The Perfect Chai Maker

A recipe by

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Reader: Prof David Brooks

Problem

	Chai: a *flavour* **NOT** a *process* No **dedicated chai machine** in market
	**2 billion** tea drinkers ↑+ in American market (Starbucks, Peet's, 7/11)
	**67% drink** 'hot beverages' at workplace: taste, socialize, pause & rest
	Making coffee at the workplace has become an integrated part of workflow, generally requiring just the **TOUCH OF A BUTTON** to make. However, making Chai, a South Asian tea, has required more **TIME**, **HANDLING** of multiple components, and **SUPERVISION** through the process.

Institute for Scientific Information on Coffee, "The good things in life: coffee in the workplace," Worcestershire, 2017.

Background/Existing Work

$199

Teas
• Insert everything manually • **Strainer** • **Induction heater**

$220

Hot beverages
• Pod ingredients • **Reservoir for water** • Milk separately inserted • **Induction heater + heating element**

$250

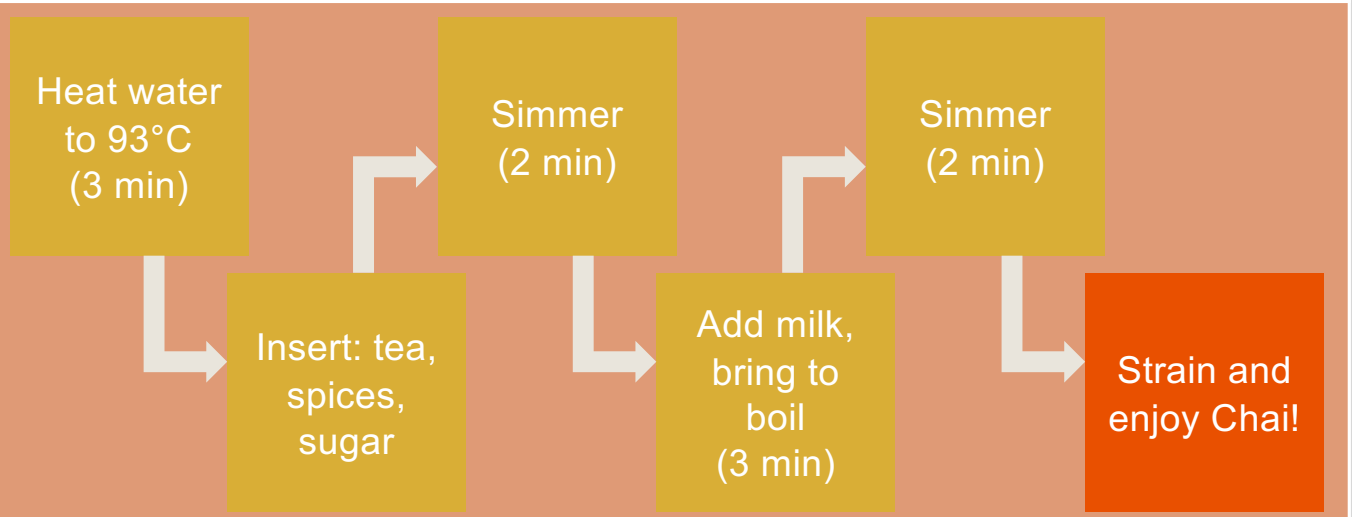
Chai
• Pod ingredients **integrated** • **Reservoir for water** • **Milk integrated with chai** • **Induction heater + heating element**

$450

Espresso
• Pod ingredients • **Fully automated** to glass • Reservoir for water, milk • Milk steamer **+ heating element**

Goal

Making coffee at the workplace has become an integrated part of workflow, generally requiring just the touch of a button to make. However, making Chai, a South Asian tea, has required more time, handling of multiple components, and supervision through the process.

PRODUCE	TRADITIONAL RECIPE
Chai in under 5 minutes	
Minimal user involvement	
Integrated ingredients	

S. Fountaine, "authentic masala chai recipe!," feasting at home, 2 January 2019. [Online]. Available: https://www.feastingathome.com/authentic-masala-chai-recipe/. [Accessed 30 September 2019].
J. Pallian, "Authentic Homemade Indian Chai," foodess, 29 November 2016. [Online]. Available: https://foodess.com/authentic-indian-chai-tea-recipe/. [Accessed 30 September 2019].

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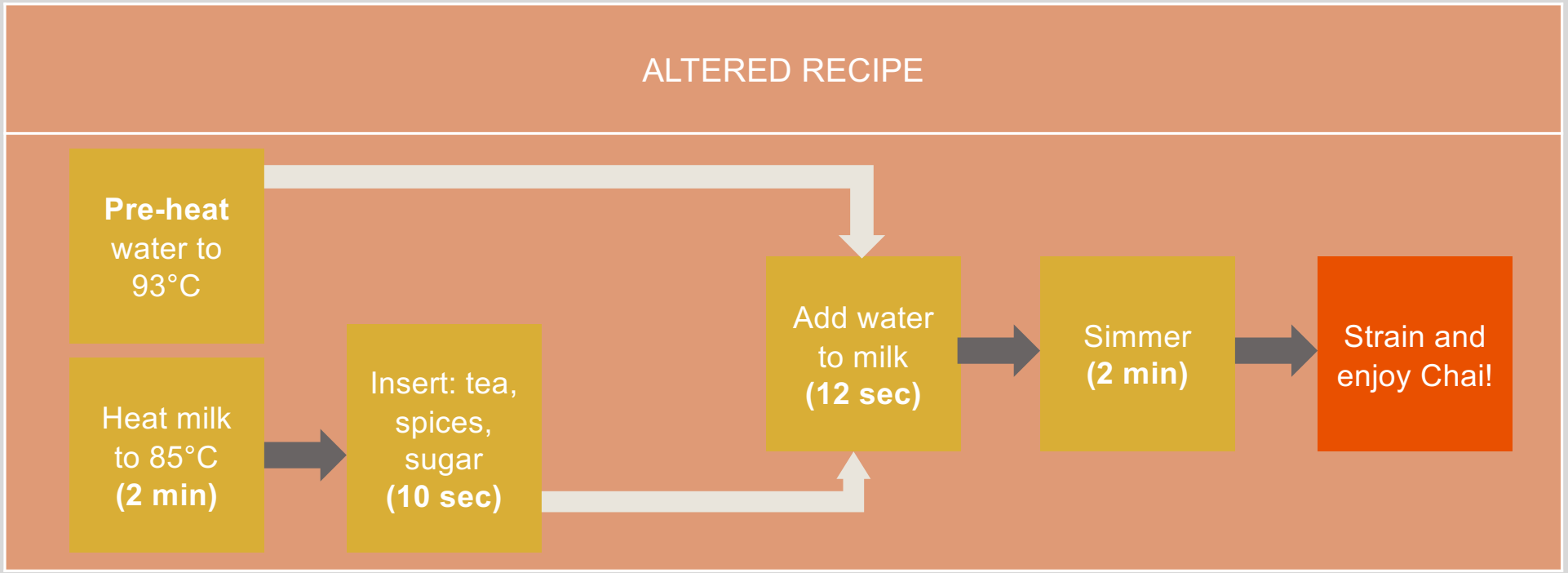
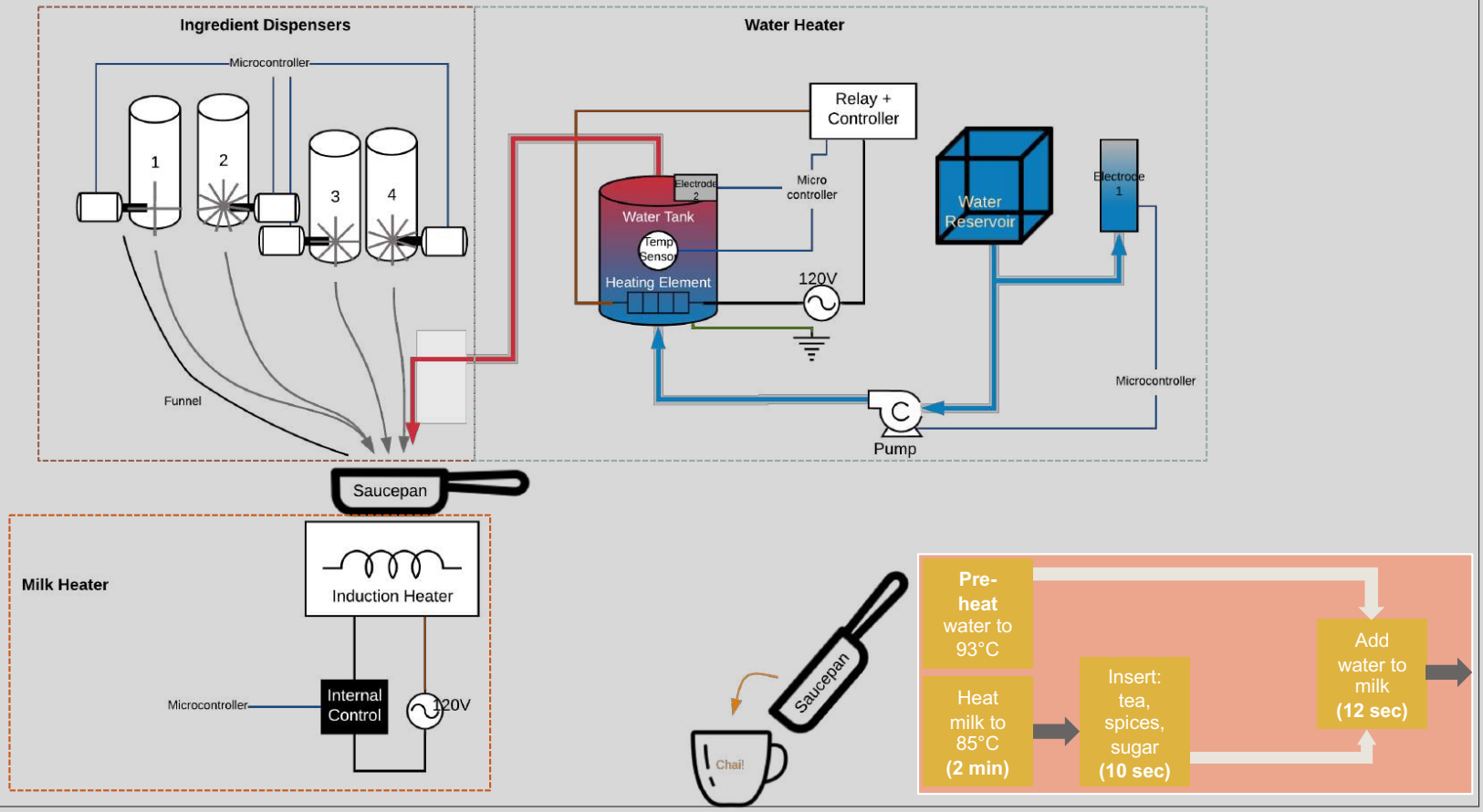


Design Choices

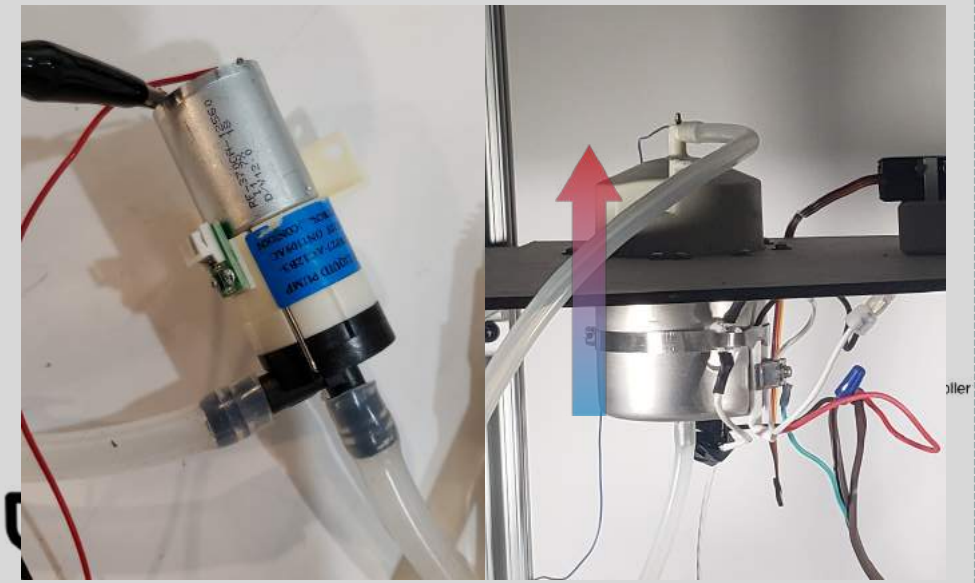
- Milk inside machine?
  - Refrigeration
  - Clogging/cleaning of tubes
- Separate brewing chambers
- Spice choices
  - No pods
  - Cinnamon, ginger not used
    - Not all required
    - Wet vs dry ingredients
    - Density of ingredients

System Overview



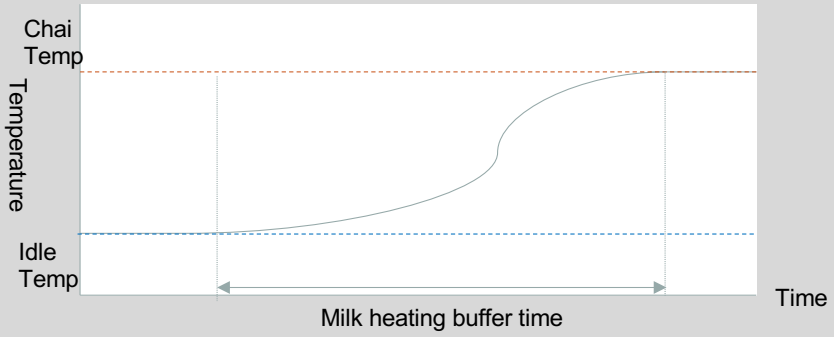
Water Heater and Controller

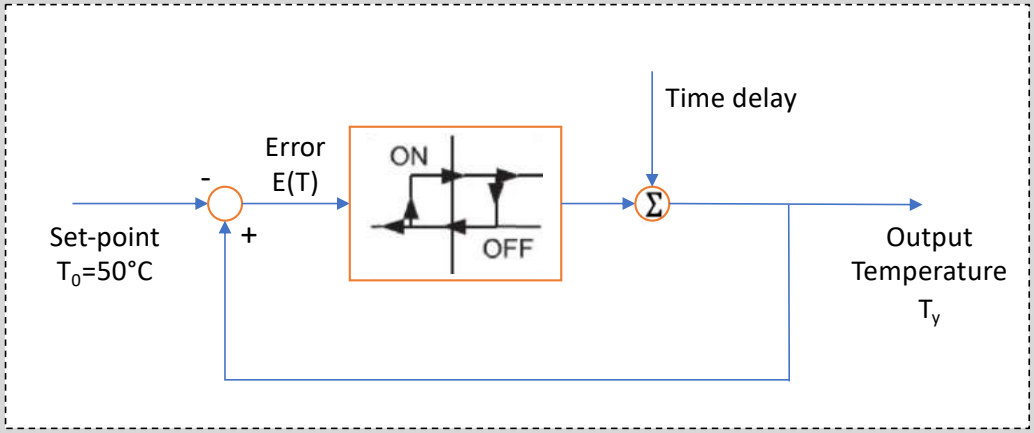
- Water tank
  - Sealed container – repurposed Keurig
    - Internally secured temperature sensor
  - Cold water enters through bottom (from reservoir), hot water leaves from top
- Keurig Water Pump
  - Water flow rate within specified time



Water Heater and Controller

- Idle temperature vs chai temperature
- Hysteresis control
- Factors for control
  - Temperature
  - Tolerance
  - Time





Ingredient Dispenser

- Individually turning dispensers
- Continuous rotation servo
  - Size
  - Torque
- 3-d printer clamp

$$N = \frac{V_{sphere} - N(V_{segment} - bo}{V_{ingredient}}$$

$$\therefore NV_{ingredient} + N(V_{segment} - bott$$

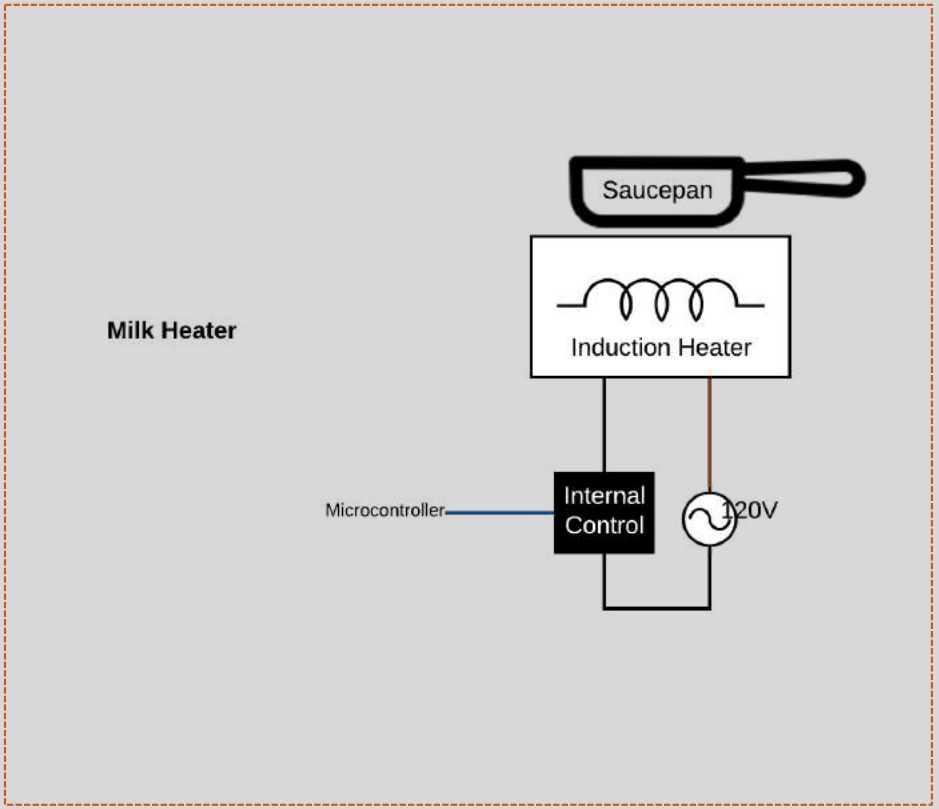
$$\therefore N = \frac{V_{sphere} - V}{V_{ingredient} + (V_{segm}}$$

$$N = \frac{\left[\frac{4}{3}\pi(r_{sphere})^3\right] - [lengt}{\frac{m}{\rho} + \left(\left[thickness \cdot \frac{1}{2}\pi(r_{segment})^2\right] -}$$

$$N = \frac{\left[\frac{4}{3}\pi(1in)^3\right] - [2in \cdot}{\frac{m}{\rho} + \left(\left[thickness \cdot \frac{1}{2}\pi(1in)^2\right] -}$$

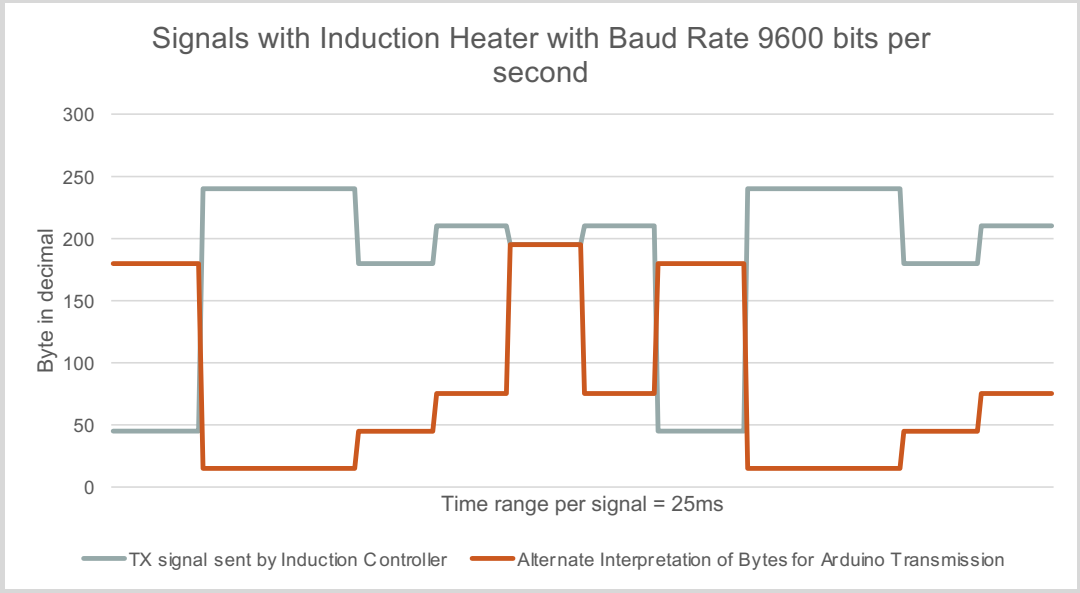
Milk Heater

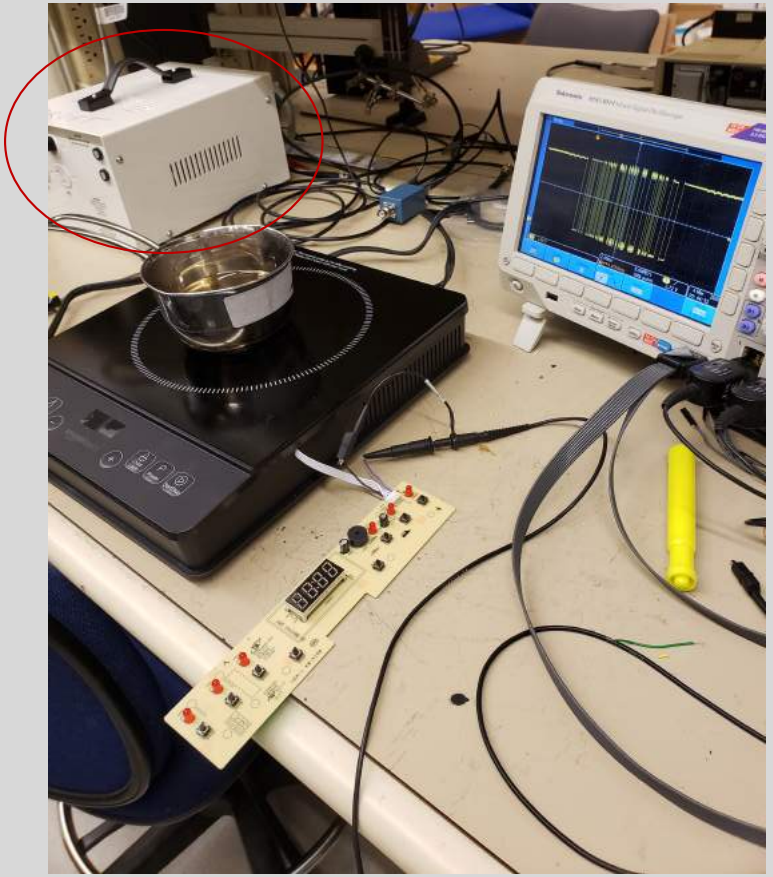
- Heating element vs induction heater
- Commercial conduction heater
  - Tap into controls
  - Safety
  - Size



Milk Heater

- Arduino to RX-TX connection
- Receive, decode, transmit 8-byte signals

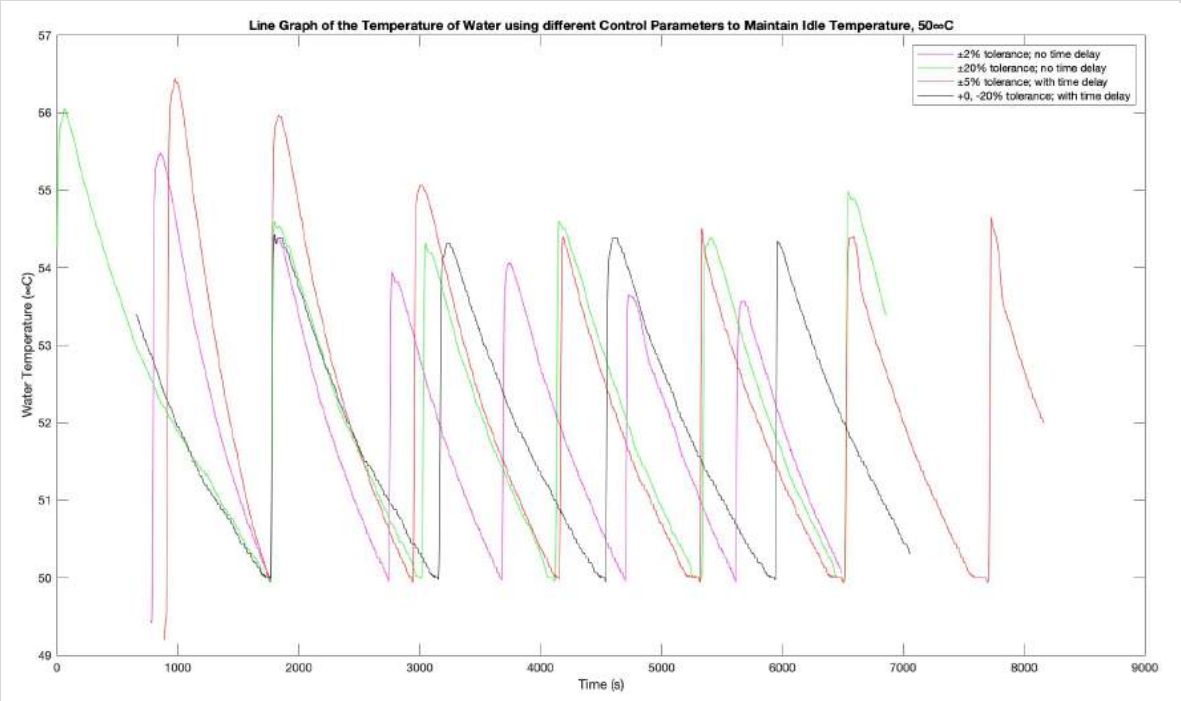




Water Heater and Controller

Factors for control

- Temperature
- Tolerance
- Time



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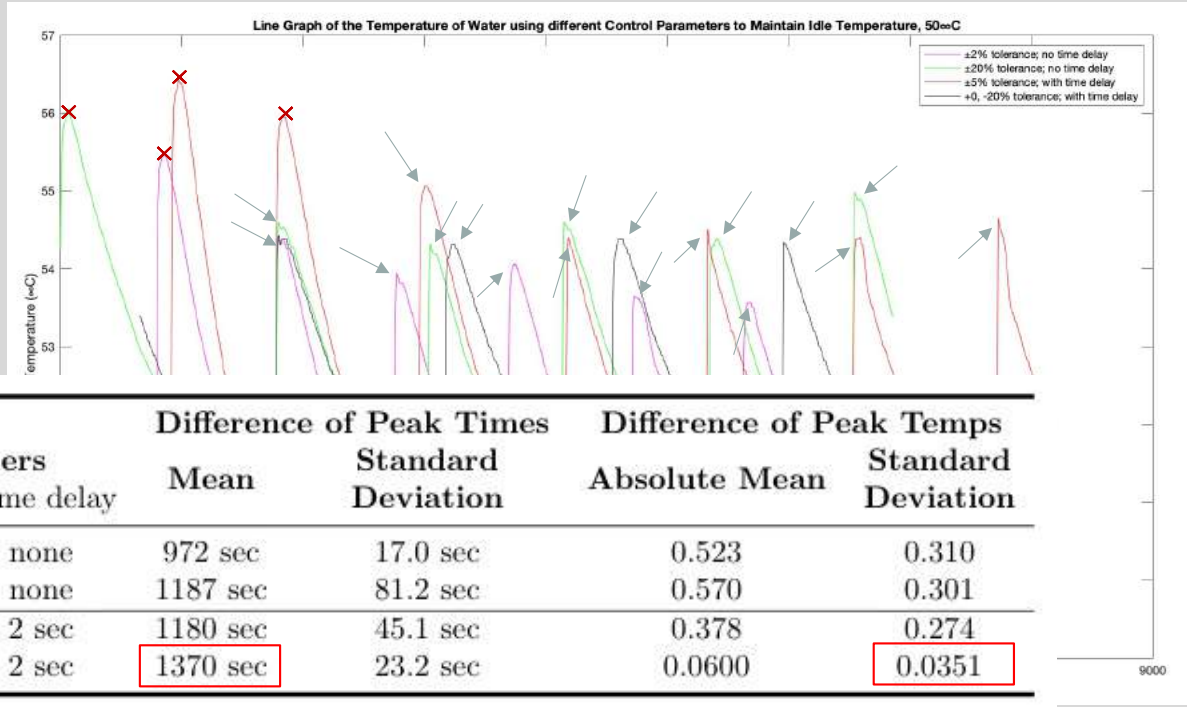
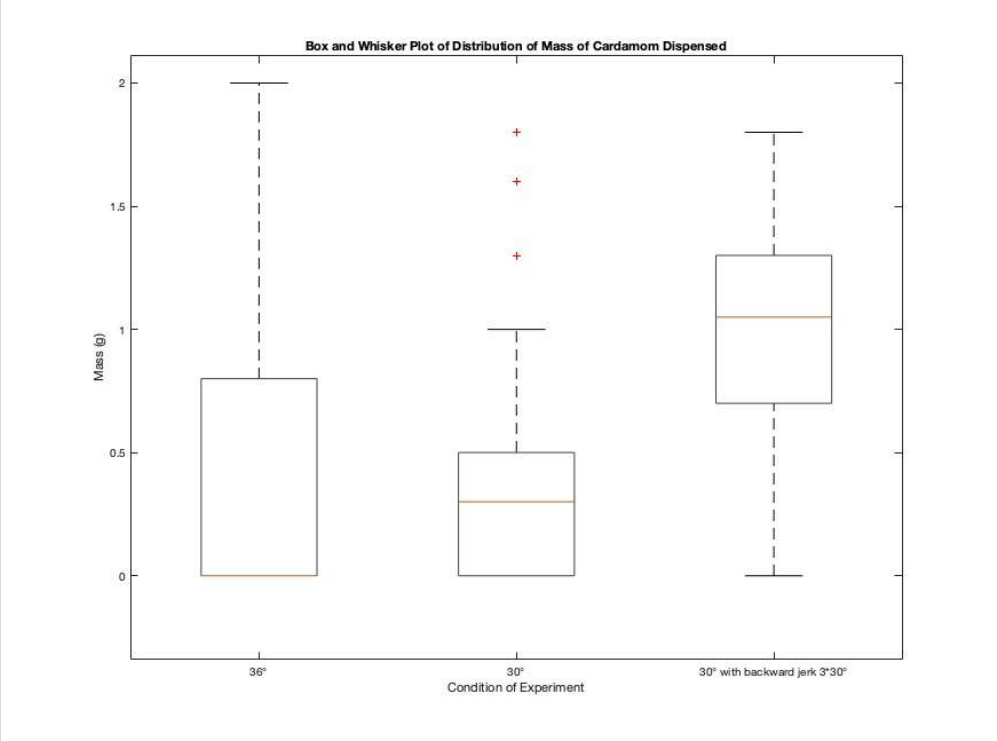


Parameters		Difference of Peak Times		Difference of Peak Temps	
Tolerance	Time delay	Mean	Standard Deviation	Absolute Mean	Standard Deviation
± 2%	none	972 sec	17.0 sec	0.523	0.310
± 20%	none	1187 sec	81.2 sec	0.570	0.301
± 5%	2 sec	1180 sec	45.1 sec	0.378	0.274
± 20%	2 sec	1370 sec	23.2 sec	0.0600	0.0351

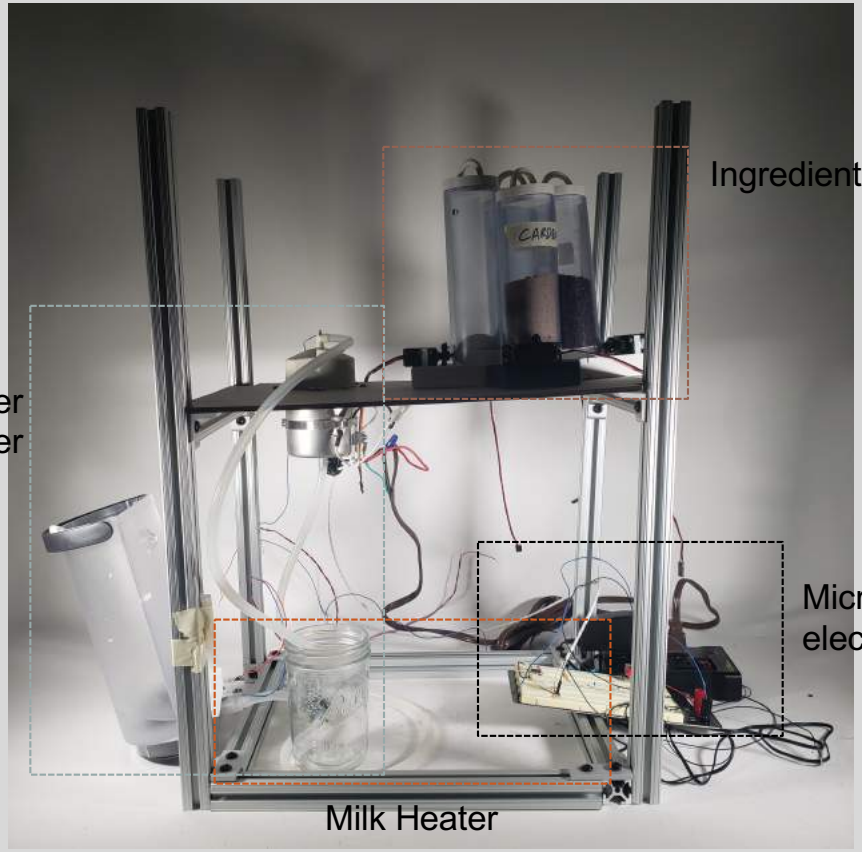
Ingredient Dispenser



Success Rate: 40% 67% 96%

Define Design Build **Measure**

Final Prototype



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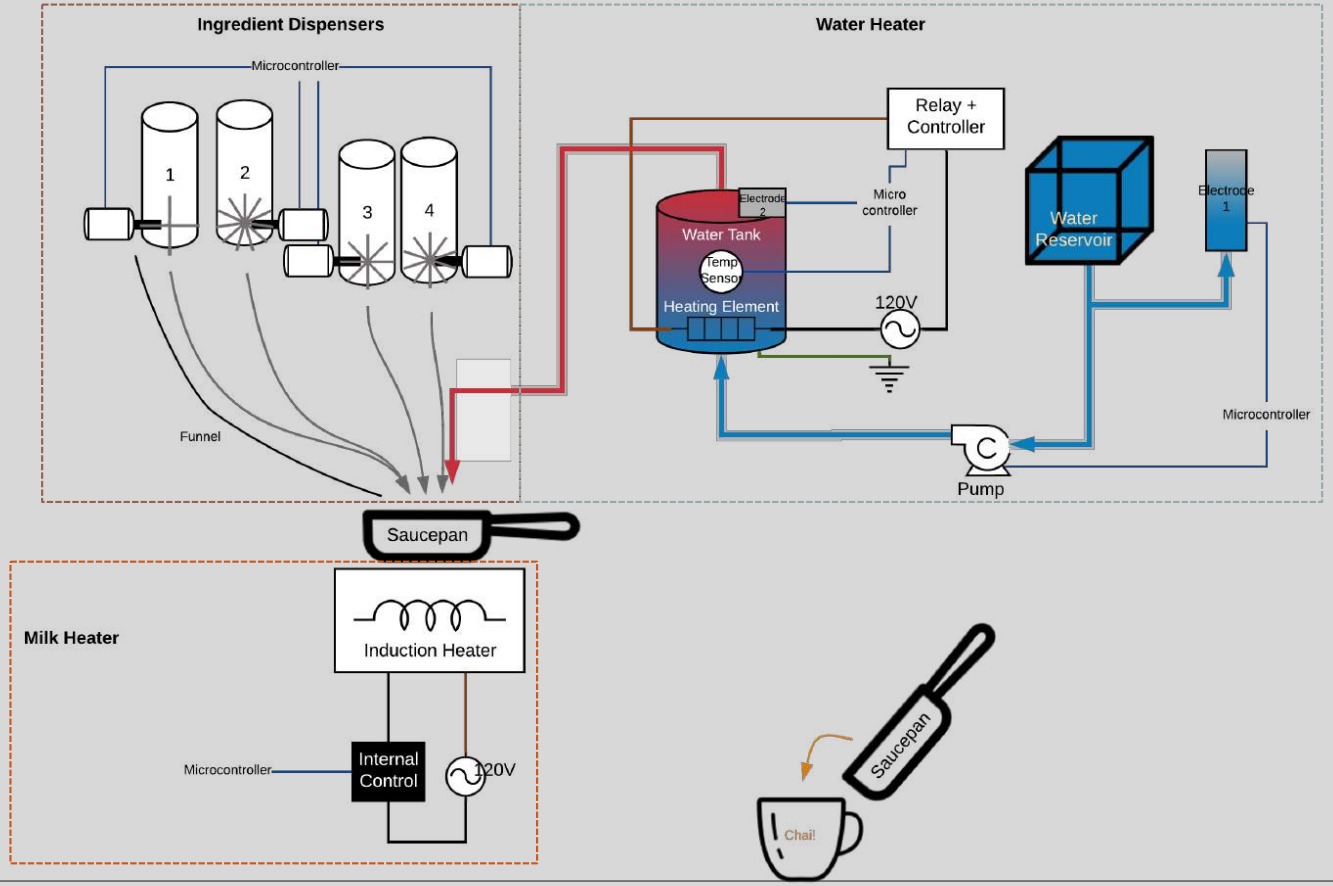

Future Plans

Integration

Testing
Time entire process
Milk heater using immersed sensor
Stable surface for ingredient dispensers
Idle power usage for water heater

Tubing fitted with pressure valves
PID water controller
Mixed spice dispenser

did it make chai?

questions