Automated Three Vessel Brewing System

Final Report

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Technologies and Components

- Atmel Studio 7
- ATMega1284P Microcontroller
- Solenoid valves simulated with LEDs
- Thermistors simulated with potentiometers
- Float Switches simulated with switches
- Mash Tun stirrer simulated with a Stepper Motor

System Design

The system design is described in much greater detail in separate documentation found at : https://drive.google.com/open?id=0B5n3YhPDtQ2rQk9LWlQ2aVlYZms

Initial Goals

It has been a goal of mine for a while to build myself an all-grain brewing system. In the past I have brewed beer using malt extract, or brew-in-a-bag using a single vessel. All grain brewing allows for a broader range of styles and recipes to be brewed, but is much more involved from the brewer's perspective.

At a family gathering over the summer, I described this as one of the few projects that I want to get time to work on after I finish my Undergraduate studies and my Uncle took an interest in it. He works for some investment group that regularly invests in startup companies and/or products, and he told me that if I could get a system working he could "definitely" find me some funding to take a product to market.

The end goal is more involved than the project we have created here, but this was a good opportunity to begin design work on what will be a part of the final product I am going to be trying to sell in the future.

Alternate Design Choices

Our initial design used liquid flow sensors to keep track of the fluid volume throughout the process. Initially we just set up timers to simulate these as I looked for parts that would be applicable to the final system. It turns out that the vast majority of flow sensors within a reasonable price are made for landscaping or gardening. They don't handle high temperature water, and aren't made from material that is considered to be food safe.

This made us rethink our design, and we decided to use float switches to maintain volume control throughout the system. In most cases, only one switch is necessary to keep track of whether the vessel is full or not. In the case of the Mash Tun, two float switches would be used: one below the false bottom which would track if the vessel was empty or not, and one similar to those in the other vessels to keep track of weather the vessel is full or not. This is

important as the grain should be stirred while pouring to avoid dry clumps and thoroughly soak the grain as intended.

Unforeseen Challenges

Our initial plan to fully automate the system caused some problems when we made the master ping the vessels for information. The design calls for the master to know information about each vessel's state including temperature, fill volume, and time remaining.

The system we created to retrieve this information caused garbage bytes to float through the system as it constantly polled for information. This caused incorrect desired temperatures, as well as run times to be set within the vessels control systems and made the system unworkable.

We demoed in class using a test master program we had created as a part of our initial milestone goals. After the final demo however, we continued to work on the system to create a system that could be used to visually demonstrate what our plan for the system would be.

The end result is the system that can be seen in our YouTube demonstration video. It is not automated entirely. Each vessel is self contained and could be expected to perform its individual workload as expected, but the pump system that is controlled by the master is controlled by user input. The valves open and close according to our transportation system design, but are not triggered automatically by information which the design specified would have come from the vessels themselves.

With the lack of our expected communication, we were unable to create visual output for the user depicting vessel information such as temperature and time remaining for the brew.

Source Files

spi.h

Contains the spi functionality for all slave devices.

https://drive.google.com/open?id=0B5n3YhPDtQ2ramk5UHpYNTQ1OFE

spiMaster.h

Contains the spi functionality for the master device.

https://drive.google.com/open?id=0B5n3YhPDtQ2rZzVtM1dZdV9Rbnc

master.c

Automated pump/valve controls including ability to poll slaves for data.

https://drive.google.com/open?id=0B5n3YhPDtQ2rVlpXT0NrTDdRNFE

testMaster.c

Used to test the functionality of the individual vessel systems and to demo for our milestone goals. Does not contain code for pump/valve system.

https://drive.google.com/open?id=0B5n3YhPDtQ2rU3FuYm12X25NNW8

demoMaster.c

Used for the YouTube demonstration video. Does not contain polling functionality that would be required for full automation of the process. User input is utilized to drive pump/valve transportation processes and trigger proper functionality of each vessel.

https://drive.google.com/open?id=0B5n3YhPDtQ2rVVhuTDZCSmlFd00

hotLiquorTank.c

Automates the process of the Hot Liquor Tank. This mostly pertains to simply heating water to a set temperature.

https://drive.google.com/open?id=0B5n3YhPDtQ2raWszazNOSnMzS00

mashTun.c

Automates the processes of the Mash Tun. This does not include the HERMS functionality to heat the mash, but would trigger the pump/valve controller to start or stop the HERMS as necessary.

https://drive.google.com/open?id=0B5n3YhPDtQ2rVXZueWJPX21Qcmc

boilKettle.c

Automates the processes of the Boil Kettle. This includes direct heating, and triggers the heat exchange cooling process similar to the Mash Tun.

https://drive.google.com/open?id=0B5n3YhPDtQ2rVWducG8wSVhZSjA

Experiences

In the final week of the quarter, before finals, we brewed a beer using a single vessel malt extract process. Because Alvin was unfamiliar with the brewing process when the project began, it seemed necessary for him to get some experience brewing a real beer.

The beer is still fermenting, and will be ready later in the month. Alvin also turns twenty-one later in the month, so he will be able to legally taste the results.

Thoughts on the Brewing Experience

Brewing a beer for the first time gave me more insight into the brewing process. I had difficulty visualizing the different steps while working on the project until this point, since I had virtually no knowledge of brewing beer prior to this. Brewing a beer myself provided a more tangible learning experience, and helped further my understanding of the necessary steps.

Future Work

As indicated earlier in this document, this is not just a semester project. There is a future goal of a marketable product and funding has already been proposed.

The next step is to uncomplicate the system. The course required us to create a much more complex, and ultimately expensive, embedded system than is required. Because the vessels will be in very close proximity to each other, there is no need for separate controllers. Initially the system will be ported to a single Raspberry Pi or Arduino, with which a working prototype will be created to determine realistic requirements.

Links

GitHub Repository

https://github.com/pelhamnicholas/homeBrew

YouTube Video Demonstration

https://www.youtube.com/channel/UCz87YVeGVptdI9lYIjVo7OA