*International Journal of Engineering Science Invention*
*ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726*
*www.ijesi.org ||Volume 5 Issue 2|| February 2016 || PP.11-14*

# Design and Fabrication of a Recreational Human-Powered Vehicle

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**ABSTRACT***:* *Human-powered vehicle (HPV) is often the only type of available transport that is underdeveloped and commonly unavailable in mass production. In many cases, it is acustom madevehicle for recreational and only few units are produced due to unobtainable off-the-shelf parts. This paper presents a modest design and development of human powered vehicle for recreational purpose. The basic constraints of the design are recumbent type of seat and wheel base and track sizes are 1.5 m and 1.0 m respectively. Commercial computer aided design (CAD) software is used for drawing and design. Stress analysis is performed on the conceptual design with possible loads and constraints. Available off-the-shelf materials and parts are used and assembled in the fabrication of the HPV to demonstrate the design for manufacture (DFM) practices. The final product is tested for basic functionality as HPV.*

**KEYWORDS –***Human-powered vehicle, off-the-shelf, design for fabrication, stress analysis*

## I. INTRODUCTION

HPV is one type of land vehicles which is using human power to move on the road [1, 2]. HPV can be defined as any sorts of transportation using only power generated from human's muscle. Despite having technologies here and there; cars, buses, and everything else, some of us still prefer to use HPV such as bicycle and tricycle [3, 4]. It is been used for many activities to have leisure time around, exercising, hobbies, interests and even going to school or workplace [5, 6]. Other than being environmental friendly, it is also available to be used anytime, anywhere as it does not need any other gas or electrical demand [6, 7]. Furthermore, in urban area, people will not suffer from the boredom of traffic jam.

In this paper, a simple 4-wheel, recumbent type HPV with constraints of 1.0 m length of track and 1.5 m length of wheel base is designed, analyzed and fabricated. Previously successful DFM method in fabrication of actual size working prototype [8-13] is used.

## II. METHODOLOGY

Commercial CAD software is used to design the HPV based on the constraint of dimensions and seat type. The major components consist of frame, drivetrain, and a full body fairing. The frame is designed to meet the appropriate factor of safety of 2. The frame is also be lightweight and reasonably low cost. It should be completed first, as it will determine the critical loading points needed to integrate the drive train and fairing components. The drive train should be designed to allow the minimum power input from the rider to achieve the maximum power output from the system. This can be done in several ways with different gearing methods. The final component is the fairing, which must be sufficiently lightweight so as not to exceed the maximum weight and there are no material restrictions. In completion of this project, a Human Powered Vehicle (HPV) was built with a recumbent seat design. There are no electrical components involved, which mean there is only muscular strength used to drive this machine. This HPV was designed to be a single seater with track length and wheelbase of 1 meter and 1.5 meter respectively. The assembly design is shown by Figure 1.

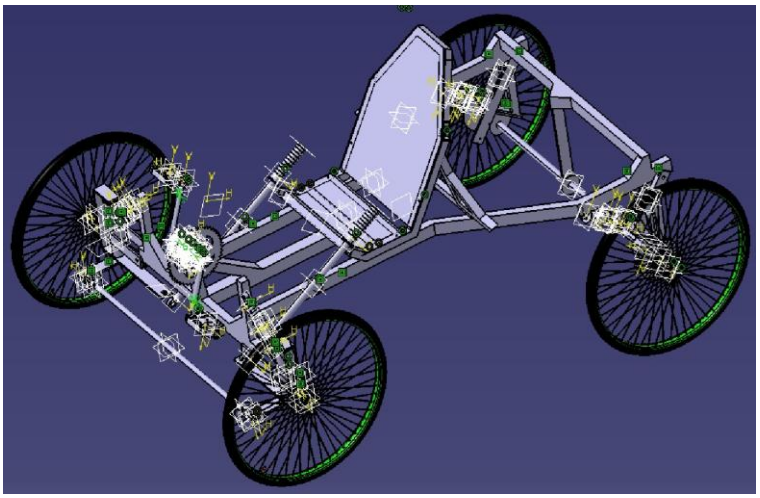

Figure 1: Assembly CAD of HPV.

The finite element analysis (FEA) is performed to study the stress [9] and safety of the design. Commercial FEA software is used for this purpose. Figure 2 shows sample of FEA analysis for the HPV. Once the safety factor is established, the HPV custom components such as chassis frame, wheel hub and mountings are fabricated using mild steel. Standard components such as seat, pedals, wheels and tires are available off-the-shelf. Figure 3 shows the final prototype fabricated of the HPV.

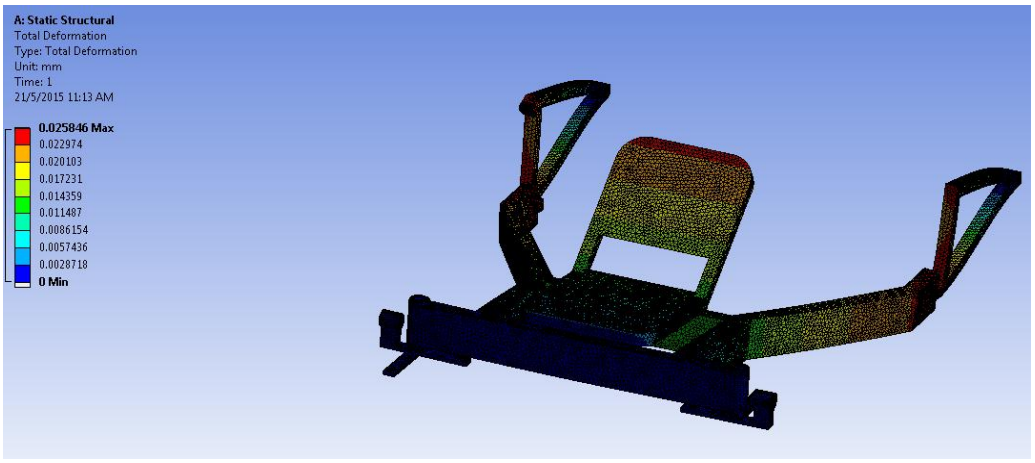


Figure 2: FEA analysis of HPV.

Figure 3: HPV prototype.

## III. RESULTS AND DISCUSSION

The minimum safety factor of the asymmetrical loading from the FEA analysis is 12.6. Since minimum safety factor is larger than 1.5, the safety threshold, thus the structure is consider safe. This can be explained with the force of 227.5 N applied at the front wheels of the HPV, the structure is in the safe condition which mean it will no crack of fracture. For the coarse angle, the equivalent stress is 3.78 MPa, for the medium span angle, the equivalent stress is 4.08 MPa and the fine span angle, the equivalent stress is 4.40 MPa as shown by Figure 4.

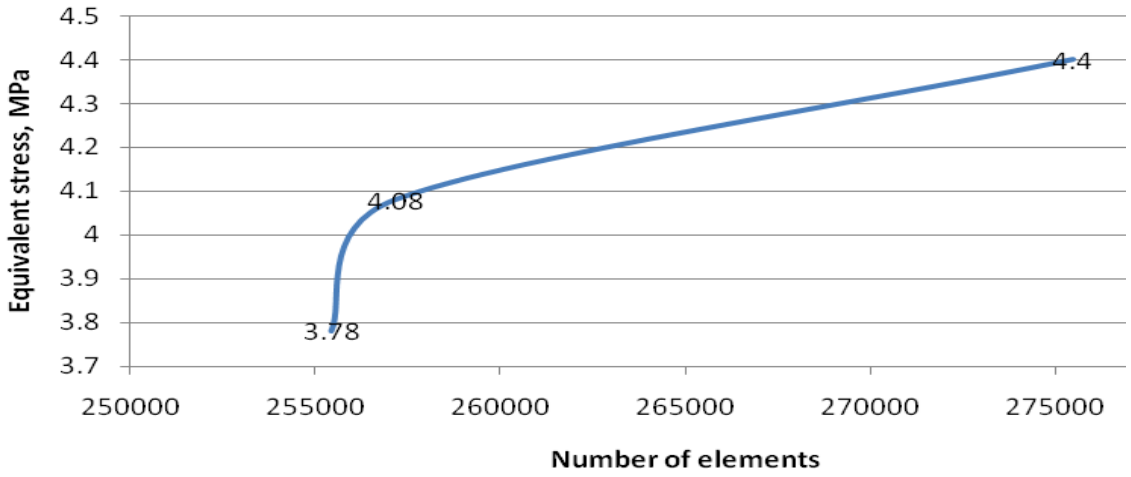


Figure 4 Equivalent stress.

The vehicle's working mechanism that includes the tire, gear system, and steering shows a positive feedback. All of them work in an awesome condition that gives the rider comfort and satisfaction. Less effort, force and work needed to put into action while riding on. Same goes to the braking system, at which the driver can rely upon. The braking system works according to what it must; as a safety measure in avoiding things to get worse. However it is, the control and dynamics of the vehicle are depends to how well the driver awareness and skills.

## IV. CONCLUSION

It can be concluded that the design and fabrication of human-powered vehicle are performed successfully. This can be shown by the finalprototype product of the HPV. The safety issue of the design is solved by the FEA analysis. The product has it all package, functioning really well and have the safety measure appropriate to the vehicle. These satisfied the need to design and fabricate the HPV up from scratch considering also the safety factor. The modest design for fabrication (manufacture) has been demonstrated with available off-the-shelf parts and components.

## V. ACKNOWLEDGEMENT

The authors gratefully acknowledged the Advanced Vehicle Technology (AcTiVe) research group of Centre for Advanced Research on Energy (CARe), the financial support from UniversitiTeknikal Malaysia Melaka and The ministry of Education, Malaysia under Short Term Research Grant, Grant no. PJP/2014/FKM(10A)/S01330 and Fundamental Research Grant Scheme (FRGS), grant no.: FRGS/2013/FKM/TK06/02/2/F00165.

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