



BACKGROUND

- Cold brew coffee is one of the **biggest trends** in coffee drinking today with an estimated compound annual growth rate of 26.44% between 2021-2025¹
- Keurig Dr Pepper (KDP) seeks **novel** advances in brewing for **future implementation**
- KDP has requested an **autonomous cold brew coffee maker** design, which requires fluid mixing and pumping, cooling, foaming, and controls functions
- Design of concentrate pod and contents is out of scope

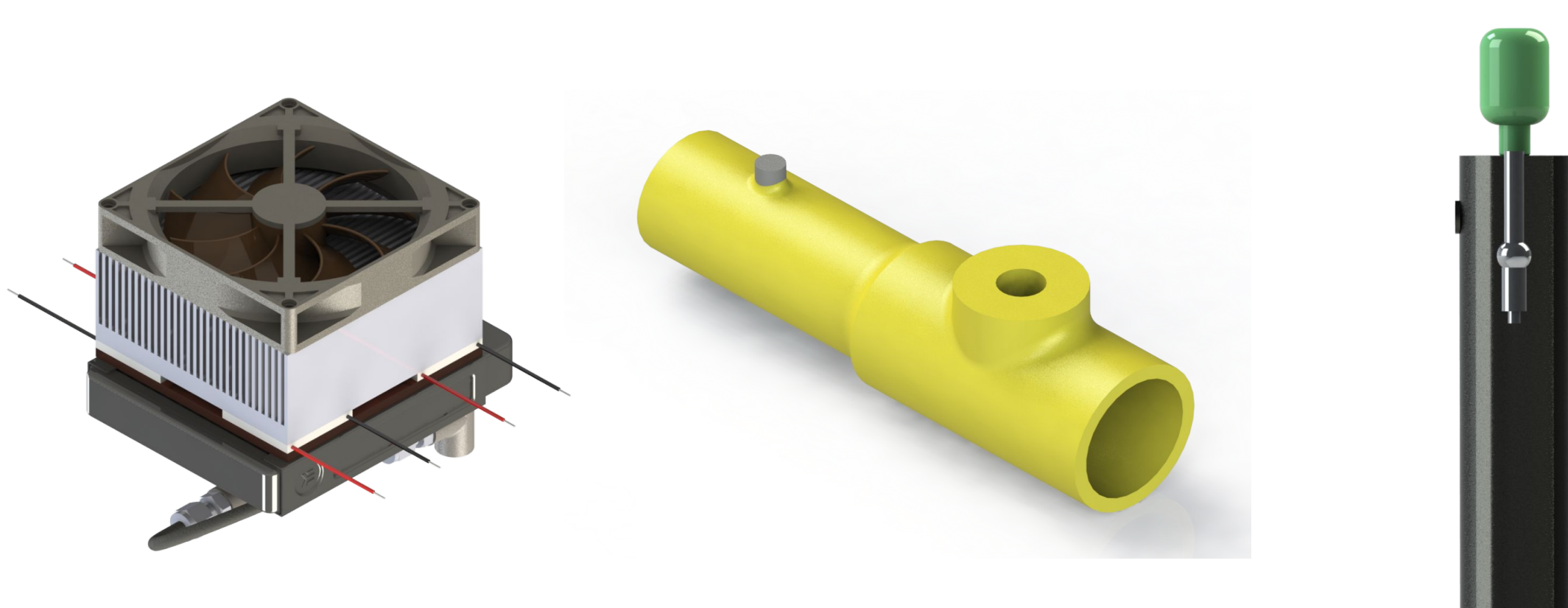
METHODS

Problem Definition

- Benchtop test predicate devices² and cold brew to **determine benchmarks**
- **Generate requirements and specifications** from scientific literature, standards³, and benchmarks

Concept Generation, Selection, and Development

- **Brainstorm** subsystem and integration concepts
- Use Pugh matrix to **select concepts** for development
- **Prototype** and test cooling, nitrogenation, and controls subsystems **individually** prior to **integration**



Cooling, In-line Mixing, and Nitrogenation Concepts

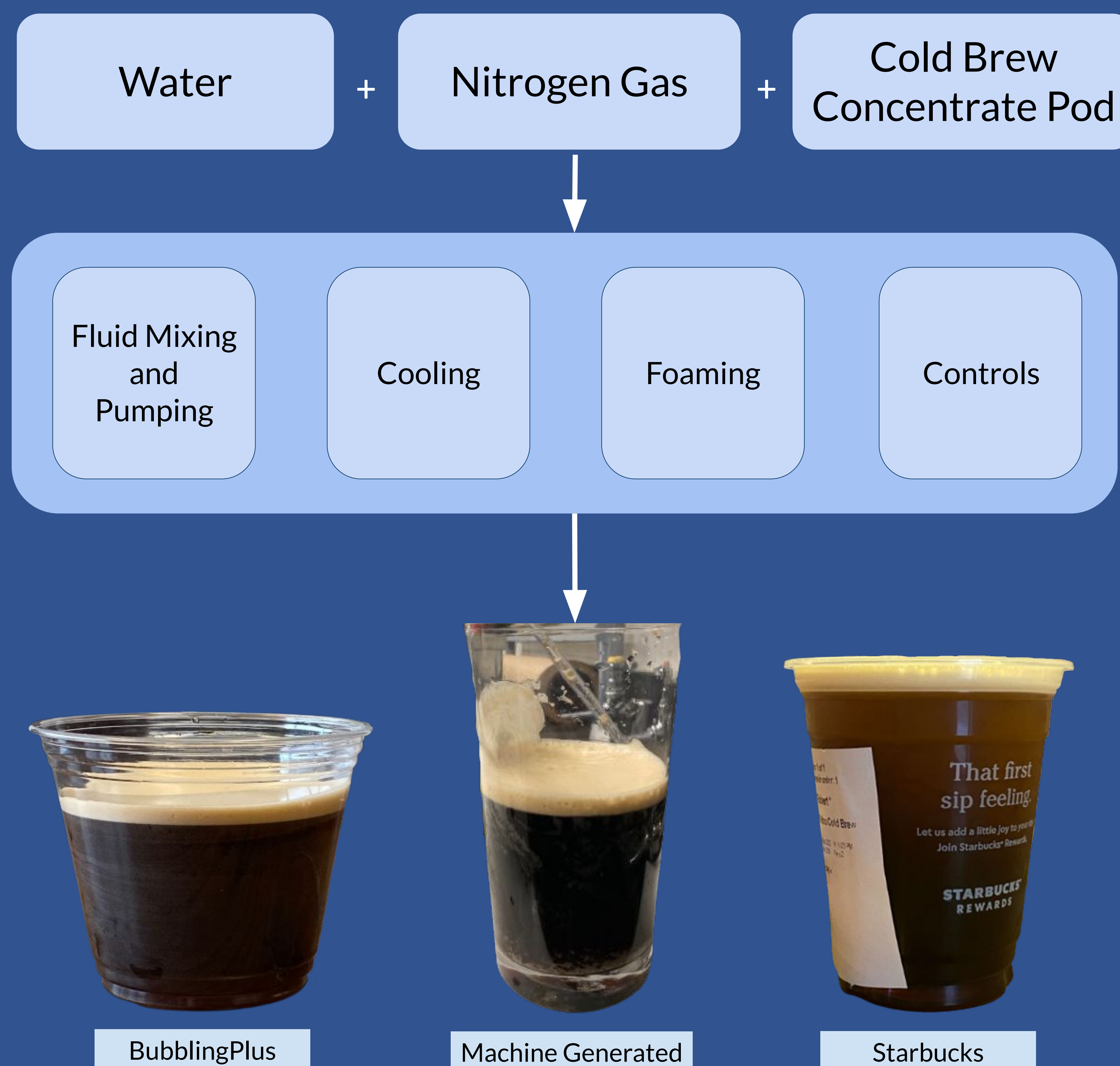
Verification

- Measure **temperature** over time using digital temperature sensor and ESP32 to calculate **cooling rate**
- Measure **bubble size** and **foam thickness** using image analysis with reference scale to determine **nitrogenation** performance
- Measure final **brew volume** and **time** to determine full system **integration** and **pumping** performance

REQUIREMENTS AND SPECIFICATIONS

Critical Requirement	Specification	Result
Average Cooling Rate	≥ 3.0 °F/min	3.59 ± 0.63°F/min
Maximum Bubble Size	≤ 1.5 mm	1.2 ± 0.5 mm
Foam Thickness (3" Glass)	0.25 ± 0.10"	0.38 ± 0.17"
Brew Size	8.0 ± 0.5 oz	6.9 oz
Brew Time	≤ 8.0 min	11.5 min

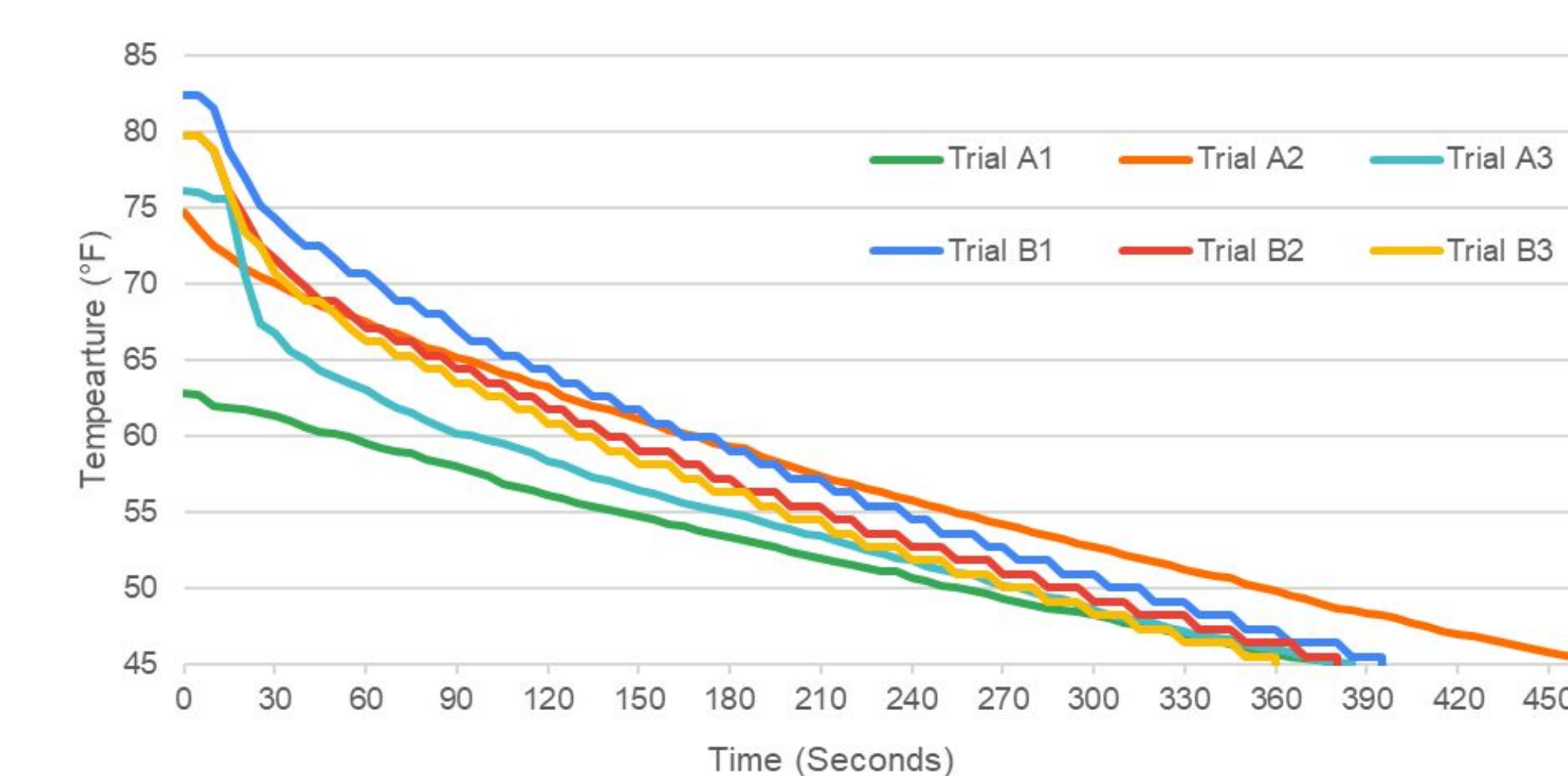
Our **nitro cold brew** maker **cools** water, **mixes** water and coffee concentrate, and **nitrogenates** the mixture, producing a dense foam.



RESULTS

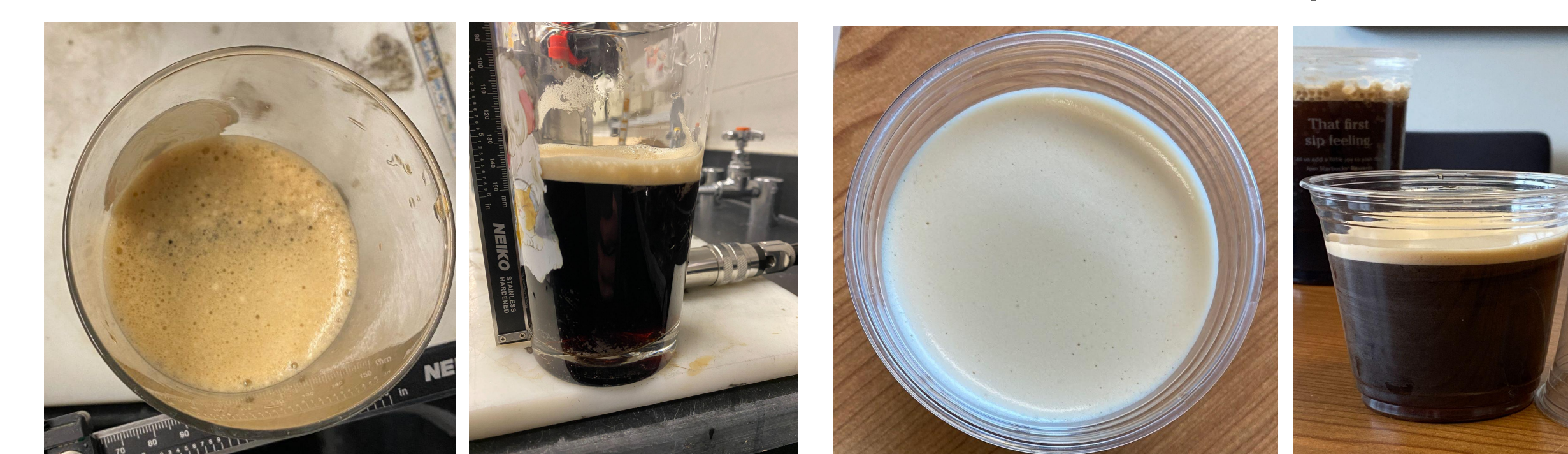
Average Temperature/Cooling Rate

Temperature measured in 2 sets of 3 back-to-back trials.



Maximum Bubble Size and Foam Thickness

Foam attributes were measured after 5 minutes of decomposition.



Machine-Generated Foam

BubblingPlus Benchmark Foam

Pumping and Integration

- Approximately **1.1 oz.** of **volumetric loss** due to pump failure to evacuate water from cooling and mixing subsystems
- The integrated system takes approximately **10.5 minutes** to pump, cool, and mix and **1 minute** to nitrogenate and dispense

CONCLUSIONS AND RECOMMENDATIONS

Cooling

- **Cooling rate increases** for **back-to-back** trials
- **Cooling** the thermoelectric cooler **hot side** **improves cooling rate**

Nitrogenation

- **Bubble size decreases** as lateral distance from tap and pour **steadiness increases**
- Automate using electronic flow control valve

Full System

- **Decreasing tube diameter** and **increasing pump power** may **decrease volumetric losses** and expedite brew time/flow rates
- Full system footprint should be **decreased** from 14" x 20" x 30" to 15" x 15" x 17"

ACKNOWLEDGEMENTS

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REFERENCES

1. TechNavio. "Global Cold Brew Coffee Market 2021-2025," July 2021, ID: 4894393.
2. Bubble-containing Liquid Supply Device for Reducing Liquid Outflow Rate. Her Sheng Chang International Co., Ltd., assignee. Patent TW559599U. 11 May 2018.
3. ANSI/NSF 51-1997 Food Equipment Materials. Ann Arbor, MI: NSF International, 1998.

Scan the **QR code** to view **prototype test videos!**
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