Team # 8

Ferris State University

Utility Event

2009 Human Powered Vehicle Challenge – East

FERRIS STATE UNIVERSITY

HPVC Team

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Abstract

This will be Ferris State University's first year competing in the Human Powered Vehicle Competition and with that in mind our goal was to keep everything simple. We started our intro into the competition by attending the 2008 Human Powered Vehicle Competition in Madison, Wisconsin. While there we took many pictures and asked many question about the different vehicles we saw. We went to the utility competition on that Saturday and looked at what designs worked and which ones did not. This was our first step in brainstorming for our design. After the competition everyone had all summer to ponder upon what we saw and come up with some of their own ideas to incorporate into our design.

When school was in session again we immediately began looking at design option. We considered a number of designs that the Ferris State team had sketched and we picked ones that were reasonable. We formed the structural frame design for our vehicle by combining many of these ideas. Once we had a sketch we decided to make a model of the design to make it more of a visual (see figure 1).

Figure 1

Small model of design

Once it was decided that this was indeed the design we wanted to go with for our first year's vehicle we modeled it using AutoCAD. After we had our design modeled we ran a finite element analysis on it to locate any areas of high stress. Minor adjustments to the design were then made. The final design is shown in figure 2.

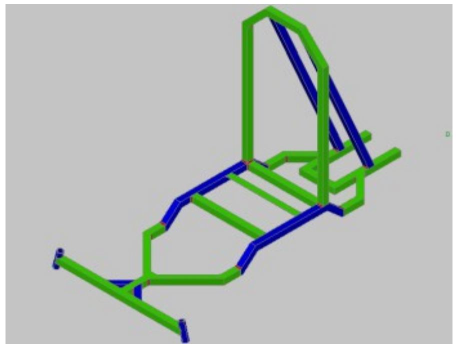

Figure 2

AutoCAD model

A number of our design highlights are based on vehicles we saw at the competition in Madison and what we thought would make the vehicle feasible to use as a daily vehicle. Our intent was to try to make this vehicle as usable as possible so that someday it could be used to run errands around town.

Design Description

Goals

This being our first year of competition our main goal was to build a functioning vehicle for competition. We decided right away to try to keep our design simple and be able to meet all the ASME regulations. After setting these goals we began some brainstorming on the design of our vehicle.

Assumptions

Since we had no previous builds to use as a basic for this year's vehicle we made some assumptions that would help us start our design. To start off we all decided to do a 3 wheeled vehicle, 2 wheels in the front and one wheel in the rear. A three wheeled vehicle would be stable while driving and also stable when turning and stopping. We decided that stability was important in a utility vehicle due to frequent stopping and to prevent injury when getting in and out of the vehicle. We also decided that the vehicle steering control would be from our two front wheels. We decided this solely on the basis of it would be easier to steering from the front wheels.

Research

Our initial form of research was to attend the 2008 Human Powered Vehicle and see how the competition was conducted. We attended many presentations and looked at the different vehicles and talked to the different teams about their vehicles. We also attend the utility event and watched the schools compete. We were able to look at what designs worked well and what designs did not work well for the utility event. We got a lot of design ideas from attending this competition.

We decided most of the dimensions by measuring off of our tallest and shortest drivers. We decided to do this because we had no previous dimension to go off of and see what we liked and did not like. By getting our dimensions this way we were able to have a start of where to begin working on the design of our vehicle.

Material

When choosing a material we had a lot of different choices. We did know that we would like to build it out of aluminum to make our vehicle lightweight. We then started looking at the price of steel versus aluminum and found that it would not cost us much more to get aluminum, so we decided that aluminum was our choice of material. Then we needed to decide on what aluminum to use. One of our main concerns about aluminum was that it loses strength when welded. To get some help with this decision we went to our material science professor at Ferris State University and discussed our options. From this we decided to go with Aluminum 6063T6 square tubing.

Scheduling

We learned very quickly that we needed to establish a timeline so that design and build aspects of the vehicle were completed in the proper order and on schedule. Being our first year some things did take longer than expected and some took less time. By setting a timeline we will be able to modify the timeline for next year and make more realistic goals and stay on track. The timeline provided a great education in time management.

Frame Design	November 1 – December 8
Power Train Design	November 5 – December 10
Steering, Suspension, and Braking Design	November 5 - December 10
Body Design	December 1 – January 21
Order Frame Material & Parts	December 10 – December 19
Frame Build	January 12 – February 12
Power Train Build	January 21 – March 5
Steering, Suspension, and Braking Build	January 21 – March 5
Body Build	February 4 – March 20
Build Report	December 1 – March 6

Testing	February 19 – April 10
Travel	April 16 & April 19
Preliminary Date Forms and Fees	January 17- January 23
Entry Date Form and Fees	March 7 – March 13
Report Send Date	March 16
Competition	April 17 – April 19

Figure 3

Sample of Timeline

Analysis

Software

The drawings and testing analysis were done in AutoCAD Mechanical Desktop 2008.

Frame

Starting with a the frame with we started our analysis with just a load added where the driver would be seated. This gave us an idea on the type of stresses that would be generate and locations that would need to strengthened. Once we established that this main design safely sustain the rider's weight with a factor of safety of 2 we began to make more additions that would strengthen it for more dynamic loads. This led to the addition of some angled supports at the front of the vehicle to support the cross member during turning and to help move some of the stress off of the welds.

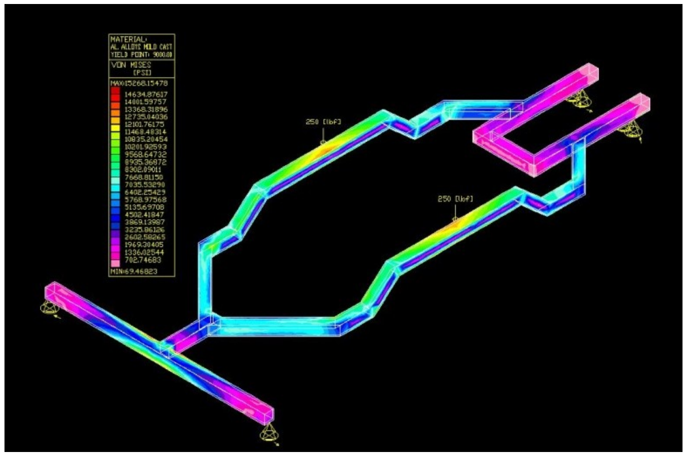

Figure 4

Frame Analysis

Roll Cage

Starting with the load applied to the top of the roll cage, we found that the maximum stress was between 7000 psi and 8000 psi. However, the way that the frame was constrained that stress around the rear wheel mounts was much higher, giving a much higher maximum stress output by the software. The vehicle was constrained this way to ensure that the constraints of the roll cage attaching to the frame were correctly accounted for. This would allow for a more accurate calculation of the deflection of the roll cage as well. The maximum deformation of the entire frame under this load is less than a 0.5 inches.

The second load of 300 lbs from the side was also looked at giving just over 0.5 inches of deflection. The only constraint for this test was locking the opposing side rail from the force on the outer edge from any movement. Both tests were estimations aimed at trying to match that of a rollover of the vehicle.

Both tests were educated estimations at trying to match a real scenario in which the vehicle was in a rollover. We will be testing to ensure that the rider's safety is not jeopardized in any way and to ensure that our results are reliable.

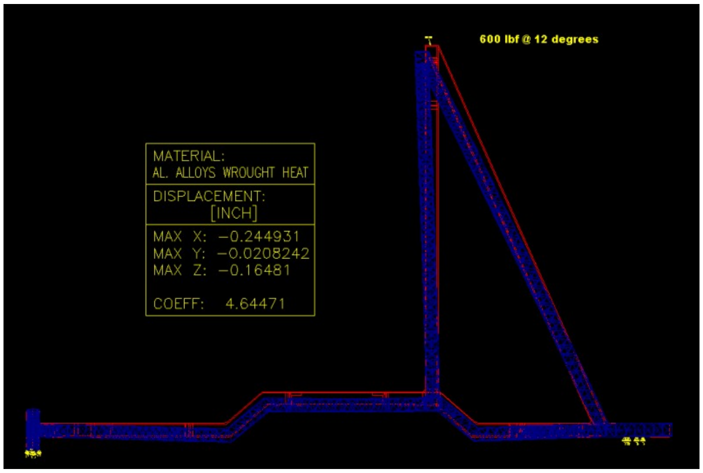

Figure 5

Analysis of top load on roll cage

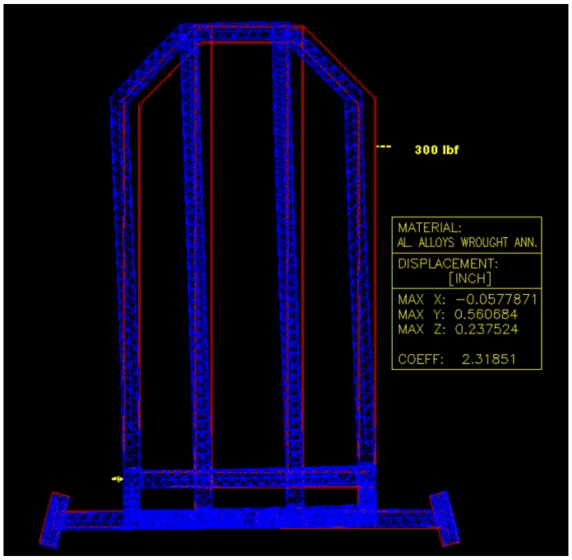

Figure 6

Analysis of side load on roll cage

Cost estimate

Initial Total Cost Estimate:

Build						
Material						$180.00
	Square Aluminum Tubing 2x2x1/8					
Bike Parts						$1,400.00
	Wheels, Brakes, Shifters, Chains, Etc.					
Body						$500.00
	Fairing Material					
Misc						$300.00
	Unknown Parts					
					Sub-Total	$2,380.00
				Unexpected Costs		10%
Total Estimated Cost						$2,618.00

Final Total Cost Estimate:

Build						
Material						$90.00
	Square Aluminum Tubing 2x2x1/8					
Bike Parts						$800.00
	Wheels, Brakes, Shifters, Chains, Etc.					
Body						$250.00
	Fairing Material					
Misc						$130.00
	Unknown Parts					
Total Cost						$1,270.00

Cost Savings:

The Ferris State University American Welding Society student chapter donated half of the final cost of aluminum tubing for the construction of the frame. Jade Cycles of Holland, Michigan generously donated the bottom bracket shell as well as information regarding the industrial manufacturing time estimate. Rock N Road Cycle of South Haven, Michigan generously worked with the team to lower the cost of bicycle components to meet an affordable dollar amount below retail value. Local businesses as well as individual sponsors made cash donations to the team cutting costs.

Production Cost Estimate:

Jade Cycles of Holland, Michigan assisted in the estimated number of hours to completely manufacture our frame design in twenty hours at a labor cost of $50 per operating hour, and was unable to disclose OEM cost on materials and components. Rock N Road Cycle of South Haven, Michigan was able to disclose dealer cost on bicycle components at $605. Ferris State University acquired the aluminum tubing for the vehicle at University cost of $180. Fairing materials were purchased by the team at retail price of $250. Assembly of the vehicle by certified technicians would require approximately five hours of labor with an hourly rate of $13.

Using the cost's that were available to the team, it was determined that the vehicle could be built at an estimated cost of $2,100. Estimated cost for this vehicle to be manufactured ten times per month for a six year time period would yield 720 vehicles at $1,512,000.

Testing

Frame Tests

We plan to do multiple strain tests on our frame to ensure safety. First, apply a torque load throughout the whole frame with the front pinned and twisting the rear of the frame. This test will help us to determine if our frame needs any other supports in the frontal area.

Rollover Protection Tests

We need to do some testing on our rollover protection system to ensure that it is strong enough in the event of a crash or rollover. ASME regulates a minimum of what the roll cage should withstand and our goal is to be able to hold more than that minimum. We plan to place our frame at a twelve degree angle, with the front in the air and the rear down, and hang a six-hundred pound load on the top of the role cage. If elastic deformation, or if there is a fracture, then we will redesign our rollover protection system and re-run the tests again.

Another test that has to be completed on the rollover protection system is to apply a load to the side of the roll cage. We plan to position our frame on its side at a ninety degree angle and hang a three-hundred pound load at shoulder height on the role cage. As mentioned previously, we will redesign if elastic deformation or fracture occurs at an unsuitable degree.

If both of these rollover protection system tests pass our test than we will conclude that our roll cage is safe and ready to be used on our vehicle.

Seat Belt

Given that we have a three point automotive seat belt we decided that no test results are needed to ensure the belt will not fail. However, we have three connection points that have half-inch bolts connecting the seatbelt to the frame. We will do the single shear calculations at the point where the belts attach to the frame ensure that the seatbelt is securely and safely mounted.

Fairing

At this point we do not have our fairing design complete. We are planning to build different fairing designs and use our laboratory wind tunnel to conduct airflow testing. The results of these test will aid in deciding on the final fairing design.

Performance Testing

After the bike is completely built we will do some performance testing as well. Our plan is to take the bike through a course similar to the one at last year's competition. We hope to fine tune our gears at this point and make sure the bike will make it through the course without a problem. It is also important that all drivers get their time on the vehicle so that they are comfortable with the way everything works for competition.

Safety

To sure the safety of all riders there will be some safety features added to our vehicle. One thing will be to round all corners down so that as drivers are entering and exiting the vehicle there is no harm to their body due to burrs and sharp edges. Getting rid of theses edges will also help in the event of a crash with another vehicle that our vehicle will not cause any more damage than the actual forces of the accident will cause.

The roll cage will also help in the event of a collision or rollover. It will help protect the driver from being wedged between any object and the vehicle. This is one of the biggest safety features of our vehicle.

There will also be lights added to the vehicle to make it easier for other vehicles to see our vehicle. These lights will most likely be battery operated and will need to be turned on by the driver before entering the vehicle. These lights will make our smaller vehicle visible to larger vehicles such as trucks or cars that may be sharing the road with our vehicle.

Utility

The purpose of the Ferris State University Human Powered Vehicle utility vehicle is to do basic errands around town or on campus. Our vehicle will be equipped with a storage area in which the operator could secure small grocery purchases. You would also be able to store a book bag and or books in the storage area so that you would be able to ride it around campus. The Ferris State University vehicle will be easy to operate and to maneuver around city streets and college campus roads. It will be easy to operate on roads or sidewalks and will easily traverse bumps, holes, or other small obstacles. Our vehicle will be a sage and environmentally "green" vehicle to use as an alternative to driving a car around town or campus.

Rules for the

2009 Human Powered Vehicle Challenge East

Sponsored by ASME and Drexel University

Appendix 5: Vehicle Description

Due March 20, 2009

(Dimensions in inches, pounds)

Competition Location: Drexel University

School name: Ferris State University

Vehicle name: Bulldog

Vehicle number 8

Vehicle type Single ______ Multi-rider ______ Utility X

Vehicle configuration

Upright ______ Semi-recumbent X

Prone ______ Other (specify) ___________________

Frame material Aluminum 6063 T6

Fairing material(s) Not finished, thinking fiberglass

Number of wheels 3

Vehicle Dimensions

Length 91.75” Width 45.25”

Height 57.25” Wheelbase 69.25”

Weight Distribution	Front	36.6lbs	Rear	30.0lbs	Total	66.6lbs
Wheel Size	Front	20"	Rear	26'		
Frontal area	$1766.6in^2$					

Steering Front X Rear ______

Braking Front X Rear ______ Both _____

Estimated Cd $1500

Vehicle history (e.g., has it competed before? where? when?)

This is our first year of competition; this vehicle has never been used for any sort of competition.