**Background**

Beer is a beverage that can be traced back to the beginnings of civilization. It forms an integral part of a variety of cultures and societies, and is the most popular alcoholic beverage in the world. The average US citizen alone drinks 20 gallons of beer a year. Unfortunately, most beer consumed in the US is produced by just a handful of large suppliers, and lacks in style and flavor diversity. For the past 30 years, there has been an incredible surge in craft- and home-brewing, as people are beginning to appreciate the diversity of beer that is possible, and the rewarding nature of customizing your own recipe.

**Vision**

The BrewBot is a beer brewing machine designed for home use, geared toward both the novice and enthusiastic beer brewer. Our vision was to create a machine that allows the user to choose a preset recipe or customize their own, then place the necessary ingredients in their appropriate dispensers and initiate the machine’s automated brewing process. By the time the user returns several hours later, the beer will already be fermenting in a sanitary vessel that can easily be detached and stored away safely for the remaining two weeks of fermentation. A major design priority has been devoted to ensuring sanitary requirements and simplifying the cleaning process as much as possible. Additionally, focus has been placed on flexibility in beer design, allowing for production of many complex ale styles.

The key selling point of our machine is that unlike other semi-automated home-brew solutions, the BrewBot will be able to perform almost all processes used in traditional home-brewing, thereby appealing greatly to dedicated home brewers that wish to create a large variety of ale styles without compromise.

These processes are performed by a range of computer-controlled subsystems as described below: The final product will be a tabletop appliance. It will be capable of preparing 2.5 gallons of finished wort, which is just a fermentation step away from the wonderful beverage that is beer.

**Grain Steeper**

Grain steeping allows more experienced homebrewers to add enhanced flavor profiles to the brew. This is generally done in the 150-160F range in order to extract the right flavors. Additionally, steeping allows converted starch sugars to dissolve in the wort. Steeping requires the grains to be added within the temperature range and steep at this temperature for half an hour. The temperature of the wort is controlled by the control system via its RTD temperature sensor, switching the induction heater on and off at the appropriate times. The grains are placed in a bag, which is mechanically raised and lowered by a lead screw. This setup provides the necessary length of travel as well as sufficient force to lift the heavy bag of grains.

**Hops & Spice Dispenser**

Hops play a role in both preserving the beer and providing the unique bitter flavors that many of us are familiar with. The flavors released by the hops can be controlled by the timing of the hop additions during the boil. Short exposures to boil cause the hops to produce more aromatic flavors, whereas longer boil exposures produce much more bitter flavors. The BrewBot was designed with this in mind, and provides the user with 4 separate hop caps that can be individually timed to add aroma and bitterness hops, as well as other individual ingredient additions. This provides the brewer with great flexibility in creating a specific hop profile, and is a crucial feature for the more advanced brewers. The dispenser cups are custom vacuum-formed and made of food-grade HDPE. They are easily removable for cleaning purposes.

**Electronics and Controls**

The BrewBot uses two on-board M2 microcontrollers that communicate wirelessly via the mBUS peripheral interface with a third host controller. Subsystem M2s are responsible for controlling each subsystem according to the user input and presets. The BrewBot’s temperature feedback mechanism provides the controller with real-time data, which is then used to control the induction heater as well as the timing of the individual subsystems.

**GUI**

The user interface presents the user with a selection of predefined recipes for novice brewers. After recipe selection, it provides simple instructions for adding the ingredients into their appropriate cups. More advanced users can create their own recipes, providing flexibility in the ingredient additions along with the timing of each process.

**Induction heater**

The heating of the wort provides the necessary temperatures required to extract flavors and sugars from the ingredients. Additionally, it ensures complete sterilization of the mixture for a quality end product. The wort is heated by an induction plate, which heats the wort significantly faster than conventional resistance coils, and is also much more efficient.

**Mixer**

The mixer prevents the sugars from burning at the bottom of the pot and helps with heat distribution. It has been designed for detachability, with a magnetic lock system and electrical quick-disconnects to facilitate painless removal.

**Liquid Malt Extract (LME) Dispenser**

The liquid malt extract provides the brew with the necessary sugars to produce alcohol during the fermentation process. It is added at the beginning of the main boil, and is stirred to prevent burning. LME is an unusually viscous substance that is a challenge to clean. To overcome this challenge, we created a custom vacuum-formed container out of food-grade HDPE. This container can be easily removed from the machine and washed in any household dishwasher.

**Wort Transfer**

Once the wort has been cooled sufficiently, a solenoid valve allows the liquid to transfer to the fermenting vessel. Subsequently the valve closes, thereby sealing the fermenter and allowing the fermentation process to begin without contamination. Quick disconnect fittings are used at the outlet of the boiler and inlet of the fermenter to allow the user to easily detach either system and seal the fermenter. Additional fermenters can be purchased and would allow the brewing of several batches simultaneously.

**Liquid Cooling System**

After completion of the timed boiling cycle, the wort must be cooled to 80F in order for the yeast to be added. To prevent the development of off-flavors (a product of prolonged exposure of complex carbohydrates to high heat), this cooling process must happen as quickly as possible. Traditional homebrewing utilizes an ice bath into which the pot is placed, a process that is often messy and requires a large amount of ice. The BrewBot’s liquid cooling system consists of a closed loop through which half a gallon of cooling liquid is pumped. The heat of the wort is transferred to the coolant through a submerged copper coil. This hot coolant proceeds to a custom-designed heat sink unit, which rejects heat via active convection powered by a fan.

**Sanitation**

All equipment must be sterilized prior to brewing the beer. As a consumer product, each system was carefully designed to make the cleaning process as easy as possible. All items in contact with the mixture are completely removable, and all ingredient dispensers are dishwasher-safe. Additionally, a cleaning cycle has been designed to clean the hard-to-reach areas such as the transfer valve and tubing.

**Team**

Kenneth “Tripp” Davis  
Maxwell Effron  
Sikang Liu  
Dietrich Neckermann  
Cole Paiement  
Advisor: Bruce Kohlmann