Chemical Manufacture Process Automation

Group 22

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Potential Sponsor: Helicon Chemical Company

Project Narrative

Making new materials at the basic chemical level is a lot like cooking. To get a recipe right, you need to be very precise in the quantity of ingredients, the order in which you add them, and the methods used to add energy to the mixture. If you need to bake two cakes, you can do it manually, one at a time, and still follow the recipe to perfection. If you need to bake 50 cakes, the task becomes much more difficult. Our sponsor, Helicon Chemical Company, has designed a manual system to increase their chemical production from the 'several cakes' level to the 'dozens of cakes' level. Our project aims to automate this system.

The problem with Helicon's system, as it's currently designed, is that its production is limited by the presence and, more importantly, the full attention of one or more technicians. If we can work with Helicon's design team to automate parts of their process, we could free up time and energy from the technicians to work on other things.

Automating Helicon's entire chemical process is outside the scope of Senior Design, and would result in their proprietary recipe being shared with the world forever. For these reasons, we find it necessary to narrow our focus to a small section, one that is generic to most chemical processes. A diagram outlining this section is shown later in this document (fig. 1). This section calls for mixing two reagents with pumps, and purging with inert gas after. We will need to control the pumps and valves, as well as add sensors for feedback. Our design must include an intuitive user interface, and the control sequence must be customizable in case the process is changed. Most importantly, our hardware and software must be extremely robust, with redundancies wherever possible. Failure at any point of our design could cause Helicon's recipe to fail, with serious consequences. So why do this to ourselves?

What motivates us to take on this project will vary among the group members, but what we all share is the desire to become better engineers. For this reason, we are choosing a project similar to what real engineers in the industry face every day. These real-world projects carry more nuanced challenges then what would normally be faced in senior design. Not only do we face the technical and interpersonal challenges of this project, if we don't communicate effectively with Helicon's design team, we will be unable to integrate our system with theirs. If we cannot address the concerns of Helicon's leadership, our system will not be adopted. If our system is adopted, and fails, it will cause significant economic loss to the company. The challenges are daunting, but they are the reality of being an Engineer, and that is what motivates us.

Requirements and Specifications –

Listed below are the current project constraints and related standards that need to be met for this specific project:

- ITAR regulations:
  - These regulations are regarding International Traffic in Arms Regulations which restrict and control defense-related articles, services, and technologies. This affects us as the company that we are potentially being sponsored by has to meet these regulations in their products, which includes this project that is being made specifically for them.
- Proprietary information regarding Helicon:
  - Due to the nature of this project, automating existing chemical processes, we must be knowledgeable and understand the basics of the existing chemical processes that exist. This must be done while avoiding any proprietary information from helicon being revealed. As helicon is also striving to complete this project, we will be working alongside a supervisor from helicon who will avoid this restriction being a problem/hindrance.
- liquid/gas compatibility:
  - Seeing as this automated chemical flow process will be in contact with hazardous and strong chemicals, we need to make sure that the materials we use that come into contact with these chemicals are compatible. We will have our supervisor from helicon advise us on the best material to use, but upon research of industry standard materials it seems that a durable and temperature resistant plastic like PTFE and PFA are our best course of action.
- Safety measures:
  - Again, due to the nature of the chemicals, we need to ensure that the product is safe to use. In order to avoid any issues that occur in an emergency situation, we must include an emergency shutoff system with sensors in appropriate areas of potential faults. This emergency shutoff system will be written directly to the main code of our system.
- Memory Log:
  - In case any emergency situation were to occur we need to have a log of all the data that lead up to said situation, before the emergency shutoff, so that we can troubleshoot them in the future to avoid further problems.
- Cable management:
  - Minor constraint. Due to the automation process we need to properly manage all the cables for the electronics that are being used for safety reasons.
- Company standards:
  - Seeing as this project is specific to the Helicon, we need to make everything according to the standards of the systems that they already have in place. This includes meeting their power, size, cost, and even appearance standards.

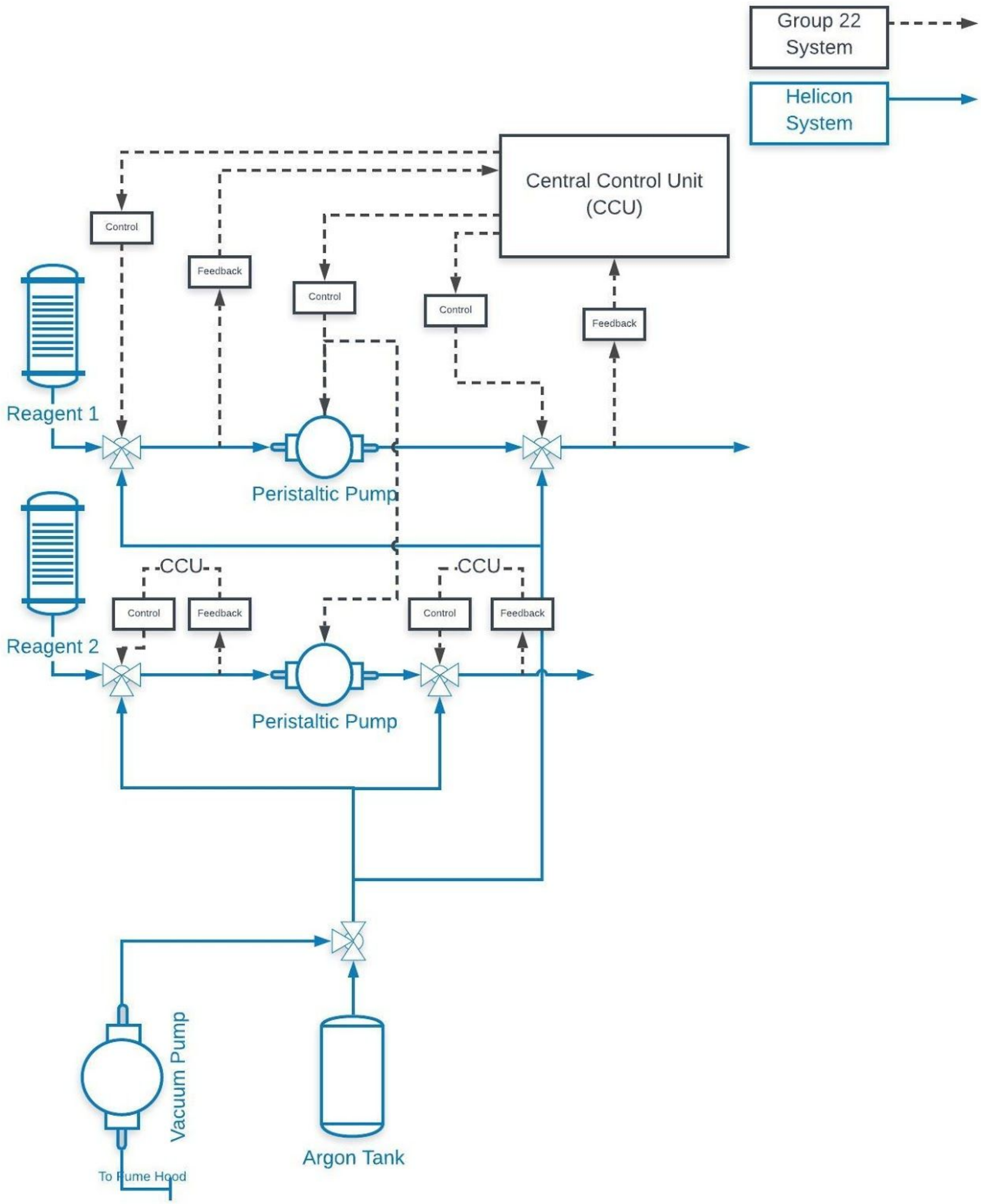

Fig. 1 - Interface of Systems

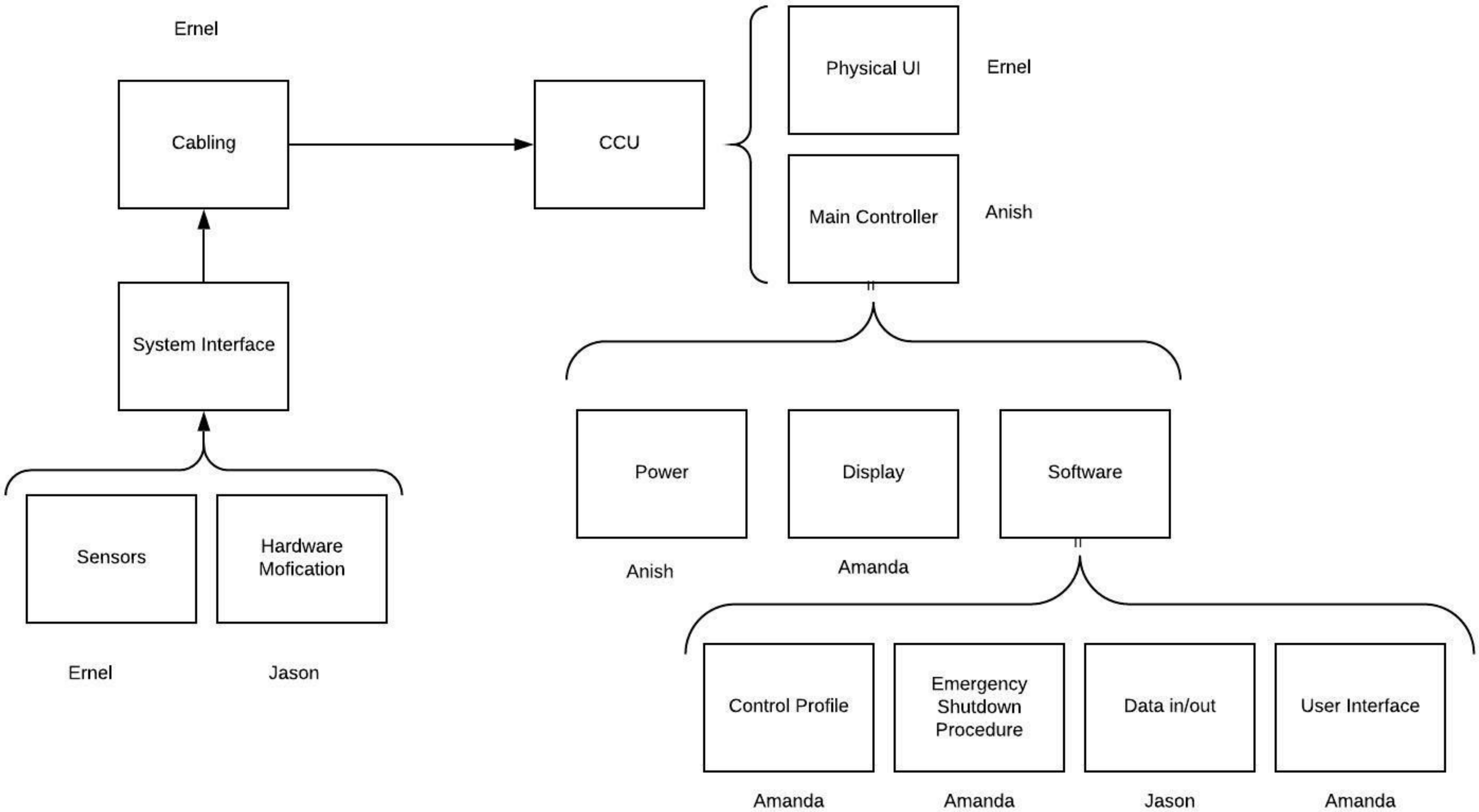

Fig. 2 - Group 22 System Block Diagram

Project Budget and Financing –

- Soft commit from Helicon to fund our design
  - CCU- Arduino Board $10-$50 plus PCB. Due to our team's familiarity with C programming and experience with Arduino boards from classes taken this could be a good choice for CCU.
  - CCU-PLC $150-$350. Significantly more expensive than the Arduino but it is more common for industry use due to its robustness and ease of programming for redundancy.
  - Feedback- Since we are unlikely to connect to Helicon system directly, flow and pressure sensors that rely on the liquids flowing through them to measure aren't good ideas. Instead, since we just need to know whether or not the reagents are flowing, a cheap ultrasonic sensor $10-$20 or similar devices should work fine.

- Control- Solenoid valves will be necessary to control the Helicon system these can range from $40-$100 depending on the specifications necessary.
- Control- Relays might be necessary in order to help control the system where the CCU cannot handle the load. $5-$10 per relay.
- Control- Emergency Stop/other push buttons, very cheap and might be useful for redundancy in case the CCU is malfunctioning or adjustments need to be made to the system without needing to go into the code.
- Power Supply- $20-$50 for 120W 24VDC 5A power supply should be enough to power our CCU and has some power left over.
- Breaker- ~$30 for a decent breaker to protect our CCU and other devices in our box
- Other- Contact blocks ~$5 for neat connections in our box.
- Other- Cables 18 gauge, ~$10 for at least 2 colors.
- Other- Box and din rails ~$40 could be more expensive depending on the rating required by the design.
- Optional- Keypad display to serve as an HMI ~$200. Keypad display preferred over touchscreen since the employees will usually be wearing gloves when working.
- Total is about $400-$1200 with a 20% overhead in case of mistakes or unknown necessities.

Item	**Estimated Cost**
CCU	$10-$350
Sensors	$50-$150
Valves	$40-$100
Misc. Circuitry Material (wires, transistors, contact blocks, etc)	$40-$60
Pump	Provided by sponsor
Push Buttons	$10-$30
Power Supply	$20-$50
Breaker	$30-$40
Box and Din Rails	$40-$50
Display with Keypad	$100-$200
Total:	$400-$1,200

Project Milestones –

- Phase 1: Design
  - D&C - Sept 20
  - Break down software plan- Begin September 30th
    - Order Development Board
  - Research additional system add-ons-
  - PCB design
  - Pick Parts
  - 60 Page draft - Oct 21
  - Testing Parts
  - 100 page submission - Nov 1
  - Financial Analysis
    - Parts list
- Pitch completed design to Company CEO
- Phase 2: Implementation
  - Order Parts
  - Assemble prototype
    - Transportation Logistics