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DESIGN OFFAIRING FOR HUMAN POWERED VEHICLES CONSIDERING AERODYNAMICS & AESTHETIC

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ABSTRACT

Human-powered transport can be defined as that type of transport that only uses the human muscle power. When considering non-vehicular human-powered transport, it should to be indicated that it exists from the beginning of the human history (walking, running, swimming or climbing to trees). The increasing environmental, concerns mostly due to the depletion of fossil fuels and a great deal of airborne pollution have been the prime topics of interest for the researchers.

We were able to finish a prototype early in order to give our riders an idea of the final vehicle handling and provide feedback. As a result of this prototype, we discovered improvements that could be included in our final vehicle. Since the construction process of the final vehicle was similar to the prototype, we were able to finish early, giving rider sample practice with the vehicle. Speed Solutions has been contracted to design and build a Human Powered Vehicle (HPV) frame and drivetrain for the Cal Poly HPV club to use in their 2011 race season.

This project is being funded by the Cal Poly HPV club and their sponsors. The goal is to design, test and build a bicycle frame that the HPV club can attach to a fairing of their design. Primary design considerations will include speed, weight, cost, rider ergonomics, reliability and ease of repair. This vehicle will be used to compete in ASME's Human Powered Vehicle Challenge (HPVC) series of races.

Keywords: ***Human powered vehicle, Ergonomic design, Aerodynamics.***

I. INTRODUCTION

Human Powered Vehicle

Human Powered Vehicles (HPV) are aerodynamic, highly engineered vehicles that may be for use on land, in the water or the air. Some land-based HPV's have achieved speeds of over 60 mph. Every year, the American Society of Mechanical Engineers (ASME) sponsors a national HPV competition in which the vehicles are judged on design, safety and performance. Senior engineering students can use this competition for their capstone project and with their efforts design and construct a fast, sleek, and safe vehicle capable of road use.

ensure the safety of the rider as well as possible pedestrians around the vehicle.

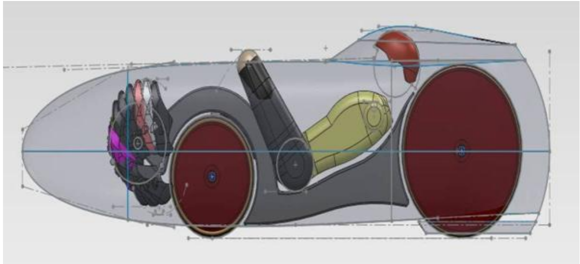

Figure.1 Human Powered Vehicle

HPVs include vehicles built for air, water, or ground transport, but the common denominator is the integration of a human into the design. They optimize the human's strengths and compensate for their weaknesses. The primary purpose of a human powered ground vehicle is to transport its rider and cargo safely and efficiently. A human powered ground vehicle in its most simple sense is the traditional bicycle. Thus finite element analysis (FEA) as well as physical testing was performed to

Human powered vehicle as a vehicle for more sustainable transportation

- Human Powered Vehicle is safer and less space consuming in today's highly dense traffic roads. It is most suitable for short distances but can also be used for long routes.
- Apart from cyclists it will also be a source of attraction for all including kids and youth because it consists of aerodynamical designed weather proof outer shell and ergonomic and comfortable driver's cabin.
- In urban markets, it can be projected as an environment friendly alternative to a car. The modern generation is concerned about the environment and would definitely like to explore cleaner options if they are marketed properly.
- This would find takers in the form of professionals working as far away as 30 km from their homes, for commuting to and fro from their offices.

Design Aspects

Certain points kept in mind while designing the vehicle are

- **Ergonomic design**: the vehicle is designedergonomically for an adult driver of normal height and weight.
- **Easy handling**: for people of all age groups.Older people can comfortably drive in recumbent position and can also avoid pedaling as per choice.
- **Easy steering**: Lesser weight, higherstrength and hence easy to steer in crowded areas in day to day life, and also suitable for long distance rides with minimum effort. The vehicle is provided with articulated steering mechanism for the rear driver.
- **Safety**: Vehicle well equipped with safetyfeatures like disc brakes, horn, rear view mirror.
- **Comfort**: The semi recumbent ridingposition reduces strain on the body, making it particularly suitable for long rides and touring. It can be very easy on the neck, wrists, hands, arms, shoulders, lower back, and sit bones, foot rests for front driver.
- **Versatile application**: means of transport inshort duration, healthy source of recreation.

- Low maintenance cost and compact structure
- **Eco-friendly vehicle**: causes no pollution and hence does not harm the environment.

II. LITERATURE REVIEW

Project implementation strategy

Having gone through study of various tangible & intangible factors for the feasibility of our project we have assigned each member of the team the following respective roles for easy and higher performance.

- Design Analyzer
- steering system designer
- Brakes and Tyre's Designer

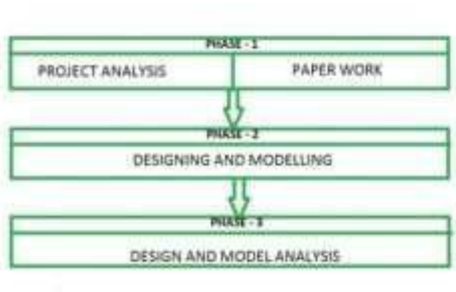

Figure.2 Project Implementation Strategy

Phase-I: Every team member Identified and Studiedthe nearest existing systems, methods, resources corresponding to their assigned roles and there by documenting every information.

Phase-II: The team designed and modeled thesystems in the appropriate CAD Software. **Phase-III**: The team analyzed the designed andmodel systems in ANALYSIS Software.

Integration of Sub-Systems

The task of design is started by conducting extensive research of each main component of the vehicle. The design of the vehicle as a whole trying to optimize each component while constantly considering how other components would be affected. Combining this design methodology with the standard engineering design process enabled us to achieve a perfect match of aesthetics, performance and ease of operation.

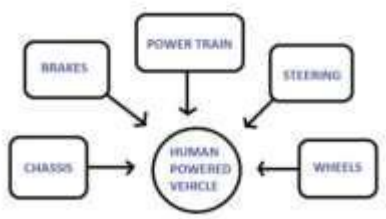

Figure.3 Integration of Sub-systems

III. DESIGN &MODELING OF HPV

The primary objective for the design of frame is to provide a 3-dimensional protected space around the drivers that keeps the drivers safe. Its secondary objectives are to provide reliable mounting locations for components, be appealing, low in cost and low in weight. The vehicle frame was designed with primary emphasis given to

Driver Ergonomics –The design of the vehicle isdriver centric. Efforts have been made to provide the best riding position by adjustment of the seat in order to attain the maximum power output while pedaling and hence minimize the effort on the driver.

Safety –The human powered vehicle is enclosed forAerodynamic advantage and protection from weather and collisions.

Weight Distribution –The weight distribution of atrike dictates how well it handles. The weight is distributed in the ratio of 60:40 on the rear and front wheels respectively. This provides better acceleration while driving.

Dynamic Vehicle Weight –Light weight chains andsprockets are selected to reduce the dynamic weight of the vehicle. Rider is seated so as to allow his weight to be on the same vertical plane of the vehicles center of gravity. This ensures the stability during steep turns.

Material Selection

AISI 1015 is a carbon alloy which is used for making the chassis of HPV & it is appropriate only for structural shapes, plate, sheet, strip, and welded tubing. Hot-rolled and cold finished bars, semi-finished products for forging, wire rods having a carbon content of 0.13 - 0.18%.

	AISI 1010 Steel (hot rolled bar)	AISI 1015 Steel (cold drawn)	AISI 1020 Steel (cold rolled)
Yield Strength	180 MPa	325 MPa	350 MPa
Ultimate Tensile Strength	325 MPa	385 MPa	420 MPa
Density	7.87 g/cc	7.87 g/cc	7.87 g/cc
Poisson's Ratio	0.29	0.29	0.29
Young's Modulus	200 GPa	205 GPa	205 GPa

Table.1 Material selection comparison

Chemical Composition of AISI 1015

- Carbon 0.13-0.18
- Manganese 0.30-0.60
- Phosphorus 0.040-max
- Sulphur 0.050 max

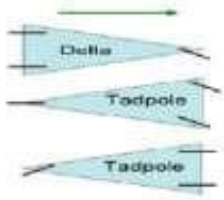

Figure.4 Vehicle configuration

Modelling of chassis

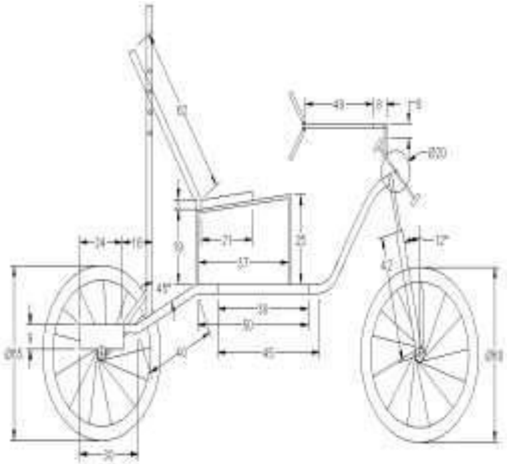

Figure.5 2D Drafting of Human powered vehicle

Solidworks

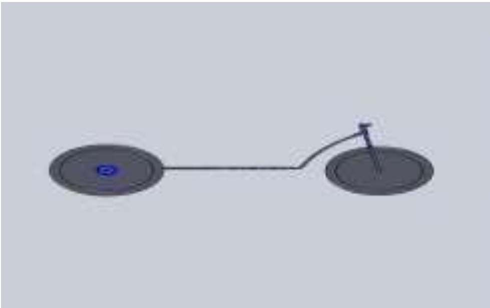

Figure.6 Side View of the Vehicle

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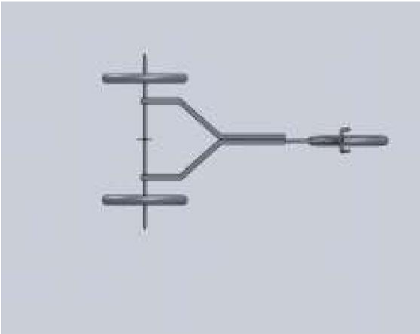

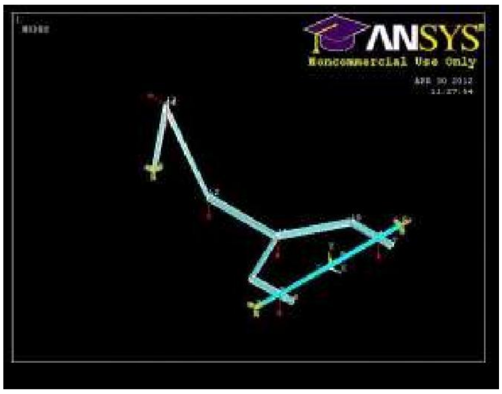

Figure.7 Top View of the Vehicle

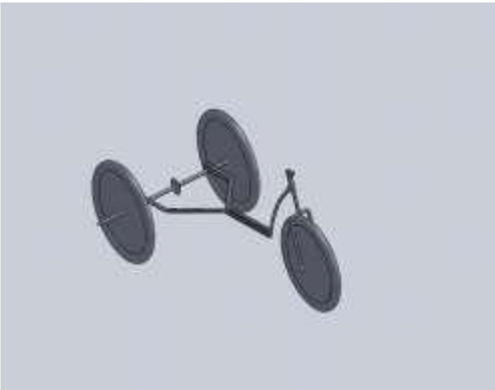

Figure.8 3D View of the Vehicle

Analysis of Chassis

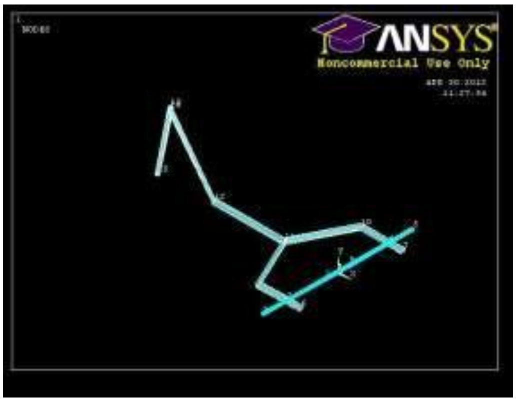

Figure.9 Analysis of Chassis

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Figure.10 Analysis of Chassis On Applying Loads

Figure.10 Analysis of Chassis On Applying Loads

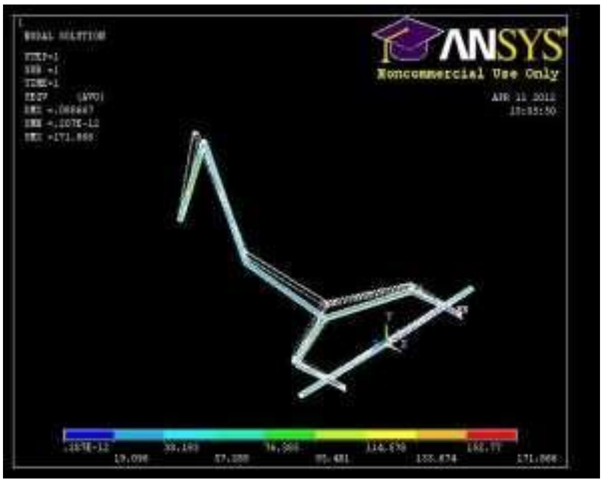

Figure.11 Von Mises Stress On Applying Maximum Loads

- The maximum stress obtained after application of maximum loads is 171.866 kN/mm^2
- The minimum stress obtained after application of maximum loads is 0.207E-12 kN/mm^2

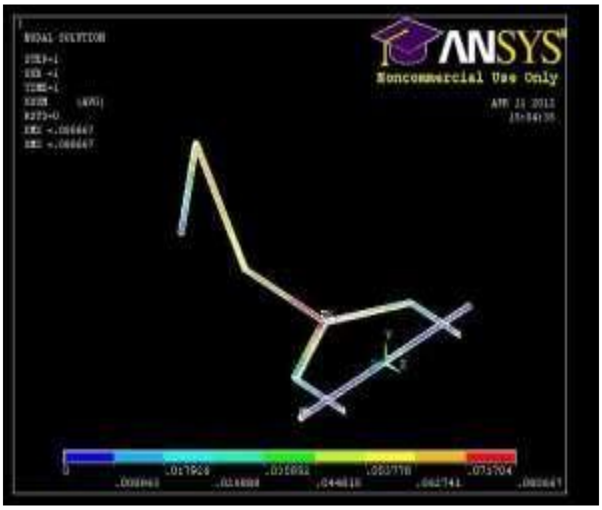

Figure.12 Deflection on Applying Maximum Loads

The maximum deflection obtained on application of maximum loads is **0.08066 mm**

Pictures of HPV

Figure.13 Pictures of Human powered vehicle

Design data

Design Data is the source of the material information that is used for the analysis of the system it is contained in. This data allows viewing, editing, and adding data for use in your analysis system. The engineering data used in our analysis is

- Material : AISI 1015 Steel
- Density : 7.87 g/cc
- Yield Strength : 325 MPa
- Ultimate Tensile Strength : 385 MPa
- Young's modulus : 205 GPa
- Poisson's ratio : 0.29

Wheel specifications

	Front	Rear
Qty.	1	2
Size	24*1.75	26*1.95
Rim Size	2"	2"
Outer Diameter	24"	26"
Maximum Load	160 kg	250 kg

Table.2 Wheel specifications

Mechanical advantage:

Teeth on Front Gear	Teeth on Rear Gear	Mechanical Advantage (MA)
46	28	0.61
46	24	0.53
46	21	0.46
46	18	0.39
46	16	0.35
46	14	0.31

Table.3 Mechanical advantage

Results and discussions

Technical specifications

Model/Vehicle Configuration- Delta type Seating- recumbent with center seating Drive- Rear Wheel Drive

Human Powered Drive Train Chain mechanism

Wheels- Front - 24" Diameter 36 spokes (heavy duty) wheels

-Rear - 26" Diameter 36 spokes (heavy duty) wheels Brakes- Mechanically Actuated Disc brakes for rear wheel

-Rim brakes for front wheel

Steering- Over Seat Steering system (OSS) Vehicle Dimensions- Track Width – 44 inches

-Wheel Base – 56 inches -Overall length – 81 inches -Height from base – 38 inches

Weight Constituents of the Vehicle

- Frame – 20 kg
- Wheels – 5 kg
- Seat-5 kg
- shaft-10 kg
- mountings - 5kg
- Miscellaneous – 5 kg
- Total = 50 kg

Target vehicle performance

- Top Speed : 30-35 kmph
- Stopping Distance : 1.0 - 1.5 meters
- Ground Clearance : 5 inches
- Turning circle : 2.1 meters

Cost estimation

The estimated cost of materials is as follows

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Roll Cage Material (AISI 1018 Steel)	1000/-
Brakes	1000/-
Shaft (Mild Steel)	800/-
Pedals + chains + sprocket wheels	1200/-
Main Cycle Parts	2200/-
Body Frame (Fiber)	800/-
Miscellaneous	450/-
Total (In Rupees)	7,450/-

Table.4 Cost of Human powered vehicle

CONCLUSIONS

1. This research work has been carried out to provide people with a new vehicle which is energy efficient, eco-friendly and economical thereby contributing our role in safeguarding the mother earth.

2.The all new design is needed these days is that drives more like a car than a bicycle with a wide soft car seat design not a hard seat as on a bicycle.

The vehicle has been modeled in such a way that there is less scope for welding by incorporating more bends which not only reduces the manufacturing cost but also the strength of the frame is retained.

3. Finite Element Analysis has to be carried out properly taking care of each and every step of the implementation.

4. Even a journey of thousand miles begins with a single step. We believe in our work and efforts and are sure that our design would change the transport scenario of the society. Look forward to see our

"Human powered vehicle" running on roads soon.

Doing the right things and doing the things right.

5. Financial feasibility as there is no such vehicle existing in our country.

6. It has good Ergonomic reasons and has Aerodynamic advantage.

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