Automated Three Vessel Brewing System

Nicholas Pelham
Alvin Thai

Overview

Most home brewers use a single vessel for a process referred to as extract brewing. Extract brewing can be done in a fairly straightforward manner by purchasing ingredients and extracts in pre-measured packages and adding them to the boil in a manner that is fairly similar to following a simple soup recipe. The variety of beers that can be created through this process is limited by the malt extracts you can find. This project aims to simplify the much more complicate process of all-grain brewing by automating the three vessel system that is required for it.

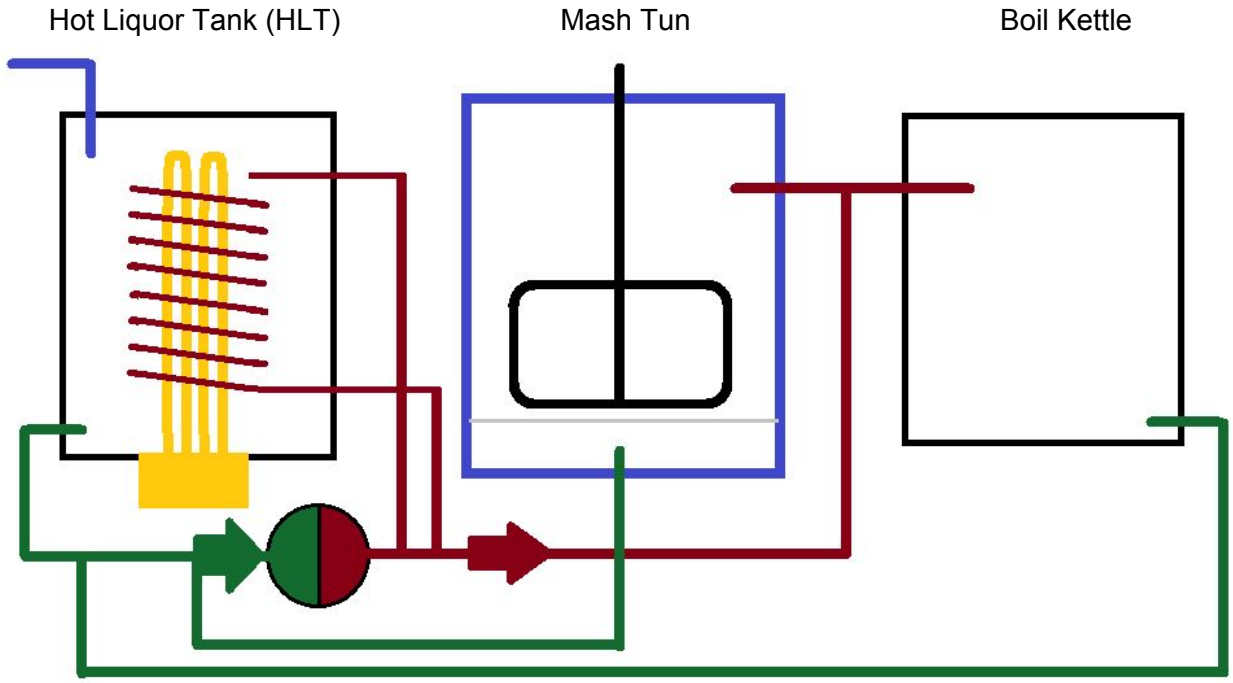
All-grain brewing includes the process of creating malt from dried barley. This allows for more versatile brewing by allowing the home brewer to control the temperature and duration of the mash, as well as making available various sparging methods; of which, we focus primarily on continuous (or fly) sparging.

The three vessel system we choose here is a single pump, single heater design. This design uses a heat exchange recirculating mash system (HERMS) to maintain the temperature of the Mash Tun. This minimizes the possibility of burning the grain which is present in a direct fire system. The heat exchange coil is also used in temperature control for the Boil Kettle, in particular crash cooling the wort before transferring to a fermentation tank where yeast will be added. The fermentation tank is not included in this system as it is a simple storage tank.

Complexities

The complexities involved in this project revolve almost entirely around synchronizing the various elements involved in the system. As such, the only “new” components in the plan are temperature sensors and a TFT Touchscreen LCD. As a result of the high price of the food-safe high temperature components involved in a working system, our prototype is done using LEDs to visually simulate simple on-and-off components like heaters and solenoid valves, and a DC motor for the pump.

Physical System Diagram



Description

1. Fill the Hot Liquor Tank (HLT)
    a. A solenoid valve is used to open and close the water inlet
    b. A liquid flow meter is used to control the amount of water allowed into the system.
2. Heat the water in the HLT to desired temperature
    a. The heater is turned on
    b. The temperature sensor senses when the desired temperature is reached
    c. The heater is turned off
3. Water is transferred between HLT and the Mash Tun (MT)
    a. Two valves are opened
        i. From HLT to Pump
        ii. From Pump to MT
    b. The Pump is turned on
    c. The stirring arm in the MT begins turning
    d. The pump turns off and the valves close when the water is fully transferred
4. Fill the HLT with water
    a. A solenoid valve is used to open and close the water inlet
    b. A liquid flow meter is used to control the amount of water allowed into the system

5. If the temperature in the MT falls below the desired temperature
    a. Heat the water in the HLT to desired temperature (above desired MT temp)
        i. The heater is turned on
        ii. The temperature sensor senses when the desired temperature is reached
        iii. The heater is turned off
    b. Three valves are opened
        i. From MT to Pump
        ii. From Pump to heat exchange coil (Coil)
        iii. From Coil to MT
    c. The Pump is turned on
    d. The Pump is turned off and the valves are closed when MT reaches desired temperature
6. When the mash is reaching the desired mash time
    a. Heat the water in the HLT to desired temperature (above desired MT temp)
        i. The heater is turned on
        ii. The temperature sensor senses when the desired temperature is reached
        iii. The heater is turned off
7. When the mash has reached the desired mash time
    a. Two valves are opened
        i. From MT to Pump
        ii. From Pump to MT
    b. The Pump is turned on
    c. After a short amount of time
        i. The valve from Pump to the Boil Kettle (BK) is opened
        ii. The valve from Pump to MT is closed

    Note: To continuously sparge with one pump, the MT must be refilled from the HLT repeatedly between transferring the malt to the BK
8. Heat the BK to desired temperature (this is not necessarily a boil)
    a. Fill the HLT with water
    b. Turn on the heater until it reaches the desired temperature
    c. Open three valves
        i. From BK to Pump
        ii. From Pump to Coil
        iii. From Coil to BK
    d. Turn on pump until BK has reached the desired temperature
9. After a set amount of time the wort must be crash cooled
    a. Move hot water from HLT to MT
    b. Fill HLT with water
    c. Open three valves
        i. From BK to Pump
        ii. From Pump to Coil
        iii. From Coil to BK
    d. Turn on Pump until BK has reached the desired temperature

Milestones

The milestone goals of this project are for us to have each of the individual vessels working in isolation. This requires us to get the individual components working, as well as a simple SPI communication that allows a master controller to start the stages self contained operation.

- Hot Liquor Tank
    - Heating Element
    - Temperature Sensor
    - Individual Valves
- Mash Tun
    - Stirring Arm
    - Temperature Sensor
    - Individual Valves
- Boil Kettle
    - Temperature Sensor
    - Individual Valves
- Basic SPI communication
    - Not enough for the complex pump/valve system

Timeline

Week 6: Research and Design
- High level design
- Order part

Week 7: Individual components
- Temperature Sensors
- Flow meter
- Pump control

Week 8: Self Contained Vessels
- Hot Liquor Tank
- Mash Tun
- Boil Kettle

Week 9: Coordination
- Master Control
- Vessel to vessel transitions
- Touchscreen Display

Week 10:
- Demo specific display
- Demo

USART/SPI Communication

SPI communication will be used between a Master control and three slave controllers, one for each individual brewing vessel. The Master control will be where all user input and output will be done, and will control the overall flow of operations from beginning to end operation.

High Level Task Diagram