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.