

Abstract

Transportation is a non separable part of any society. It exhibits a very close relation to the style of life, the range and location of activities and the goods and services which will be available for consumption. Advances in transportation has made possible changes in the way of living and the way in which societies are organized and therefore have a great influence in the development of civilizations. Transportation is responsible for the development of civilizations from very old times by meeting travel requirement of people and transport requirement of goods. Such movement has changed the way people live and travel. In developed and developing nations, a large fraction of people travel daily for work, shopping and social reasons.

But transport also consumes a lot of resources like time, fuel, materials and land. While analyzing the present major modes of transportation, we have observed the shortcomings such as stability, safety, rider comfort, luggage problems, fatal accidents and aerodynamic resistance in using a Bicycle. Also the shortcomings such as green house emissions, parking problems, maintenance, fuel prices, driver skills and vehicle cost in using a Car. The purpose of our project is to overcome the limitations in both the Bicycle and the Car by designing and developing an Eco-friendly Energy Efficient Hybrid Human Powered three wheeled Vehicle, having the simplest of design capabilities that can deliver optimum performance at a reasonably low cost.

Keywords: Human powered vehicle, Ergonomic design, Aerodynamics.

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.

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

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



Figure.1 Human powered vehicle

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 aerodynamically

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 designed ergonomically 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, higher strength 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 safety features like disc brakes, horn, rear view mirror.
- **Comfort:** The semi recumbent riding position 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 in short duration, healthy source of recreation.
- Low maintenance cost and compact structure
- **Eco-friendly vehicle:** causes no pollution and hence does not harm the environment.

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

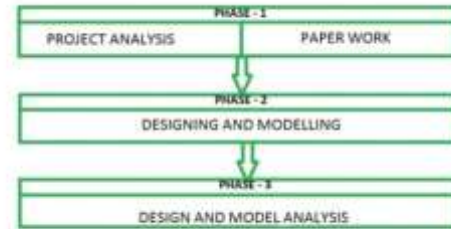


Figure.2 Project Implementation Strategy

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

Phase-II: The team designed and modeled the systems in the appropriate CAD Software.

Phase-III: The team analyzed the designed and model 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.

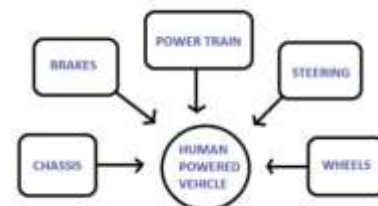


Figure.3 Integration of Sub-systems

Design & modelling 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 is driver 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 for Aerodynamic advantage and protection from weather and collisions.

Weight Distribution – The weight distribution of a trike 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 and sprockets 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

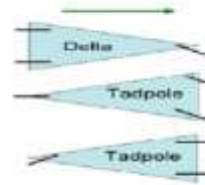


Figure.4 Vehicle configuration

Modelling of chassis

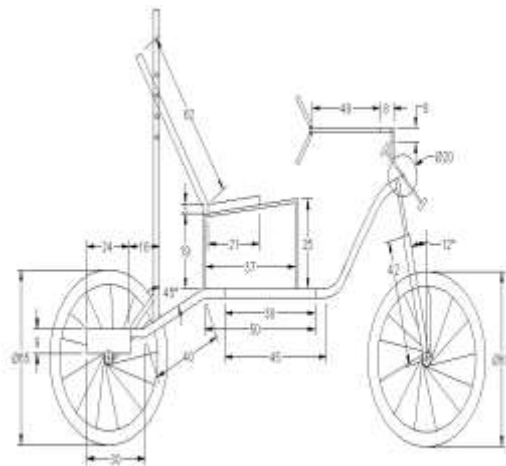


Figure.5 2D Drafting of Human powered vehicle

Solidworks

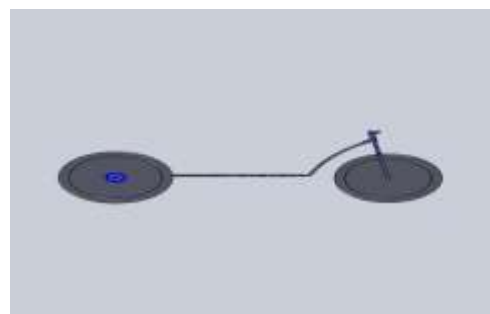


Figure.6 Side View of the Vehicle

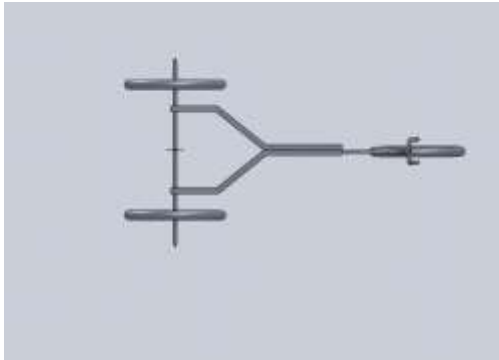


Figure.7 Top View of the Vehicle

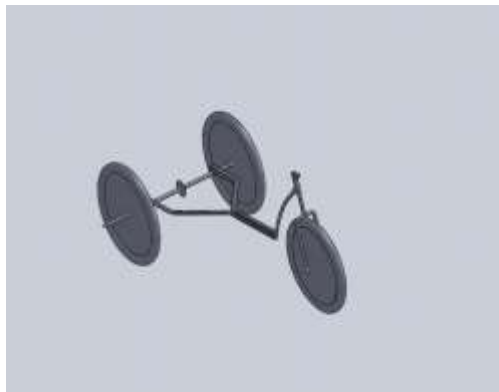


Figure.8 3D View of the Vehicle

Analysis of Chassis

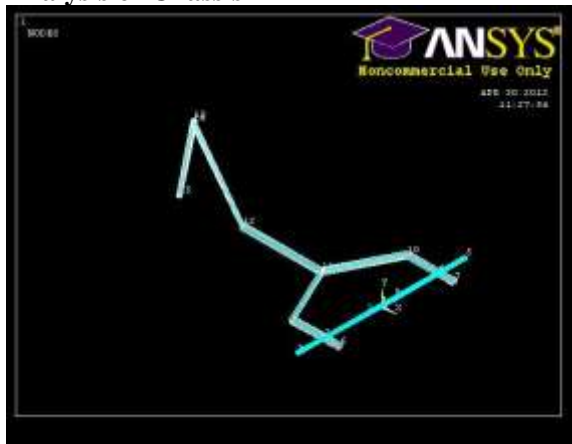


Figure.9 Analysis of Chassis



Figure.10 Analysis of Chassis On Applying Loads

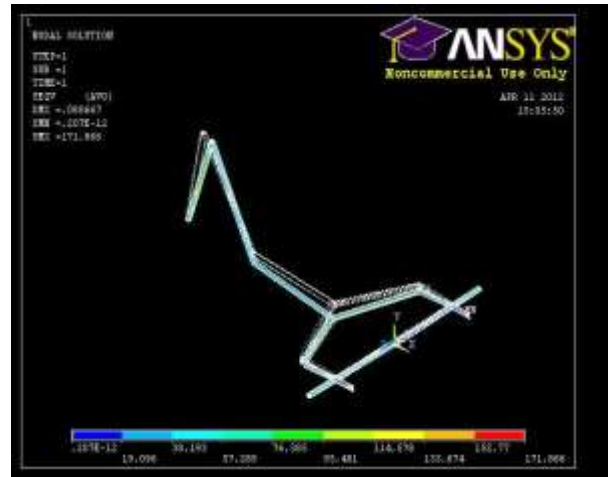


Figure.11 Von Mises Stress On Applying Maximum Loads

- The maximum stress obtained after application of maximum loads is 171.866 kN/mm²
- The minimum stress obtained after application of maximum loads is 0.207E-12 kN/mm²



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

[http:// www.ijesrt.com](http://www.ijesrt.com)

- 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

Roll-Cage Material (AISI 1018 Steel)	1000:-
Brakes	1000:-
Shaft (Mild Steel)	800:-
Pedals + chain + 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

4. S.S.Rattan, “Theory of Machines”, Tata McGraw Hill Publishing Company Limited 2008
5. Jobst Brandt, “The Bicycle Wheel”, AVOCET Inc. U.S.A
6. Dr. Kirpal Singh, “Automobile Engineering-VOL.1”, Standard Publishers Distributors 2007
7. Scientia Iranica - H.Sayyadi, H.Kouhi, H.Salareih, “Control of car like(wheeled) multi robots for following and hunting a moving target”, 2009
8. <http://www.ihpva.org/home/>

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.

References

1. A.K. Tayal, “Engineering Mechanics-Statics and Dynamics”, Umesh Publications 2010
2. S.Ramamrutham, “Strength of Materials”, Dhanpat Rai Publishing Company 2008
3. R.S.Khurmi and J.K.Guptha, “A Textbook of Machine Design”, Eurasia Publishing House (Pvt.) Ltd. 2010