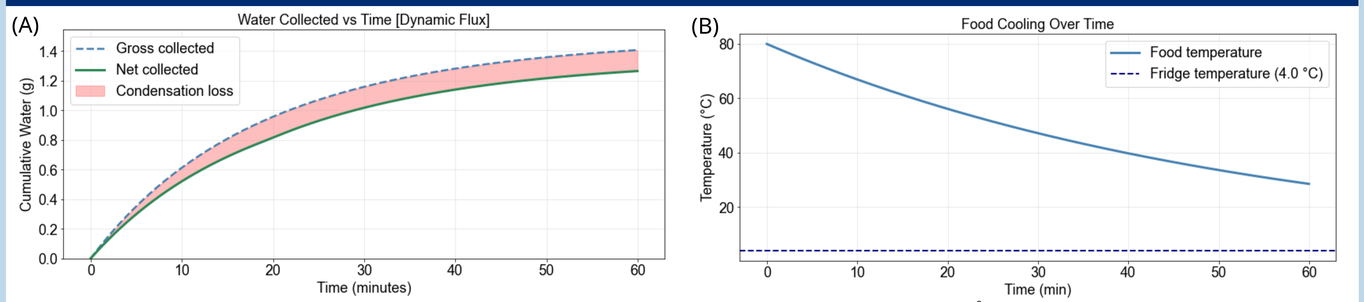

Figure 4. (A) Water accumulation and collection efficiency over a 1 hour cooling. Based on a 500 mL food volume (ρ=1000 kg/m^3) initially at 80°C placed in a 4°C environment. The model predicts an ideal (gross) vapor collection of 1.4 g and a net (actual) collection of 1.3 g resulting in a ~90% collection efficiency. The red shaded region represents the loss of water to condensation on the inner guard plate. **(B) Thermal decay of food with system boundary.** Heat transfer at the food surface (blue) following Newton's Law of Cooling. Guard plates are assumed to be 55°C.

References & Acknowledgements

References and Appendix:

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