Microgravity Press Washing Machine Development Log

05/08/23

Today I would call my official start-up of the project again. I’ve had to shelve this project due to schoolwork and my activity in the various clubs I am in at school, but now with the semester over and me having moved up to my job for the Summer, it seems like a good time to start up again. I would like to work on this at least daily, getting something opened for the design.

05/09/23

Today I am recording an update to the design. I found that I could save on vertical space to maximize piston travel by moving the load cell assembly, so it is no longer directly in line with the piston head. The lead screws driving the piston extend to the lower assembly, and are not in line with the piston, so by putting the load cells at the thrust bearings, the same load can be measured. Additionally, the load cells can be used to measure the force application of each lead screw, helping for troubleshooting, diagnostics, and alignment on assembly. Smaller load cells can be used since multiple would be taking the brunt of the load as opposed to one. This does leave a potential disadvantage of only being able to sense load in the thrust direction since the current design is to use two thrust bearings at opposite ends of the screw such that the lead screw is only ever in tension. Without adding additional load cells, knowing the force application cannot be accomplished with the current bearing set up. Since the brunt of the force is only experienced while the piston is compressing the clothing, the possibility of the lead screw only being supported by thrust bearings at one end of the assembly could be explored, allowing for force application to be read with one load cell.

05/11/23

Today I reached out to Dr. Gold and Glenn Johnson via email to kickstart the project again.

05/12/23

Today I made a free body diagram for the drive train system to define force application and required lead screw sizes. From here I plan to spec out load cell sizes to attach to the lead screws. From here I plan to get a torque rating to inform the design for the frame and pick out a gearing box and other components for the drive train.

05/13/23

Today I started work inputting some of the work I’ve done to the documents which are being displayed on GitHub. I plan to streamline this system so I work directly from these documents, so I also did work to make them readable as documentation and organized, which will help tremendously in the design process. I also wrote a design process strategy which will be used to map out how known values are used to derive design aspects of various components and subassemblies. I also found some documentation for the basic problem and design overview that I wrote during the Fall 2022-2023 semester, so I added it to the repository. Other previous work being reimplemented is the PowerPoint document being used to detail the wash process.

05/18/23

Today I worked on a slideshow presentation and continued work on an updated P&ID (piping and instrumentation diagram) to present to my initial NASA HUNCH supervisors. I am hoping to get some contacts who would be willing to discuss this idea with me and help to further the design.

05/19/23

Today I had my meeting with Dr. Gold over Microsoft teams. Glenn was unable to attend the meeting, so we will be having a meeting later the following week.

05/20/23

Today I started setting up the raspberry pi to begin working on and learning the programming portion of the project. I plan to set up the GitHub repository so that it can be accessed by the Raspberry Pi, allowing the code created on it to be saved to the repository as well. I also moved the old files from the washing machine into a new repository, making it so that it is less resource intensive for those viewing to download the repository, and also to make using the repository more usable with the raspberry pi. I also sent an email to Glenn Johnson with some of the contents of the repository attached so we could try an organize another meeting before I have to leave for school.

06/13/23

First return to work since the start of Summer Sea Term. Likely few updates will be made before the end of sea term due to the workload associated with the semester. Today I outlined potential pseudocode which would utilize lists in a for loop to define state conditions such as sensing criteria to move to the next wash state, actuator and valve conditions, and sensing conditions which would prompt a halt in operation for a given part of the wash cycle. Through this method, wash processes can be made from data structures with varying length and tailored to various clothing types and extent of cleaning required. Additionally, changing and saving a wash cycle for later use is made relatively easy by this process.

08/21/23

Save from initial entry lost, so retyped on 08/22/23

Today I began work on the washing machine project again after returning from my final Summer Sea Term aboard the T.S. Kennedy with Texas A&M Galveston as part of the USCG Unlimited Engine License requirements. While underway, the school’s Chief Operations Officer, TAMUG and Vice President, TAMU, Vice Pres & Chief Operations Officer, Michael Fossum. Admiral Fossum is actually an astronaut and has had numerous space flights on both the space shuttle and aboard the ISS. In my time aboard the training ship, I had the pleasure of talking with him on several occasions, and shared my work on this design problem. When I told Admiral Fossum about my work on the washing machine project, I was delighted to hear that he thought the idea had merit, specifically the simplicity of the concept. He shared how aboard the space station, he actually fashioned a process to wash his running clothes with a plastic bag, soap and water since they got too dirty for him to comfortably wear.

While underway, I had several ideas to iterate on the current design of the washing machine:

I decided that it would be best to remove the load cell placed in line with the shaft for the compression piston as it would free up space allowing for greater piston travel. Additionally, the complexity of the design is reduced by removing electronic components that would be on a moving assembly. This still leaves a need to read how much load is being applied to the clothing item. To replace the load cell, one load cell will be placed on both ACME Screws for force application with the thrust bearings putting load on the load cell. The sum of the load cell readings would equate to the force experienced by the piston. This maintains the advantages of removing the load cell in line with the compression piston shaft, however the reliability of the washing machine gets worse as there is another failure point in the system. There is the possibility of the system actually being able to operate with only one load cell in this configuration due to how moments are understood, in which case having two load cells in this configuration could be a point of redundancy with software changes allowing the system to be configured to use either one or the other load cell readings.

I purchased a touch screen for the raspberry pi that utilizes a ribbon connection for power various signals to and from the pi for display. This will allow control over the system through a touchscreen and a user interface while using the raspberry pi to control the machine.

For ease of design and to make quick layout designs of the various components of the frame, I created a drawing in AutoCAD to lay out the frame assembly. Inventor modelling will still be used, but for the design to create models for FEA, but for the purpose of laying out the assembly with bought parts and ensuring proper fit of off the shelf parts during design AutoCAD.

For a while I have had trouble coming up with a design for the access hatch assembly. I haven’t been able to find anything I could purchase to serve this purpose, for this, I was exploring the options of casting components for this given my budget and manufacturing capabilities. I do not believe I mentioned this in my previous entries to this log, especially since towards the end of my time interning at Iron Heart Welding, but I was able to acquire stock which I could use to turn down components for the pistons and access hatch assemblies. Specifically for the hatch, ideally, opening and closing would be relatively easy, but shifts in load causing deflection makes using gaskets an option I would like to avoid. As a result, I am looking into using O-rings or a similar sealing method to seal similarly to how it is done with the pistons, only with a slight draft on the hatch to allow for easy closing and removal.

Another Idea being explored is creating another “soft” base around the screen and other parts of the user interface which allow space to put the screen without having to compromise the structure of the base of the washing machine, since a 4” by 3” hole in the frame for a screen would be a lot less forgiving to the structure than to have a component outside the structural frame housing the frame and a small hole for a ribbon cable to a raspberry pi.

Given these design considerations, below is a drawing of what this design might look like. The actual method for clamping the hatch shut.

08/22/23

Today I began work trying to migrate the servo assembly from being controlled by Arduino to Raspberry Pi. Today I mostly refreshed my knowledge on python and learned how the raspberry pi interfaces with hardware, but I hope that tomorrow I will get the valve actuators working. In beginning work on the Raspberry Pi after a long hiatus, had to make sure I had GitHub access on the Raspberry Pi and that I remembered how to push and pull files from the command line.

I also did research on sealing components and found that a better sealing method for the dynamic seals of the piston rod should be X-rings, which have less contact area and therefore generate less friction, leading to reduced wear. Furthermore, X-rings have a higher tolerance for sizing, easing machining requirements. I plan to use these for all dynamic seals including the chamber top,

Finally, I came to a frame bottom interface design for the wash chamber which reduces the number of static seals required for the assembly, and reduces the piping required going into the chamber. This change also means that no machining is required for the pipe used to make the chamber, again simplifying the build process for this design. Depicted below is what the assembly would look like.

08/28/23

Today is mostly finishing work that I set out to do earlier this summer. I have had difficulty with mostly everything so far, but today I actually finished a lot. Here is a list of portions of the project now completed:

* Set up Raspberry Pi with touchscreen, and find hardware to make working from and moving the electronics assembly easy
* Install GitHub on the Raspberry Pi and pull the microgravity washing machine repository to the systems files
* Install Arduino IDE and run a hello world program uploading code from the raspberry pi
* Set up program to control previously made valve actuators, and detect when they have reached their set point using an ammeter in series with the servo motors (In parallel)

A lot of the trouble I had was due to my lack of familiarity with the command prompt and linux in general. I have had tried and failed to do this in the past, but this time I have had uninterrupted time to figure this out, and I have taken care to record how I found the correct commands and procedures, and plan to write an itemized list in the near future to reference.

Next I plan to set up serial communication between the Arduino and raspberry pi so that I can establish control over the Arduino from the raspberry pi using a user interface like an astronaut would use aboard the space station. This would also be used to record real time data and save for diagnostics/testing once the prototype is completed.

I also made a rough outline for the hatch and chamber bottom assembly, which I am getting dimensions for so I can cast a rough piece of stock for out of aluminum. I plan to machine this to proper specifications once I get back to school at SUNY Maritime to turn it down with a lathe.

03/06/2024

Since my last update I improved my manufacturing capabilities through lobbying and work at school. We now have an operational lab furnace which can reach temperatures of 1850 degrees F. This opens the possibility of casting components of the frame in the machine shop. This combined with improved access makes making various components much more feasible. With this, I plan to rough cast aluminum parts for the pistons, frame base assemblies, and some components of the drive train and then machine them to proper dimensions using the schools CNC router/lathe as needed. To connect the bases I plan to cut the stainless steel I acquired while working at Ironheart welding using a plasma cutter (also at ironheart welding). Other components will be 3D printed such as valve actuators, UI and electronics mounts, pipe supports, and other non-load-bearing components of the design.

As mentioned above I now have better access to the school machine shop, meaning I can now reasonably get access for an entire day and on weekends when I do not have obligations such as class. This gives me room to make a clear and actionable plan for building the washing machine. Starting this weekend, I will be making molds for the rough casts made for the bases, which will just be an open, rectangular mold welded from scrap steel in the machine shop.

With this, I have also began working with one of my former professors to start taking actionable steps towards the electronics and other similar portions of the project.

For the electronics, I still need to approximate the load for a required motor size, but once this has been done, all the needed electronic components for the project will be ready for building.

03/29/2024

After a bit of deliberation, I came to the conclusion that casting each of the frame bases was likely something that wouldn’t be feasible given the time frame, and how much work and material that would be needed to make various components of the frame from castings. Instead the entire frame will be made from the plate metal I received.

I have also found the required

03/23/2025

A lot has changed since I last made an entry in the log for this project, but I have not abandoned it. I have been working on it rather consistently, but have been running into trouble along the way in various forms. This has halted my progress on the project rather significantly. I would mostly sum up the difficulties in the project as the following- latency, poor Information and file management, and redesigns prompted by changes in my personal life.

Lacking tools: In the past I have been trying to build the machine based on the tools I had available to me and the skills I had. This strategy was not great as I went from graduating college where I had limited access to some of the tools I needed for a particular design path, moving back home and needing to source new tools. Now, I have been able to locate places with the tools I think I would need to complete this project, and don’t foresee needing to face this issue again for the duration of the project. For the bulk of the project I will be going to Baltimore Hackerspace. They have a great community and a lot of expertise, but more importantly for the project, they have a wide variety of tools including lathes, drill presses, and milling machines. They also have storage which is extremely helpful as it allows me to spend less time dealing with the limited space available to me at home.

Component sourcing and availability: This project would not be possible if not for the websites Amazon and McMaster Carr. I have a lot of difficulty finding places I can source components, and without a baseline of fasteners, stock material, and other components, I have to buy parts. Amazon is the most likely place I can source components for cheap, and sourcing most my materials from Amazon makes managing my parts list relatively easy, and I can safely assume components purchased will not disappear from the internet as listings might be taken down over time. That said, documentation is not great on Amazon, and often times I need to order parts, wait for them to arrive before measuring them and validating their utility compared to the listing. From there I would update the design. Sometimes these descriptions do not match, and I need to adjust my design accordingly. This may sometimes require significant redesigns. I am also limited by part selection on Amazon and McMaster Carr. One particular instance is trying to find ANSI #25 sprockets for the drive system. For the design path I chose to take for this particular iteration, I could find .5” sprockets needed but frustratingly, could only find the required idler sprockets with a similar sized bore in metric. To try and accommodate this would require a significant redesign. At times when I cannot find parts on Amazon, I am able to find components on McMaster Carr that are not too expensive, though it can be seen that exceedingly few components on the parts list are present purchased from McMaster. Regardless, this feedback loop of juggling availability, having to purchase parts before verifying their utility for the project, and dealing with lackluster documentation, and tracking required parts on my bill of materials has made the design process long and arduous, but I think I am coming close to finishing this part of the project.

CAD trouble and version control: A big part of continuing work on this design is learning modern design techniques. One aspect of this is parameterized design using CAD- defining geometry based on relationships and constraints with patterns. For a complex assembly such as this one, I have been using Autodesk Inventor on my student license from when I attended college. I found doing this to be extremely difficult in practice. I was not taught inventor or parameterized design and have been unable to find the correct way to do this with the program. Often times, I would take a given approach to modelling in inventor, only to find that there would be issues with creating global parameters, or sharing measurements between part files, or differentiating parts from a layout sketch used to outline the relationships between multiple parts. I honestly do not understand how this type of design is accomplished using Inventor. I tried numerous approaches to creating assemblies with a middle-out design approach, with very limited success. Even then, the workflow is not great, and parts I make that work and have working relationships with other parts seem to break after I would leave the project and come back to it later. I was hoping to finish this project with Inventor and move on to learning other programs, but my student license ran out, leading me to look for other alternatives. This leads me to FreeCAD. I decided to continue work on the project using FreeCAD for a variety of reasons- the program is free, I found very useful and up to date documentation and tutorials, and the program appears to be capable. I need to learn a new CAD program, which will certainly slow down the project again, but overall moving to FreeCAD might turn out to be a net benefit for the project.

Design changes since my last entry:

I will be making adjustments to the lid assembly again hopefully for the last time. I am reducing the number of O-rings being utilized in the lid to one O-Ring to save space and increase the allowable piston travel. To still allow for redundancy in sealing I am including a gasket material to seal on the lip of the conduit as I did in my last prototype.

I also shrank the footprint of the machine occupying the space for the chain drive and piping systems. This was done when I found I just had enough room for the load cells when moving the frame design to being made from steel plate. This allows for a dedicated space for the electronics, allowing for ease of design, assembly, and troubleshooting. This change should also

This happened a while ago, but I found the torque required for producing the force desired for this prototype. I ended up lowing the force output of the machine as I was unable to find motors powerful enough for this design. This was interesting considering the force I was able to produce with the previous prototype with the motor I found, but I digress. I also raised the voltage of the motor to 24 volts, again for torque and power requirements. Initially I have been controlling the motor with relays, but I will be moving to using a motor controller for primary control in conjunction with relays for safety stops.

Figuring it would be an easy addition to the design, I bought a peristaltic pump to include in the design for dosing detergent as part of the wash process. This was added in light of NASA partnering with Tide to make a detergent compatible with the water reclamation system found on the ISS. This highlights a key advantage with this design, functionality can easily be appended to the design.

In summation of my work on the project thus far, this project is taking so much longer than anticipated, and I feel that someone with more knowledge and experience could easily design and make this prototype in much less time. Things are getting to a point where I feel like continuing work on the project would be a farse. That said, I am close to finishing it, and I cannot give up. I am really excited to see it finally come together and work. This project has served as a decent vehicle for me to learn new things, and hopefully my work on this project can inform my design philosophy and learning when I finish this and move on to other projects.