Senior Design Proposal Deliverables

Project: IntelliRoast

Team Number: 1

Revision Number: 4

Semester: Fall 2018

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Team Lead: Chaise Farrar

Team Members: JR Jamora, Noah Siano, Drake Bolland, Rebecca Siciliano

Project Keywords: Coffee, Control System, Temperature Control, Temperature Sensor, Wireless Interface, App-enabled

1. High-level project description (problem solved by design and functionality).

With the growing popularity of artisan coffee shops, more people are wanting access to freshly-roasted coffee at home, which has led to a rise in home coffee roasters on the market. These machines can roast a personal batch of coffee as often as one would like, but they are either cost-prohibitive or very crude in their control mechanisms and roast configurability. Roasting coffee is a complex and nuanced process that requires exact temperature control following specific roasting profiles to bring out the best flavors from the coffee.

We propose to create a budget-minded smart roaster that will provide precise monitoring and control throughout the roasting process by way of temperature probes. It will be paired with a smartphone app that acts as the user interface and allows users to customize and save roast profiles, start and monitor the roast, and record any additional notes about the roast afterwards.

For the mechanical process, a user can add a specified amount of beans to a hopper. Once the roast profile is selected in the app and the process is started, the beans will drop into the roasting chamber. Hot air will be blown into the roasting chamber at a high velocity to agitate and mix the beans while roasting them. As coffee begins to roast, a paper-like substance called chaff flakes off the beans. Chaff is exhausted along with the hot air out of the top of the chamber, and is then collected in a cyclone-style filter and the exhaust gases will pass through a smoke filter before exiting the machine. The roaster will then deposit the finished beans into a removable bin, which can then be stored for up to two weeks. This heating and chaff-collecting design is the simplest and most elegant solution at our proposed target price.

2. A brief discussion of relevant technical background material on which the project is based (identify at least 3 published references).

The below source considers some of the issues and precautions to be taken in applying the thermocouple in temperature measurements.

[1] I. B. Smith. "Applications and limitations of thermocouples for measuring temperatures." *Journal of the American Institute of Electrical Engineers*, vol. 42, no. 2, pp. 171-178, Feb. 1923.

This source includes an outline for computational modeling of the coffee roasting process.

[2] N. O. Oliveros, J. A. Hernández, et al. "Experimental study of dynamic porosity and its effects on simulation of the coffee beans roasting." *Journal of Food Engineering*, vol. 199, pp. 100-112, 2017.

This reference outlines the effects of time and temperature on the kinetics of coffee roasting. It also discusses different roasting profiles and curves.

[3] D. Pramudita, T. Araki, et al. "Roasting and Colouring Curves for Coffee Beans with Broad Time-Temperature Variations." *Food and Bioprocess Technology*, vol. 10, no. 8, pp. 1509- 1520, 2017.

This reference highlights a proposed numerical model which can predict the performance of coffee roasting.

[4] D. Bottazzi, S. Farina, et al. "A numerical approach for the analysis of the coffee roasting process." *Journal of Food Engineering*, vol. 112, no. 3, pp. 243–252, Oct. 2012.

3. Projects are evaluated, in part, on the inclusion of a number of the following "real-world" concerns. Provide preliminary comments on how these issues relate to your design.

Economic: The only comparable product feature-wise is an app-enabled precision temperature home coffee roaster. It currently sells at $1800 and is far beyond what could be considered affordable for a countertop kitchen appliance. It tries to justify this cost through the use of very premium construction materials and its monopoly of the feature set mentioned above. A competing product with a budget-minded focus and a more affordable price would have a larger mass-market appeal.

Environmental: The coffee roaster will be operated in an area with similar household kitchen appliances, so it may be exposed to water and other liquids from spills. The device should be operated away from liquids since air will be cycled into the roaster near the bottom through a fan, and the presence of added moisture at this stage could harm the heating element and the coffee beans. The casing must be able to withstand handwashing semi-regularly.

In addition, the roaster will need to be durable enough to withstand minor bumps from daily usage. The coffee roaster will need to take smoke and exhaust outputs into consideration due to the high operating temperatures inside the coffee roaster. A filtering method may need to be implemented to account for this.

Sustainability: The device must be able to withstand many repeated uses and the stresses of heating and cooling rapidly. This device will take a non-trivial amount of power, mainly for the heating element. The roaster will have a removable, washable chaff collector, and the user will need to dump out the chaff after each use. As long as the chaff is removed from the collector and no dust builds up near the intake, the device should be able to function consistently without any further user maintenance. The heating chamber will not require any user maintenance.

Ethical: N/A

Health and Safety: Because of the heated air produced by the roaster, considerations should be made towards proper insulation of the outer casing and diffusion of the hot exhaust gases before they leave the machine. Because of the high power draw, special care and attention must be made to the proper fusing and standard electrical safety precautions. Hard-wired temperature failovers, such as a physical disconnect to the high-voltage section of the device, should also be included to cut power in case of overheating.

Normally, coffee roasters have an inherent fire risk because of the paper-like chaff falling off the beans and collecting in unwanted places such as in a rotating drum or exhaust vent. If an inline chaff filter is not cleaned, the hot air can be restricted, heating up the chaff to the point of combustion. Because of our plans for a cyclone chaff separator system, chaff will be filtered to not restrict airflow at any point, removing the risk of flare ups.

Social: An affordable, automated coffee roaster allows the everyday coffee lover an easier entry point into high-end coffee. The automated nature of this product reduces the time allocated for roasting coffee beans by providing a hands-off alternative to the imprecise manual roasting methods currently used.

Political: N/A

4. More detailed description of hardware and software design components (both hardware and software design are required for CPE students and both are strongly encouraged for EE students).

Heating element:

- Small form factor centrifugal fan for a high static pressure output
- Air flow sensor (sail switch) to monitor for air flow passing through the system and provide feedback for the fan
- Custom coiled heating element made from resistance wire

- Piping wrapped in insulating tape to reduce temperature loss

Heating chamber:

- Double-walled housing containing beans for roasting
- Pressurized air flow from bottom to top of housing to agitate beans during roasting process
- Trap door for removal of beans at the conclusion of the roast
- Heating controlled by temperature sensors located in the intake and exhaust of the heating chamber

Exhaust Filtration:

- Cyclone chaff separation system
- Activated Carbon Filter smoke system

Controls:

- Microcontroller to monitor temperature of heating chamber and adjust voltage of heating element to match the preset roast profile of beans
- Wireless communication with cell-phone to customize and upload roast profiles to the roaster
- LED outputs to show progress of roasting and provide visual feedback during process

Phone App:

- Connect to the roaster via wireless communication protocols
- Ability to start, schedule, and customize roasts

5. Vision for participation in project by team members.

Drake Bolland

- Electrical Design
- Mechanical Design

Chaise Farrar

- Embedded System Design
- Application Development
- Resident Coffee Nerd

JR Jamora

- Thermodynamic Modeling
- Electrical Design

Noah Siano

- Application Development
- Website Design

Rebecca Siciliano

- Thermodynamic Modeling
- Electrical Design

Everyone

- Research

- Documentation

6. Preliminary schedule of what you are planning to do and discussion of feasibility.

August: Research and Ordering Parts

September: Building/Programming, Phone App Development Begins

October: Finish Building/Programming/App, Start Testing/Debugging

November/December: Final Testing/Debugging, Presentation