Keur-Keg

Divide and Conquer 2.0

Senior Design I
EEL 4914

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Due:
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1. Automatic Brewing Description

1.1. Motivation and Goals

Home brewing has become significantly more popular as craft brewers have introduced people to the different flavors that can be achieved with beer brewing. Although this has allowed the public to narrow down and understand what specific flavors they may enjoy from the beer, the beer may not be easily accessible. By having an automated beer brewing system then the user would be able to make more of their favorite batches to keep it readily available for themselves and loved ones. The automation of the brewing processes also allows the user to still enjoy the brewing process but spend that time on something else. Currently there is nothing on the market for small scale personal brewing systems that can achieve proper consistency and temperature throughout the process for the steps described previously. In this chapter, we will discuss the project guidelines in further detail such as project motivation and goals, project objectives, the project requirements, and project specifications.

1.2. Project Objectives

Our objectives for this project include having the total output current as minimal as possible, all parts to work in sequence with the MCU, a battery backup for the MCU, and to obtain a successful output product of 5 gallons using multiple different recipes and being consistent every time. We want to be able to plug the system in to any 120-volt outlet and have the system operate at full capacity. This objective can be complete by performing careful research on the parts needed to build the system. To achieve the optimal output and proper consistency, we will need to make sure that the MCU is coded proper. This will allow communication between the timers and the components. It will also allow communication between components. Consistent products every time relies mostly on proper coding of the MCU to ensure precise timing, temperature, and mechanical operations. A battery backup for the MCU is an important objective because if a power loss occurs at any time, a notification can be sent to the user so alternate measures can be performed so the batch can be saved instead of spoiled.

1.3. Description

The process of brewing beer can be tedious and take a lot of time tending to the process which allows room for error and inconsistency of the product. A perfect brew of a certain ingredient can be difficult to achieve because the timing, temperature, and process needs to be precise. Big companies can get all these aspects precise with huge and expensive equipment that automates the entire process to achieve perfection in bulk of every batch. The home brewer has to purchase all the individual equipment and can get the temperatures close but not perfect. The brew process typically takes around 3 hours of time to complete, the fermentation process takes anywhere from 2 to 6 weeks to complete and also takes some tending to throughout this time, and the bottling process can take 2 hours as well. We are proposing an auto-brewing system (Keur-Keg) that after loading all of the correct ingredients, the system will complete the entire brewing and fermentation process with the push of a button saving hours of time and making it so the user can achieve a consistent product every time they brew beer.

A person that brews their own beer can spoil their product or have an undesirable flavor by having too much or too little heat at certain steps, adding ingredients in at the wrong times, having the wrong ratio of water to ingredients, and not achieving certain temperatures for a specific amount of time. Boil overs can also occur if heat is too high or the product is not stirred correctly causing a huge mess that is difficult to clean. This system will monitor temperature at every step, control the heat for the malting and brewing process and control the cool temperature needed throughout the fermentation process. It will also add ingredients at specific times and automatically transfer the product from stage to stage when complete. The user should only have to bottle or keg the final product and clean the components when complete. Our objective is to build this auto-brewing system (Keur-Keg) to brew a maximum of 5 gallons of product using a standard 120 VAC wall outlet.

The power supply for this design will consist of contactors and relays that control the pumps, motors, heating element, dispensing units, cooling unit, refrigeration system, and supply power to the input or control components. These components consist of temperature sensors, fluid level sensors, and a user input display. The user input will allow different recipe inputs to be achieved and along with the temperature sensors and fluid level sensors will communicate with a microcontroller which will control the pumps, motors, heating elements, cooling unit, refrigeration system, and dispensing units. The microcontroller will consist of the timers so each step can operate with precise timing. This system can also be connected to wi-fi in order to send notification to the user when something is complete, an error occurred, or perform an extra step which was not automated.

1.4. Budget

Table 1: Proposed Budget

Description	Quantity	Price
Heating element	1	100.00
Power supply components	1	100.00
PCB	1	100.00
Motor	1	50.00
Pumps	3	100.00
Stainless steel containers	2	200.00
Hoses and components	1	50.00
Cooling unit	1	50.00
Sanitation materials	1	50.00

Brewing material (Hops, malt)	2	100.00

The parts listed in the description portion are general components that will be needed to complete the project. The PCB and power supply will consist of many individual components and the cost of each item will vary depending on what is needed. The goal for estimated total cost should not exceed 1000 dollars. This project will be funded by the members of this senior design group.

1.5. Automatic Brewing Requirements and Specifications

Table 2: Market Standards and Requirements

Parameter	**Min**	**Typ**	**Max**	**Unit**
Temperature Sensor	-2	±1	+2	°F
Brewing Capacity	4.75	5	5.25	gal
Sanitation Level		C		n/a
Liquid Volume Sensor	4.75	5	5.25	gal
Timer accuracy	-10		+10	secs
Equipment Temperature Endurance	-20	250	+20	°F
Recipes in Memory		10		n/a

Table 2 lists all the standards that the project intends to meet in the implementation process of the “Keur-Keg”. Buy meeting the parameter requirements for temperature sensing, brewing capacity, sanitation level, liquid volume, and timer accuracy, we can ensure repeatability of recipes for every brew. In order for the product to be durable, all the sensors and miscellaneous equipment must be able to withstand the high temperatures for brewing beer. By providing enough memory for at least 10 recipes, this sets a goal for the engineers designing the product, but also makes it marketable for the user interface.

Table 3: Constrains

Parameter	**Min**	**Typ**	**Max**	**Unit**
Containers	1		3	n/a
Power		1800	1920	W
Current Draw			16	A
Project Cost			1000	$
Power Supply Voltage			120	V
Power Supply Frequency		60		Hz
Power Supply Phase		1		n/a
Footprint		5x5		ft2
Height		5		ft
Weight		70		lbs

Battery Backup Time Period	4			weeks
Supported Brewing Process		Malt Extract		n/a

Table 3 lists all the constraints under which the “Keur-Keg” will be designed. These constraints are the guidelines by which our design will be guided by to provide a low cost, durable, portable quality product

Software Specifications

1.5.1. The Brew Kettle

Text

1.5.2. The Mashtun

Text

1.5.3. The Cooling System

Text

1.5.4. The Pump

Text

1.5.5. The Control Interface

text

2. Research Related to the Automatic Brewer

2.1. Existing Similar Projects and Systems

Text

2.2. “The Brew Boss”

Text

2.3. “SYNEK”

Text

2.4. “Pico Brew”

Text

2.5. “Automated Brew Extractor”

Text

2.6. Relevant Technologies

Text

2.7. Components

Text

2.8. Architectures

Text

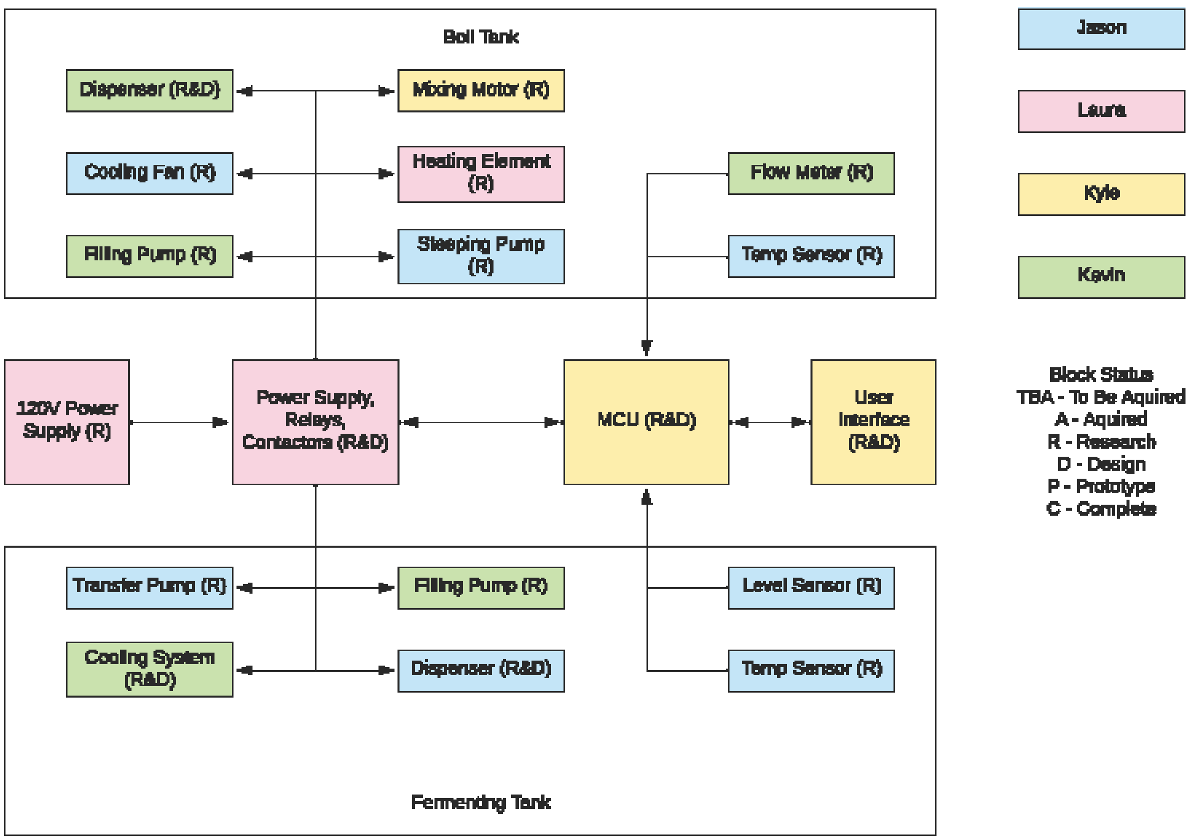
3. Automatic Brewing Hardware and Software

Text

3.1. Architecture

Text

3.2. Block Diagram



3.3. Thermodynamics

Text

3.4. Automation and Controls

3.4.1. Heating

Text

3.4.2. Cooling

Text

3.5. Communications

Text

3.6. Recipes

Text

3.7. Process Control

Text

3.8. Temperature Control

text

3.9. Fluid Level Control

Text

3.10. Flow Control

Text

3.11. Sensor Data

Text

3.12. Sensors

Text

3.12.1. Temperature Sensor

Text

3.12.2. Fluid Levels

Text

3.12.3. Flow Control

Text

3.12.4. Time Control

Text

3.13. Components

Text

3.13.1. Microcontrollers

Text

3.14. Output Circuit Designs

Text

3.15. I/O Pin Layout

Text

3.16. Power Supply

Text

3.17. Data Logging

Text

3.18. User Interface Overview

User Input Interface

- Initial water level
- Initial mash temp/time
- Boil temp/time
- Stages of hops/times 1,2,3,4,5 etc…
- Fermentation temp

Inputs #1 (For mash and boil)

- Initial flow control for water
- Temperature sensor 1
- Timer 1 and 2

Inputs #2 (For fermenting)

- Fluid level sensor
- Temperature sensor
- Timer 3

Outputs #1 (For mash and boil)

- Filler pump
- Mixer motor
- Heating element
- Dispensing unit
- Valve and pump for transfer
- Transfer pump

Outputs #2 (For fermenting)

- Cooling unit
- Same pump for water
- Contactor for temp control

· Dispensing unit 3

4. Design Summary Hardware and Software
Text

5. Prototype Testing
Text

5.1. Hardware Testing
Text

5.2. Software Testing
Text

6. Parts (Bill of Materials)
Text

7. Administrative Content
Text

7.1. Milestone Discussion
Initial project milestone for both semesters

The first two weeks of the summer semester should be picking an idea for the project, learning the process of brewing beer, determining what needs to be automated for our design, doing research on what components are needed, and determining operation and cost. The next two weeks will be going in further detail with the design and parts needed for power, control, and automation. This process will include detailed schematics for the PCB and power supply, generic step-by-step process for the entire project, and final production output of the system up to the bottling or kegging process. The next month will include a more detailed step-by-step process and how each component interacts with the next component as well as what the control unit will read and control such as heating, cooling, motor and pump control, temperature sensors, and any other automation needed. Each step will include what is supposed to happen, specific timing process, and detailed description of parts needed and what each part does. The board layout for the PCB should be completed and the power supply The last month of the semester will include finalizing the design and process, reviewing the research and paper, and making sure nothing else needs to be added or removed from the design. At this point we should be ready to order parts and start building the project.

The next semester will consist of ordering parts, assembling the project, connecting the power supply and PCB, writing all the code needed for automation, testing everything for proper operation, and successfully complete the entire brew process before demonstration. The idea is to have the entire project built, including the power supply, PCB, and all attaching components in the first month. All of the coding should also be complete in this first month. This will allow us to test sooner and fix any issues we may have in the second month and add or remove features to the design if needed. At this point we should have a fully functional and working project. Since the process takes time to complete 1 cycle, we would have to start testing final operation in the third month. This will allow us to be completed and fix any final bugs in the system if any. We would like the project to be completed in the third month. Every two weeks should be a good check point for both semesters as a checkpoint to see where we are at for the project and how much was done and that needs to be done to meet these goals. Any modifications to the process should also be completed and updated every two weeks.

- **5/13/2019** Semester begins. Gather team together and start research on projects.
- **5/27/2019** Project decided on and research on idea and operation completed. Block diagrams, cost, parts needed, and basic drawing completed.
- **6/10/2019** Further details on operation, schematics, and parts needed
- **6/24/2019** Step-by-step design specifications for operation should be completed
- **7/8/2019** Coding, PCB schematic and board layout, and power supply design specifications complete
- **7/22/2019** Final project report should be completed and parts should be ready to order and assembled.
- **8/26/2019** Parts should be ordered and assembly of the project should begin
- **9/9/2019** PCB, power supply, and brew components need to be assembled and completed.
- **9/23/2019** Coding is to be completed and testing of individual component operation
- **10/7/2019** Initial testing and modifications completed if any
- **10/21/2019** Final tweaks to project and all operations to be tested at this time.
- **11/4/2019** Testing and operating
- **11/18/2019** Testing and operating
- **12/2/2019** Final testing and ready to present

7.2. Milestone Issues

Text

8. Executive Summary

9. Text

10. Appendix

10.1. House of Quality

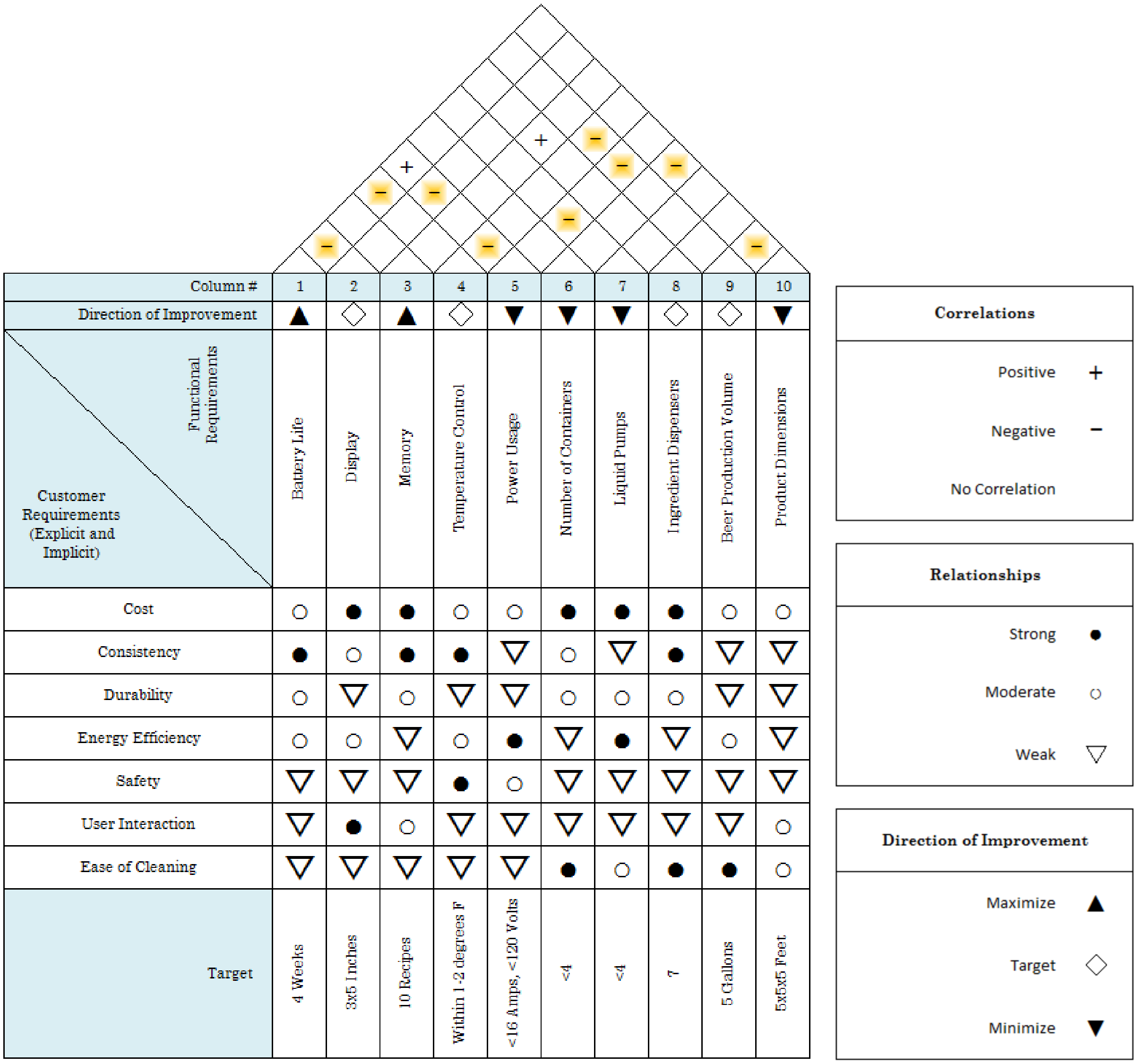


Figure XX-House of Quality for “Keur-Keg”

The House of quality shows the correlation between requirements and expectation that are important to general consumers and the engineering specifications required to meet those expectations. Prior to beginning the design of the “Keur-Keg”, we had to determine what consumers deemed important for product success. We found that cost of product, consistency of brew, durability of product, energy efficiency, safety, user interaction, and ease of cleaning product were some of the most commonly stated topics in reviews. As engineers, we established that with the length of battery life, size of display, size of memory, ability to control temperature, power usage, number of containers required for the brewing process, the number of liquid pumps, the number of ingredient dispensers, the volume of beer productions, and product dimensions we can directly impact how well we meet consumer requirements.

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