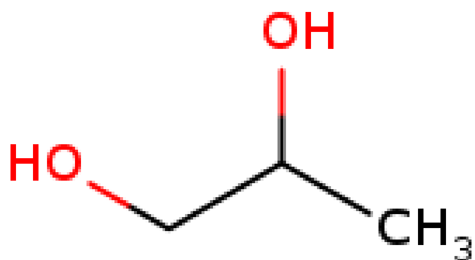
Department of Computer Science & Engineering
The University of Texas at Arlington

Project Charter
CSE 4316: Senior Design I
Fall 2020



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Glycol Chiller Fermentation

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Revision History

Revision	Date	Author(s)	Description
0.1	09.29.2020	JB,AD,CG,ER,JV	document creation
0.2	10.01.2020	JB,AD,CG,ER,JV	document additions
0.3	10.06.2020	JB,AD,CG,ER,JV	document additions

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1 Vision

Consumer grade Glycol-Chilled Fermentation systems are expensive, and prohibitively so to new brewers. Glycol-based cooling isn't explicitly needed for brewing, but having one can increase the quality of a brew. However, because of the prices of these types of systems, its is often reserved for slightly more experienced brewers. Our goal with this project is to provide consumers with a cheaper option, at a similar quality level to those that are currently on the market.

2 Mission

Our mission for this project is to develop a prototype Glycol-Chilled Fermentation system. With the development of this system we hope to be able to put something together that can perform at a similar level to consumer grade chillers, while being much cheaper to produce.

3 Success Criteria

At then end of the 2020 Fall Semester we expect to have the following completed:

- A fully complete and polished project charter
- An itemized list of prototype components
- A budget proposal, complete with anticipated spending, and projected costs
- A software outline, containing the high-level systems involved with our Glycol Chiller software
- A completed schematic of the hardware base for the prototype
- A high-level schematic that contains the main overarching systems important to an operating prototype
- A series of low-level schematics, that contains info on each individual systems hardware

At the end of the 2021 Spring Semester, and subsequent completion of this project we hope to have completed the following:

- A prototype Glycol-Chilled Fermentation System
- The prototype will be able to maintain a temperature within 10% error
- The prototype will be able to be produced at a price that fits within our allotted budget
- The user will be able to interact with the prototype and define a set temperature to maintain

4 Background

Currently, there is an estimated 1.2 million home-brewers in the United States. All of them require a good quality glycol fermentation chiller in order to be able to brew beer. However, there are not very many options available in the market offering them at inexpensive prices.

For example, SSbrewtech, a popular seller, sells glycol chillers ranging in price from $700 to $1000 dollars. Many aspiring home brewers cannot afford this price and are simply forced to pay the costly fees. Additionally, many commercial glycol chillers are not fully automated and require some adjustments at various levels of the chilling process. This leaves many local level home-brewers to be even more limited in their options in selecting a chiller for their brewery.

Taking these issues into consideration, our glycol fermentation chiller would be a fully automated system, affordable to home brewers. In addition, by offering our chiller would be able to create more competition in the market, especially at the local level, potentially reducing prices. As a result, by building our proposed glycol fermentation chiller, we would be able to help local and aspiring home-brewers.

5 Related Work

There is a wide variety of ways to ferment wort. The easiest way is by manually icing the wort. This is extremely affordable option because one only needs some ice and an icebox. However this solution is a very slow nonscalable process that requires much human oversight to do effectively. Very few people use this method since it is made obsolete by the abundance in consistent commercial solutions that are available.

Multiple websites sell a wide variety of electric glycol fermenters that, according to user reviews, seem to operate fairly well. Examples of several top fermenters that seem to be widely used are the Brew-built Icemaster and the Blichman engineering glycol chiller. Both of these top-of-the-line fermenters are far more consistent than manually icing the wort. However, The main problem with these purchasable solutions is that they are prohibitively more expensive to the average brewer with most glycol fermentation systems costing upwards of $900 [ ]. This is an extreme up-charge above the price as opposed to physically making one oneself, with current estimates ranging as low as $200.

The vast majority of the parts needed for a glycol chiller fermenter can be directly transferred from a $100 miniature air conditioner. All that is needed besides the air conditioning unit is tubing for the cooling fluid, the glycol itself, a container for the wort, and a sealed case for the machine itself. The combined total should be estimated at an affordable rate for the average home-brewer. Even if $200 is an inaccurate estimate and the team ended up paying double that amount, we could still severely undercut the online prices of most brewery equipment vendors for an outrageous profit. There is evidence of multiple enthusiast brewers who make their own glycol fermenters which could theoretically compete with us. However, it seems the vast majority of brewers only make them for personal use and have no interest in selling their products commercially and therefore most would not impact our bottom line.

With regards to automation, almost all of the commercial fermenting solutions work in similar ways. Usually you just manually insert the wort, then set a target temperature, and wait a specified amount of time to then move on to the next step which is very bare bones. The only really part the process that is automated is only the temperature controller as it ramps up and down in order to stay at the specified temperature. Perhaps when we make our own fermenter we can setup it's workflow to follow a recipe and automate even more of the tedious tasks such as moving the wort from the brewer into the fermenter and out of it. Although automation is a secondary objective to just making a cheaper version of the fermenter.

6 System Overview

To perform at a comparable level to commercial grade systems and give a higher quality service to home-brewers, our Glycol-Chilled Fermentation system will be designed to be automate the temperature of the brew based on the desired beer recipe. To start with the overall system design, we will utilize a compressor, evaporator, condenser, a mechanism for temperature control, and a cooler.

We are currently analyzing our design options for temperature control. As such, we are considering a design that combines the use of an Air Conditioner (AC) unit and a wireless tilt hydrometer. The AC would cool the liquid as desired, and the hydrometer would consistently measure the temperature of the liquid as well as receive a desired specific gravity for the brew. Through software integration, the user would be able to set up a desired temperature for the brew, and the AC would make temperature adjustments accordingly to the current readings of hydrometer.

Expanding on the temperature control mechanism, it is planned to have pre-recorded temperature settings based on a library of beer recipes that will allow the use to only select the recipe desired and the chiller will adjust the temperature accordingly. The system will also allow input of custom temperature settings that user the may be able to save for later use.

Once we have gathered all of our needed parts, we will begin steps to set up the chiller. This begins with breaking down the AC unit outer shell to locate the evaporator and condenser that we will need for heat transfer. Following the AC unit breakdown, the internal thermostat will be disconnected to ensure that the AC unit will consistently run on its highest cold setting with its fan on high. However, the fan for the evaporator is useless for this so we will be removing it to create space. Next, the internal copper tubings will be bent and organized in such a way that allows the condenser to fit inside the cooler. The result will then be boxed up to house our system. Following housing, glycol hoses will be run through the system for fermentation. At this point, we will be able to load a glycol and water mixture into the system and plug in our system. The result will be our prototype of the overall system design.

7 Roles & Responsibilities

For the Computer System Senior Design project we were provided with a list of potential projects to choose from. They were either sponsored by the Computer Science and Engineering (CSE) Department at the University of Texas at Arlington or by various external sponsors. We decided to work on the Glycol-Chilled Fermentation System. This will be a project funded by a home brew team by the name of "Los Dioses de la Cerveza". Being the sponsor, they are one of the stakeholders of this project. Similarly, since our team is working on the project, we are also the stakeholders of the project. As the instructor of the Computer System Senior Design Project course, Dr. Christopher Conly will work closely with our team. He will also act as the point of contact from the sponsor side for us.

Our team consists of five Computer Science and Computer Engineering Seniors- Janine Batong-malaki, Abhishek Dhital, Connor Glasgow, Elmer Rivera-Molina, and Joshua Venter. Starting from Sprint 1 (09/18/2020), we will be working equally on different aspects of the project until the demonstration of a working prototype. The roles of individuals within the team are not specific at this point, and we will continue to work on several parts of the project as per our strengths and what the project requires. This is supposed to be a two semester long project, and we expect the roles of Product Owner and Scrum Master to change periodically as per requirement. Changes in roles and responsibilities within the team can occur every sprint or every two sprints.

8 Cost Proposal

So the most pricey and important component of the build will be the air conditioner. There are a wide variety of options of which air conditioner to buy and at first it can be overwhelming . However we can narrow our options down by comparing size, quality, and price which are the main deciding factors for which one will fit our needs. Taking into account the overall goal of this project we can safely assume that we would want air conditioning on the cheaper and smaller side which would narrow down our price range but it still would be the the most expensive part of the project. Even so the price would be worth it because it is the most functional component and the difference in quality would definitely be noticeable. The second most expensive part would be the raspberry pi which would be in charge of all the automation of the machinery. This expense is also required since otherwise you would have to manually work the chiller which is not efficient or worth it. The third most expensive parts would be the tubing and insulation foam. These would be critical in cooling the wort properly. Poor tubing might need additional maintenance or even replacement that we would want to minimize if possible. The insulation foam would help cool the pipes so as to not let the coolant heat up while being transported to the actual cooling container which could really help the efficiency of the chiller over all. The main funding from the project will come directly from our budget allotted by the school which should be able to cover all expenses.

8.1 Preliminary Budget

Miniature air conditioning unit $50 - $150
Plywood $20
Cooler $20
Insulation Foam $50
Tubing $20
Raspberry pi 4 Cana kit $70
Additional unseen costs $50
Total (including possible unforeseen costs) $460

8.2 Current & Pending Support

The main funding from the project will come directly from our budget allotted by the school which should be able to cover all expenses.
Funding $800

9 Facilities & Equipment

Our group plans to use the UTA Lab, if available, to build most of if not all of the hardware needed for the glycol chiller. Additionally, we also plan to use the lab for testing the equipment and if the opportunity is available we can also test the chiller with Dr.Conly and go brew with it. Our group will also require components such as a compressor, coil, evaporator, and condenser. Buying an AC unit is the most likely option the team will take to get these parts. Any circuit boards needed will be made using the PCB printer and soldering equipment at UTA. Lastly, we will use any other equipment such as circuit components from the lab and also self-provide any form of micro-controllers, if needed.

10 Assumptions

- We will be able to meet in person safely during the hardware phase of the project
- We will have an area that we can store and keep our prototype secure
- The prototype will be able to be developed within budget constraints, and no unexpected costs will arise
- We will have access to UTA's facilities and the equipment within for use on our project

11 CONSTRAINTS

The following list contains key constraints related to the implementation and testing of the project.

- Final prototype demonstration must be completed by May, 2021.
- The team size must not exceed five members who are assigned at the beginning of the project.
- Total development costs must not exceed the allocated budget of $800
- The final working prototype of the Glycol-Chilled Fermentation System must be able to maintain a specific temperature within a marginal error.
- All social distancing measures and safety protocols must be adopted while working in the lab to limit the risks of COVID-19.

12 RISKS

The following risks outlined below we have calculated to be the most critical risks we may encounter for our project. Each is followed by a brief description of the risk's probability of occurrence, size of loss, and potential risk exposure. The detailed risk descriptions are then followed by a high-level risk census that contains our overview of identified project risks with the highest exposure. Mitigation strategies will be discussed in detail in future planning sessions.

- **COVID-19 exposure due to team meet-ups for physical project building.** The COVID-19 pandemic has limited in-person team meetings to physically build the project. Team meetings may be minimized on an as-needed basis to reduce the probability of team members contracting the virus, but it does not reduce the risk by 100%. We are estimating a low 0.20 chance of contracting the virus due to team due diligence in practicing CDC health safety guidelines and self-care and analysis for symptoms. If a team member has been exposed to the virus and has met up with the team before confirming positively, the team will be required to quarantine for at least 14 days before determining a new meeting date, losing time to physically build the system.
- **Budget Negligence and Loss.** The primary goal for this project to develop an affordable system. With that in mind, the team is taking great care to ensure we do not go over the provided budget. However, there is always room for human error. If we do not take care to do proper research and consultation of needed parts to build the system, there is a 0.40 chance that the team will either overspend on materials, or the materials will prove inadequate for the build, resulting in further purchase of replacement materials. The estimated size of loss here would be 7 days, but may be variable on the type of materials needed.
- **AC Unit Temperature Inaccuracy.** As we will be using an Air Conditioner (AC) unit as our primary cooling source, there may be 0.70 chance for margin of error in achieving accurate temperature control of the fermented liquid. With variable trial and error experimentation to achieve our desired results, we are estimating a possible loss of 10 days on account of temperature research and experimentation.
- **Insulation Issues.** In addition to the prior risk of maintaining temperature accuracy with the AC unit, there is also a 0.35 risk for maintaining temperature due the possibility that the container by which the system will be housed is not well-insulated. This would result in the gain of unnecessary external heat, driving up the inaccuracy of the desired temperature. The size of loss is estimated to be 10 days on account of further research and experimentation.

- **Software is Faulty.** The program isn't going to go without any bugs during its development, especially in the implementation for temperature control. There is much thought and design that will need to be considered for control implementation. There is a 0.75 chance that we will run into software issues and will need to make some adjustments accordingly, and is estimated to result in 14 days of lost time due to software changes and debugging.

Risk description	Probability	Loss (days)	Exposure (days)
COVID-19 exposure due to team meet-ups for physical project building	0.20	14	2.8
Budget Negligence and Loss	0.40	7	2.8
Temperature Inaccuracy	0.70	10	7.0
Insulation Issues	0.35	10	3.5
Software is Faulty	0.75	14	10.5

Table 1: Overview of highest exposure project risks

13 Documentation & Reporting

13.1 Major Documentation Deliverables

13.1.1 Project Charter

This document will be maintained in a shared overleaf document, which allows for editing of the LaTex code and can show live updates. Updates will be made regularly, as needed and as new information is made available. The initial version will be delivered on October 9th, 2020. The final version will be delivered at the end of the Spring 2021 semester.

13.1.2 System Requirements Specification

Similarly to the Project Charter, this document will be maintained in a shared overleaf document, which allows for editing of the LaTex code and can show live updates. Updates will be made regularly, as needed and as new information is made available. The initial version delivery date is pending. The final version will be delivered at the end of the Spring 2021 semester.

13.1.3 Architectural Design Specification

13.1.4 Detailed Design Specification

13.2 Recurring Sprint Items

The recurring sprint items currently are the project charter and the SRS.

13.2.1 Product Backlog

13.2.2 Sprint Planning

On the first meeting of every sprint, we will take time to discuss how we will move forward planning the subsequent sprint.

13.2.3 Sprint Goal

The Scrum master will have final say, but we as a team will come up with Sprint goal.

13.2.4 Sprint Backlog

Scrum master will decide, the backlog will be maintained with the Atlassian suite of software.

13.2.5 Task Breakdown

Each member will volunteer for a task using the Atlassian suite of software for task handling.

13.2.6 Sprint Burn Down Charts

Burn down charts will be handled by the Atlassian suite of software, as it generates them automatically at the end of sprints.

13.2.7 Sprint Retrospective

The last meeting of each sprint we will take time to have a discussion on the previous sprint.

13.2.8 Individual Status Reports

Individual status reports will be submitted through canvas weekly. Report contents will be outlined in the status report document found in canvas.

13.2.9 Engineering Notebooks

Each team will update their own notebook at the last meeting of every sprint. Minimum of 1 page. Witnesses will be each other.

13.3 Closeout Materials

13.3.1 System Prototype

Included will be the final working prototype glycol-chilled fermentation system. Demonstration date is TBA.

13.3.2 Web Page

Links to readme.

13.3.3 Demo Video

A full demonstration of the glycol chiller will be shown in the demo video. The temperature function will be demonstrated as well as the ac components being powered. Additionally, an explanation of the way the system is constructed will be included in the video.

13.3.4 Source Code

We will use git with bitbucket. Source code will be provided to the customer. Not open source.

13.3.5 Source Code Documentation

Overleaf and google docs will be used to create the documentation. We will output them to PDFs.

13.3.6 Hardware Schematics

No plans to make custom PCBs but if we do make one we will add the schematics later.

13.3.7 CAD FILES

No plans to make CAD files but if we do make one we will add the schematics later.

13.3.8 INSTALLATION SCRIPTS

By copy pasting the binaries.

13.3.9 USER MANUAL

We will add a readme file to the installation.