HPV Propulsion System

Team Post Mortem Analysis of ME 476C

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22 August 2021

ME 486C - Section 1

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Introduction

The HPVCP project was assigned to our team in capstone one, and is a design project which specifically requests an improved version of human powered vehicle propulsion system. The goal of this is to adequately use the power provided by a human operator and generate maximum power of muscles. The objective, developed later on, for this project is to design a vehicle capable of storing extra energy that can be utilized whenever extra power is required. This project has started in capstone one and the team has started the work together over this project where they have worked together to form the team charter. The team charter is really important because it contains all the necessary information about our project and the roles and responsibilities of each team member. Also set forth in the document are ground rules for working on the project, time management, coping strategies and communication to overcome the potential barriers. The team charter played an important role during summer semester working as each team member was required to follow the rules that were initially agreed upon. Each one of us has known his or her role, and each member has contributed to the final deliverables for the project.

Questions

The previous semester consisted of the Human Powered Vehicle Competition Propulsion (HPVCP) team designing a propulsion system that differed from the typical bicycle drive. The ultimate goal was to involve more muscle groups than just the legs, and to provide a system that ultimately had a more efficient output as well. The team did match these expectations, set forth in the team charter, and even exceeded them. Not only does the final design have two methods of power input for the propulsion system, but the team has included a method of storing energy as well. With the energy storage system, it is now possible to reclaim expended energy through regenerative braking. Aside from reclaimed energy, the storage system can also be directly loaded, for later use. Through these improvements, the team was able to accomplish the goal of boosting efficiency, as compared to a stand alone bicycle drive. The energy storage system is a flywheel driven by a hand-crank, which can be permanently engaged as well, in order to power the drive axle directly, which meets the requirement for using more than one muscle group. As a team, the members all agreed to move towards the goal of completing the described mechanism, but to do so as a group that put in an equal amount of effort from each person, as described in the team team charter. It was also agreed upon that all members would try to aim for a grade of an A, assuring that not only is everyone doing the work, but that each member is doing the best work possible.

The ground rules set in the charter were followed for the most part, with the majority of the team members doing their best at any given time to put forth the best effort that they could to aid in the success of the project. I believe the main struggle was the lack of direction from the client, as well as the physical separation of the team. Not much could be done about unclear directions from the client, so the team did their best to meet the client's requests and requirements/. To deal with the physical separation, the team leader contacted individuals that were falling short of their duties, however due to the physical separation, communication was often difficult between certain members. Going forward, the team is optimistic that communication between all members will improve, as four of the five students are all back in person now.

Past the communication, the most apparent difficulty for the team was time management. Often it was seen that some members would start earlier on collaborative assignments, while others waited until the last minute. This practice seemed to be the most detrimental to quality of work, as having everyone on a similar schedule would allow for a more evenly distributed workload, as well as more time for final editing, prior to submission of any assignment. Ultimately this caused a less refined final output, as well as undue stress on some of the team members that were forced to compensate.

The design process is where the team had good collaboration, and developed a great final design. Between some of the mechanical engineering majors, it was possible to get a great baseline idea for a system, as well as some input from the computer science major on possibilities for sensors and LED displays. Once that was accomplished the team was able to start tweaking the design ideas to refine and iterate as needed. Having a pair of outside eyes (not a mechanical engineer) was crucial to solving the issue of the team's pedal drive system. While designing this portion, it would not be possible to use cranks on a straight axle, as the operator's legs would run into the axle, rendering the system inoperable. To negate this issue, one member proposed a standoff from the frame that would house the bottom bracket portion of the cranks. Going with this method would mean that a custom frame would need to be constructed to display this, rather than a simple rail chassis layout that would easily display the functionality of the drive. The solution came when the team's web designer and resident computer science major pitched the idea of a pedal boat style pedal system. Doing this allowed the team to work within the original "chassis" layout, as well as be able to place the sprocket in multiple locations, and not have to try and incorporate a standard crank system. Collaboration between differently thinking individuals is what made the final design more elegant, and practical.

The most effective tools for team productivity and collaboration were Discord, SOLIDWORKS, and AutoCAD. Discord allowed our team to communicate effectively especially for team members who were not located in the US and were not inhibited by any technical errors on behalf of the platform. Pooling our resources, notes, and thoughts into Discord allowed for all team members to understand the flow of knowledge and work. AutoCAD and SOLIDWORKS were useful tools for the development of the Human Powered Vehicle Propulsion System prototype and proof of concept in a meaningful and clear way.

The team primarily used the Waterfall Model of research, design, and development which allowed the team to move steadily and sequentially forward with the Human Powered Vehicle project however, the team might decide to move forward with an Agile approach to ensure that our process is more iterative and flexible as the team moves on to the build and test phase of the HPVCP capstone project.

The most inhibitory methodologies that were used was the assignment of parts in developing our reports and irregular scheduling of team meetings. The approach of assigning individual parts on the reports didn't allow for cohesive writing or collaborative responses. Perhaps the team will abandon this practice for future reports and meet before the team writes the reports, or collaborate in person on the reports.

Over the course of the semester the team ran into a few technical and team related problems. As stated before, the team had difficulties with communication and time management. This will be remedied with better time management skills, and more consistent in-person meetings. We plan to meet during our scheduled class time off days (Wednesday) to make sure we have consistent in-person team meetings. These will also improve since four of the five team members are now in person at NAU.

One of the main technical difficulties was in designing a working energy storage system, which was one of the customer requirements. This was difficult, as it had never been done before, and nobody on the team had previously studied flywheels, clutches, or anything of the sort. After a great deal of background research, the team was able to come up with a flywheel and clutch system, connected to a row mechanism.

The next problem was that the flywheel spun in the opposite direction as the wheels. In order for the energy to be transferred from the flywheel to the vehicle, the team decided to change the direction of rotation with a simple 1:1 gear ratio. While prototyping, the team also ran into a major problem that had been overlooked previously. The original plan was to have the main source of power to be a pedal system similar to a bicycle. While prototyping, the team realized that it would be nearly impossible to mount such a system in the middle of a four-wheeled vehicle while allowing it to still be functional. A redesign was required for the pedal system. Ultimately the team decided to use a different type of pedal, similar to what is found in paddle boats. It is a continuous rod, bent in two places for pedals, that runs the entire width of the vehicle. In the future, the team will make sure to thoroughly think through each design aspect in order to avoid problems such as the one encountered while prototyping.

Going forward in the semester, it will be much easier to mitigate stresses due to communication, as the team will be in person. This will be accomplished easiest using the team's in class time to organize our project approach. The team will be more organized dude to sero lag communication, and having a concrete weekly schedule. During the summer semester, the biggest issue was connectivity, and time zone differences. Due to these issues, the team was not able to quickly and effectively talk to each other, and because of this, planning meetings was the most difficult task. With the lag in communication ability, the team had no way of solidifying plans for meetings in a timely manner, and in some cases, there were team members who's communications ability were restricted due to foriegn governments, further hindering the ability to plan meetings. The difference in organizational ease was immediately apparent in days prior to the semester starting, as all team members but one are now in Flagstaff. Since this change, meetings have already been cemented, and tasks have been planned to be accomplished as a group more easily.

After a summer course study, the team learned the specific design process flow. When designing the propulsion device, the team adopted a flywheel design. In the design of the entire propulsion system, our team learned the functions and connection methods of gears, sprockets, chains, flywheels and clutches. In the actual design, the team needs to pay attention to more technical issues, such as market comparison and prediction of failures. In order to avoid engineering errors and different problems. According to the FMEA table we made, we will plan the size and position of each component before building the model, and display the specific meshing data of the gear flywheel in practice.