ASME HPVC
Hardware Review Memo 1

ME 486C (Section 002)

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Introduction

Within this memo the team will discuss the work done throughout the Summer 2020 semester. A general description will be given along with each members' personal contributions to the project thus far. Any significant progress that has been taken this Fall 2020 semester will be noted and a detailed account of how the team plans to stay on track will be defined. All materials that have been acquired and plan to be acquired will be listed respectively. The purpose of this memo is to provide the instructor with a detailed description of what each student has done and where the project is at the current point in time.

Previous Work

Work done throughout the Summer 2020 semester included creating a SolidWorks frame and fairing and performing the FEA and CAD analysis respectively. Extensive research was done, and a drive train was also created on SolidWorks. Safety features are being considered for the vehicle and several ergonomic features will be added to the vehicle through the end of the Fall semester. Braking for the vehicle has also been considered and the team is thoroughly looking into different options, as well as the final roll cage design for the frame. Lights and electrical additives were looked at and the HPVC official rulebook was thoroughly read by several members of the team. Multiple steering options were proposed to the team and are being evaluated for the final design.

Significant Progress

Significant progress this semester has been highlighted by starting the prototyping process seen in both figures one and two. By acquiring PVC and being able to physically see in person, as a team, the size and geometries developed over the summer of the frame, the team was able to quickly collaborate on decisions for modifications to the initial design. This quick prototype has brought forth minor changes that are now being analyzed prior to purchasing raw materials for actual frame manufacturing. The team has also utilized the self-learning assignment to acquire new skills for better analysis of several of the sub-systems of the design including the fairing and gear train. Lastly, the team has made contact with Nova Kinetics in regards to assisting with the manufacturing of the fairing as well as several local companies which we hope to obtain sponsorships or donations for other miscellaneous components necessary to complete the HPV.

Figure 1: HPVC Prototype, back wheel

Figure 2: HPVC Prototype, back wheel

Steps to Stay on Track

The primary step that can be taken to ensure the team stays on track is to create weekly action items/ goals and updating the progress of each. The team started PVC modeling in August to get an idea about how the frame would look like and what changes need to be made to be feasible for the Solidworks frame model. The team's goal is to start finalizing design concepts such as the

frame, roller cage, gear trains, fairing within the first few weeks of September. Another goal to achieve during this period is to conduct physical testing such as the wind tunnel test for the fairing and frame strength test. The team will start building the HPVC at the end of September and continue the manufacturing and assembling process through October while continuing to test the design. By the end of November, the testing and building procedures will be completed.

Materials Acquired and to be Acquired

To date the team has acquired a handful of PVC pipe and an assortment of fittings in order to mockup the planned frame and roll cage design prior to manufacturing it out of final materials. This allows for cheap and easy changes to be made to the design based on physical fitment of team members in the vehicle, planned location of components, and desired comfort parameters. The list of materials acquired thus far can be seen in Table 1.

Table 1: Currently Acquired Materials

Part Number	Description	Qty
1	0.5" ID 0.75" OD x 10' schedule 40 pvc	5
2	0.75" ID 1" OD x 10' schedule 40 pvc	5
3	0.5" pvc T fitting	10
4	0.75" pvc T fitting	10
5	0.5" pvc 45* elbow	10
6	0.75" pvc 45* elbow	10
7	0.5" pvc straight coupling	10
8	0.75" pvc straight coupling	10

In addition to the materials listed in Table 1, the team has gained access to the project room in building 98C where miscellaneous parts left over from past HPV's are available as well as two complete and drivable previous HPV's are currently located for benchmarking.

Based on the initial mockup of the PVC frame and benchmarking done from testing past HPV's, the team has made some minor geometry changes to the initial frame and roll cage design and plans to re-analyze the changes by 9/11/2020 so that a purchase order can be made for the raw materials by 9/14/2020. The team has also been advised to research into possible pre-manufactured gears that could work for the gear train. This research will be completed by the same time as the frame analysis so that the purchase order placed on 9/14/2020 will include all raw materials needed for manufacturing the frame and roll cage, as well as either raw materials to manufacture the gear train, and/ or gears that will be utilized for the gear train. If possible the team will utilize as many pre-manufactured gears as are available and plan to manufacture the remaining parts in house.

Individual Progress Thus Far

Anu

During the summer semester, research was conducted to identify different types of fairing available (partial front or back, fully enclosed), what material can be used to make the fairing. After the literature review, the team decided to use a fully enclosed fairing with a good streamline shape for the HPV as this could help reduce the drag acting on the vehicle and increase its speed. The team initially had seven different concepts, and each was analyzed using "Ansys Fluent." The vehicle's drag coefficient was calculated for the analysis, assuming that the HPV would travel at 17m/s (~40mph) under constant pressure conditions. The final proposed fairing was the design with the lowest drag of 0.162. The fairing dimensions will be finalized when the frame, roller cage dimensions are confirmed. Carbon fiber and Kevlar will be incorporated together to build the fairing as these two materials are strong, lightweight, and cost-effective. The proposed design (scaled-down version) will be tested in the wind tunnel to ensure the accuracy of the numerical results. The team is currently working on a backup fairing design if the proposed design is not feasible due to budget constraints.

Ryan

During the summer semester, Ryan took the lead on designing an innovative gear train with the goals of greatly increasing the output speed of the HPV while maintaining useful gear ratios for lower speeds and increased reliability over previous designs. To do this, a 2-speed gear box was designed that would mate to a traditional style road bicycle chain and sprocket system. The gear box would allow the rider to choose from 1:1 input to output ratio utilizing all of the standard gear ratios common on a road bike, as well as a high overdrive 1:2 input to output ratio that theoretically will double the speed of the vehicle pending fighting drag forces. This semester Ryan has done more optimization to the gear train utilizing SolidWorks Simulation to identify areas that were over-engineered as well as began research into pre-manufactured gears that may be compatible with the design. As Budget Liaison, Ryan has completed the first team purchase acquiring PVC materials for preliminary mockup and will be completing another purchase by 9/14/2020 for raw materials needed to begin manufacturing the frame and gear train.

Paolo

Thus far, the primary frame iteration has been completed. There are three versions that are all consisting of different materials: AISI 4130 tubing, 6061-T6 aluminum tubing, and 6Al4TiV titanium tubing. Since this project is aimed at developing nations where cost and environmental impacts should be minimized, it is clear that titanium is not the best choice. While the benefits for competition would be second to none, this does not precede the value of the project description given by ASME. All frame versions have been subject to FEA analysis using Solidworks Simulation. Failure is not an option because we are limited to building one single vehicle, so all

designs must stay within the material elastic region and have a yield factor of safety of at least 2.0. The 4130-steel frame with a wall thickness of .035” and 6061 aluminum frames with .065” wall thickness have met the criteria. Due to further analysis and testing of previous HPV available to the team, some frame modifications have been made. The analysis of the second iteration will be completed within the next week so that material can be ordered, and fabrication can begin.

Samantha

Two different steering options were provided to the team, these including a two-arm steering placed at the hips of the rider and a one bar steering handlebar similar to that of a regular bicycle. These options have been discussed by the team and the one bar steering handle has been chosen. Trail head was calculated to be 5.30 inches with a head angle of 63.5 degrees. These calculations were based on a front tire of 16 inches, these will have to be re-calculated as the final design is finished and the angles of the riders and the front tires are changed. Safety elements of the rulebook were thoroughly researched and there are several types of five-point harnesses being considered along with different SFA numbers that need to be calculated in order to achieve a high safety rating. Clip in shoes are being used for the competition as to not allow the feet to slip from the pedals. Several helmets have to be chosen as the team has riders of various sizes. The size of the rider along with the helmet and the seat cushion should be known before the roll cage is fully designed. A rough draft of the roll cage has been developed on SolidWorks, this design will eventually change based on the final design.

Sebastian

During the summer semester of capstone, Sebastian worked on defining the ergonomic constraints and criteria that would lead to an overall ergonomic design of the human powered vehicle. This included conducting research to learn what the optimum body positioning is on a recumbent bicycle as well as the materials that will be best suited for a seat. The research led to finding the best body seating and pedaling angles for maximum power output, rider endurance, and overall rider comfort during use. To accommodate our tallest and shortest riders, Sebastian is currently using these findings to develop a seat that will have adjustability for pedal distance and reclining. Along with ergonomics, Sebastian is also working on a fairing design for the human powered vehicle. He has partnered up with team member Anu to develop a good fairing design that produces low drag effects and is manufacturable and functional. Multiple designs of fairings have been developed using SolidWorks, which will be 3D printed in small prototypes that can be used for wind tunnel testing to decide on a final design.

Allison

Over the last weeks of the summer capstone, Allison worked on the lighting system for the design. The design constraints originated from the HPVC guidelines where the front light must emit 300 lumens, and the rear light must emit 10 lumens. The team also came up with the suggestion of

blinkers. The front light will be wired such that the switch is located on the handlebars. The rear light will be actuated by applying the handbrakes. If blinkers are included, they will be actuated by a double pole double throw switch with an internal system to alternate the current. Previous HPVC designs used LED strips as the lighting sources. The LED strips allow for the lights to adhere the best to a fully enclosed fairing. To note, the summer capstone, Allison worked on energy storage systems and concluded that any energy system proved to be inefficient for this design.

Conclusion

In all, the team has made progress on the HPVC modeling by constructing the frame out of PVC. During the summer semester of capstone, the team has done extensive research on ergonomics, safety, the fairing, roll cage, FEA, and lighting system. The current plan for constructing the design is to create a PVC model in August, finalize the design in the beginning of September, begin testing analysis in the middle of September, begin construction of the design in late September, continue manufacturing in October, and finalize manufacturing and testing in November. The only material that has been acquired is the PVC, and the plan is to order material by 9/14/2020. Anu has been working on the fairing material and coefficient of drag while Ryan worked on making an innovative gear train and manufacturing plan. Paolo worked on different variations of the frame meanwhile Samantha worked on steering, safety harness, and roll cage. Sebastian worked on ergonomics and the fairing design while Allison worked on the lighting system.