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Design, Analysis and Fabrication of Human Powered Hybrid Vehicle

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ABSTRACT

From the beginning of our civilization, automotives have been always all integral part of the society, bicycles or what we commonly called cycles is the primitive stage of all automobile. The term Efficycle stands for what we called all efficient cycle or hybrid cycle. It is the special kind of cycle moves with higher efficiency than the normal bicycle which has the maximum 60% efficiency & increase in magnitude is almost impossible. In regard to the recent surge of development in the automotive industry, and the growing need for alternative energy source for mobility in day to day scenario, this project carried aims at providing an energy efficient human powered three wheel electric vehicles capable of carrying two passengers. All the features like drive train, differential, suspension, brakes, steering, and frame structure has been designed to comply with the requirements of the people.

Key words: Hybrid Drive, PDMC Motor, Tad-pole Design, Differential

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INTRODUCTION

The tri-cycle has the unique frame structure, designed for maximum stability, manoeuvrability and safety of the passengers. It consists of a tad pole configuration [2F 1R] and the independent steering which provides maximum driver control and least turning radius. The frame of the vehicle is designed for optimum space utilization for housing the motor and the chain differential. The differential facilitating a boost of energy of vehicle. The drive train comprises 2-free wheel sprockets for combining the power obtained from the two passengers. The vehicle is front wheel drive which helps in off road condition.

A literature survey before the design phase, allowed us to determine the basic raw material required. The dimensional tolerance and the process for manufacturing in order to optimize the manufacturing cost and make it commercially viable, the concept of DFM [design for manufacturing] was utilized. The FMEA [failure mode and effect analysis] enabled us to fix the potential problems in the design phase itself. Hence a commercially feasible and production ready vehicle was generated.

TECHNICAL SPECIFICATION

Vehicle Details

Overall dimension -77.3X46X56.5, Kerb weight-80kg and Gross weight -250kg

Table-1 Vehicle Specification

Vehicle configuration	Tad pole configuration (2F 1R)
Vehicle performance	Maximum speed of vehicle:- 40kmph, Acceleration :- 0.5m/s^2
Chassis structure	Approximately pentagonal chassis with rectangular frame work to provide maximum space for mounting of
Power	PDMC Motor , 400W, 24V
Steering	Type: - bell crank mechanism, steering wheel is used. Turning radius:-2.67m
Suspension	Front suspension:- wishbone suspension, Rear suspension:- mono shock absorber
Brakes	Front:-disc brake, Rear :-disc brake
Wheel	Front wheel diameter:- 28 x 2.35 inches, Rear wheel diameter:- 28 x 2.35 inches
Seating	Parallel seating arrangement
Electrical	Battery -12V (2No's), connected in series to give 24V.
Safety	Seat belts , kill switch, covered chain mechanism, driving kit, front impact reducer(innovation)
Additional features	Chain Differential, bell crank steering system

Table -2 Performance Targets

Vehicle configuration	The wheels are not in straight line capable of carrying two riders with a maximum dimension of 100x50x60
Seating arrangement	The seats are placed parallel. maximum seating height is Inches & rider height is up to 190.3cm
Chassis structure	Must be made up of steel alloy with minimum diameter of 1 inch.
Load character	Weight of riders, PDMC motor, battery, utility box.
Brakes	Positive locking brakes on all wheels. Disc brakes must be mounted on the wheel and not on the drive axle.
Power	Must be driven by both human in addition to electric power
Safety	Kill switch should be accessible to both riders. Vehicle to consists of **ROLL-OVER** protection and **FRONT IMPACT** protection

DESIGN METHODOLOGY

VECHILE CONSTRAINTS

Driver-oriented Cockpit design while designing cockpit initial phase vehicle took a force of 8G. This condition should be according to the industries compliance. We perform the analysis on ANSYS software. The result was satisfactory after analysis we found that deflection occur only in the front part of the cockpit. While designing cockpit design we have taken 6.2 foot height for two passengers to ride it comfortably.

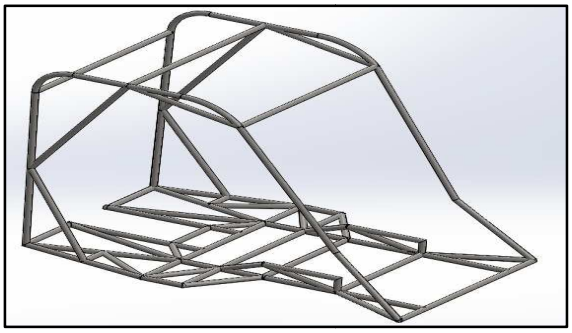
Light Weight, Compact and Simple -Light weight of the vehicle is considered while designing. And our requirement was to design compact vehicle so that our aim of designing human driven vehicle is easy because in human driven vehicle power required to move the vehicle is provided by the passengers.

Structural Rigidity – As a roll cage can resist a force of 8G while performing analysis we have testified roll cage in 4 conditions:-

- Front impact
- Rear impact
- Rollover impact
- Side impact

FRAME CONFIGURATION

- Driver-oriented Cockpit design
- Light weight, Compact and simple
- Structural rigidity
- Rule Book Compliance
- Easy egress during mishap



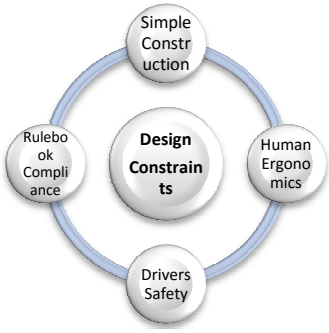


Fig. 1[Design Methodology]

Table -3 Materials used

Option	Selection Criteria	Material Selected	Properties
AISI 1018 ASTM A106 GB AISI 1020	Rulebook compatibility Weight, Cost Market availability	ASTM A 106 grade B OD = 1 Thickness= 2.8mm	Yield stress = 410MPa Ultimate stress=531MPa

POWER TRAIN

The most significant advantage of the chain drive system that reinforces our commitment to it is its ability to transmit large torques without slipping. Also, torque transmission is independent of weather conditions and tire pressure, while the friction drive system was very dependent on those unpredictable factors. A chain drive transmission is also more efficient than a friction drive system. Very high radial forces in a friction drive design put large stresses on bearings and more Power is lost to friction than in a chain drive system.

Power Transmission Combination -
(i) Combination of both drivers (ii) Only motor (iii) Single driver mode (iv) Dual driver mode.

Each driver have their own pedal system which is connected to 44 teeth sprocket and it is connected to other small sprocket by chain mechanism which is attached to the chain differential box, and this differential transmit torque to front two wheels, 44 tooth sprocket is also placed which is connected to differential, second sprocket is connected to rear wheel by 18tooth sprocket by chain. Vehicle can also run on electric, PMDC motor of 400W, 24V supply 1400rpm. Motor transmits power by reducing gear ratio.

Differential Box

Differential we are using is Chain type differential. Differential box is placed in the front axle. Crown gear is replaced by 40 tooth sprocket. Which is connected to driven sprocket? It is simple, high mechanical efficiency, reliable, space saving, less weight.

Brake Parameters

Brakes

Front & rear = disc brake

Calculation

For de acceleration = 0.6g

$= 5.88 m/s^2$

When we covering 50m in 15 sec then velocity should be

$v = (50/15) = 3.33$ or 12kmph

$v^2 = u^2 + 2as$

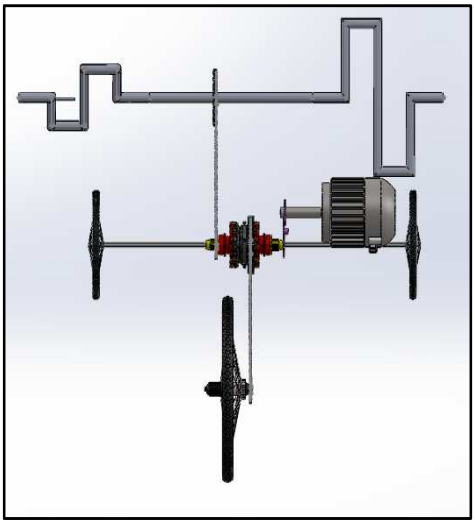
$s = (3.33^2)/(2x\ 5.88)$

$s = 0.942m$

This means we can stop the vehicle from 1m distance only

Time required = (3.33/5.88)

=0.56 sec



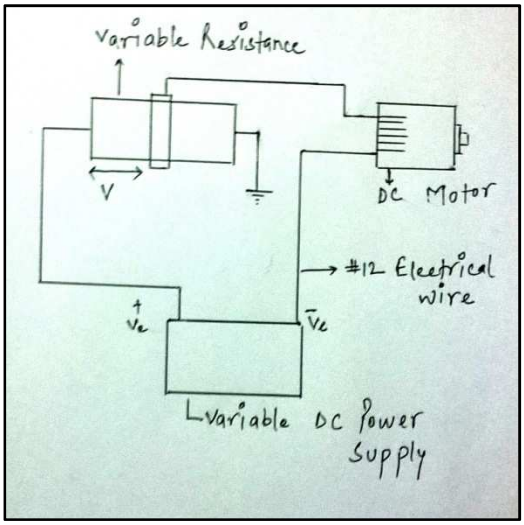
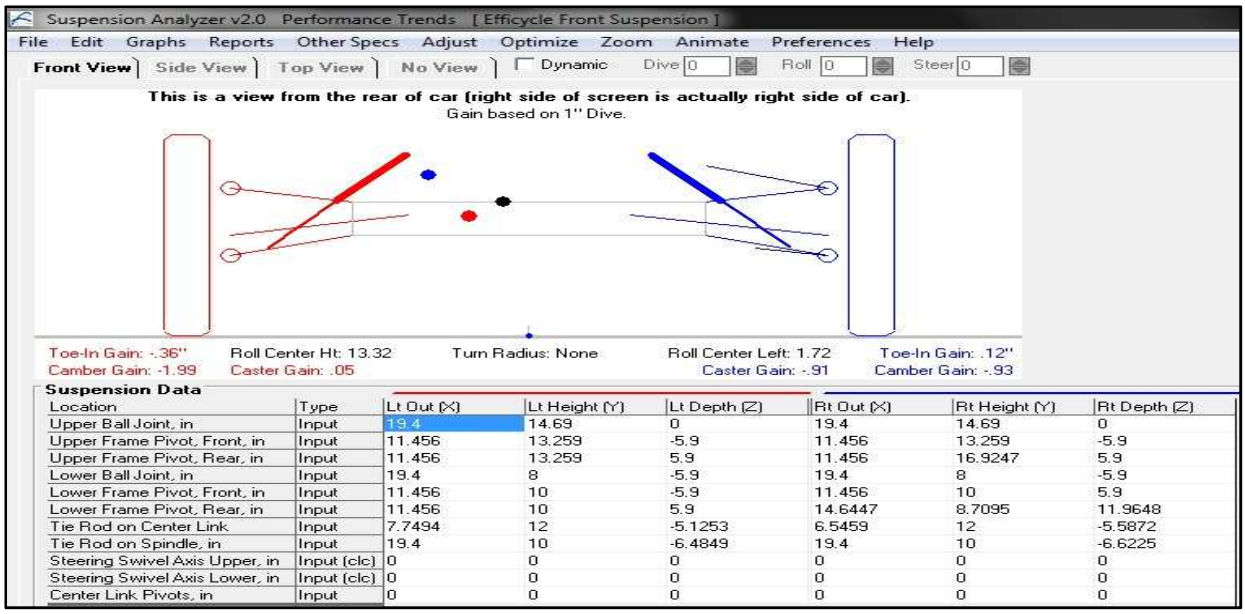


Fig. 2 Power Train and Speed Control of Motor

Suspension

The suspension used in the front of the vehicle is wishbone type suspension and in the rear the mono shock absorber is used. We have performed calculation on SUSPENSION ANALYZER V2.0 and the calculation was satisfactory according to our need of the vehicle.

Table -4 Suspension Calculation



Location	Type	Lt Out (X)	Lt Height (Y)	Lt Depth (Z)	Rt Out (X)	Rt Height (Y)	Rt Depth (Z)
Upper Ball Joint, in	Input	19.4	14.69	0	19.4	14.69	0
Upper Frame Pivot, Front, in	Input	11.456	13.259	-5.9	11.456	13.259	-5.9
Upper Frame Pivot, Rear, in	Input	11.456	13.259	5.9	11.456	16.9247	5.9
Lower Ball Joint, in	Input	19.4	8	-5.9	19.4	8	-5.9
Lower Frame Pivot, Front, in	Input	11.456	10	-5.9	11.456	10	5.9
Lower Frame Pivot, Rear, in	Input	11.456	10	5.9	14.6447	8.7095	11.9648
Tie Rod on Center Link	Input	7.7494	12	-5.1253	6.5459	12	-5.5872
Tie Rod on Spindle, in	Input	19.4	10	-6.4849	19.4	10	-6.6225
Steering Swivel Axis Upper, in	Input (clc)	0	0	0	0	0	0
Steering Swivel Axis Lower, in	Input (clc)	0	0	0	0	0	0
Center Link Pivots, in	Input	0	0	0	0	0	0

INNOVATION

During front collision of vehicles, all force is transmitted to the components of the vehicle and most important thing is driver not safe so to overcome and to prevent drivers various safety measures are taken place (air bags, sensors, etc). So to reduce it we make a mechanism to absorb the collision force and prevents from other components of the

vehicle. We take from the concept of power gripper in which 3 springs are placed between two handle bars. It is wrist exercise mechanical device. So that in front side of our vehicle, one part is fixed to the frame and other part is free to move. Two springs are placed between them which help to absorb or to reduce collision force. Most important is drivers are safe. More efficient, less wear and reduction of cost.

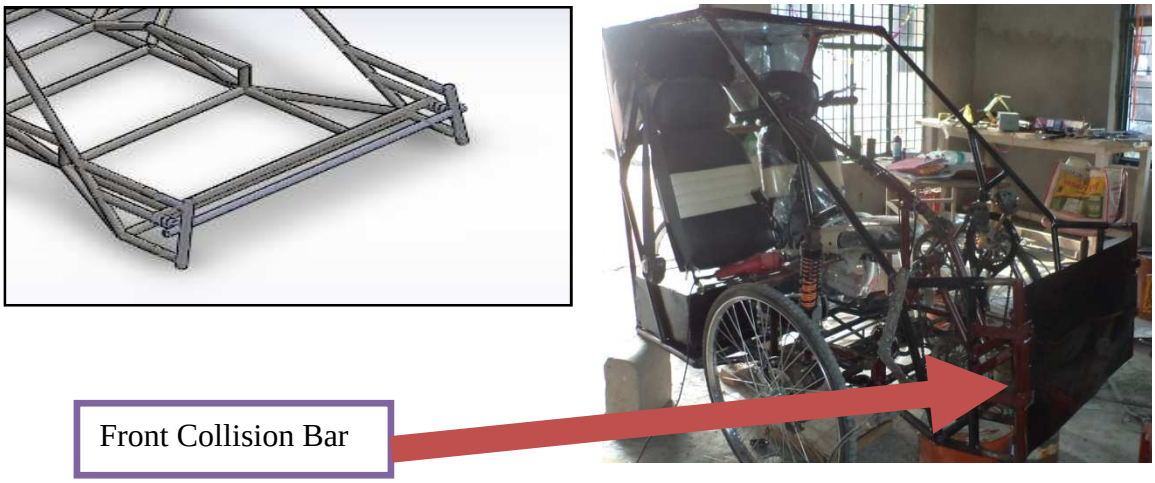


Fig. 3 Front Cpllision Bar

RESULT AND ANALYSIS

This human powered hybrid vehicle (HPHV) is eco-friendly which is one of the advantages for environment. To reduce the rolling resistance, it should consider about the weight and properties of material. The component and frame using the right materials which ensure there are not over design. Also, the alignment of shaft, brakes and pedal should be high accuracy which can reduce friction and heat loss. In addition, the design of the frame should be considered the loading distribution. The evenly loading distribution can reduce the extra energy losing through moving.

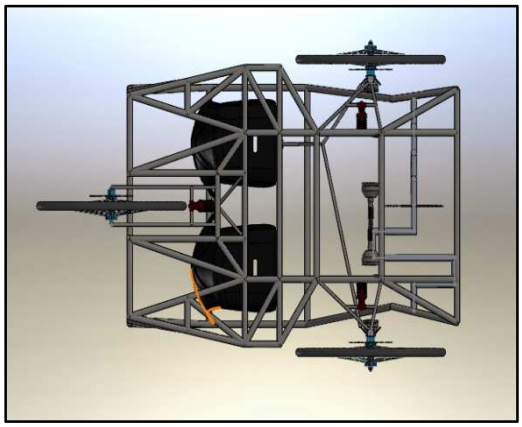
Also, the losses may because of the bad suspension alignment which affected by toe, castor and camber. The track, width and bending of the frame will also affect the stability and cornering. The design should also consider the ergonomic which provide the best sitting position for the driver.

Recyclability and Green Approach

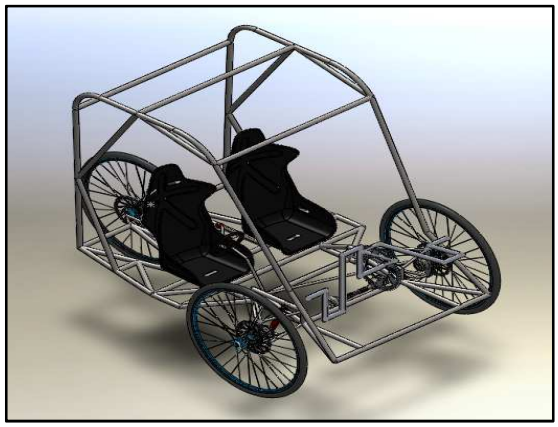
The primary purpose behind the design and fabrication of the vehicle was to go in sync with the GO GREEN anthem.

- The concept of (reuse, reduce, recycle) was appropriately applied during the fabrication process as all the material used in the frame are recyclable. The frame also sports few resale parts hence absorbing the concept of reuse.
- Since the drive chain is a combination of pedal drive and motor driven, this hybrid technology is pollution free and supports the environment.
- The key feature and innovation in the design**.**

SOLID WORKS MODEL

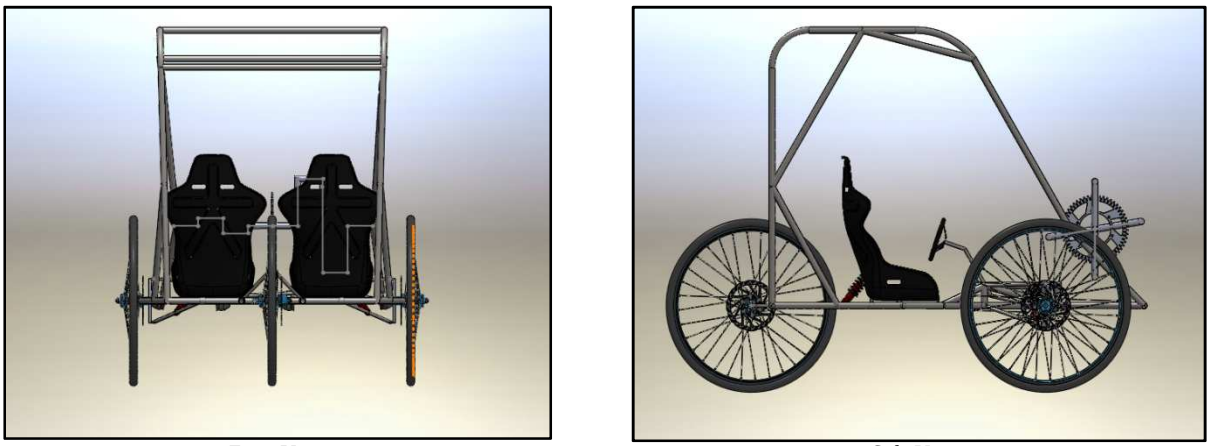


Top View



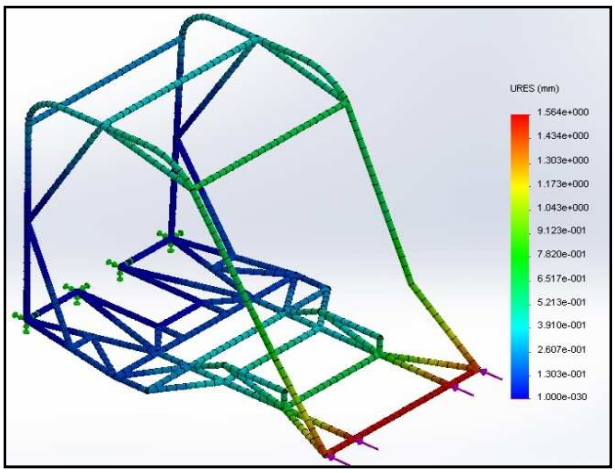
Isometric View

Isometric View of Mock Up with Driver

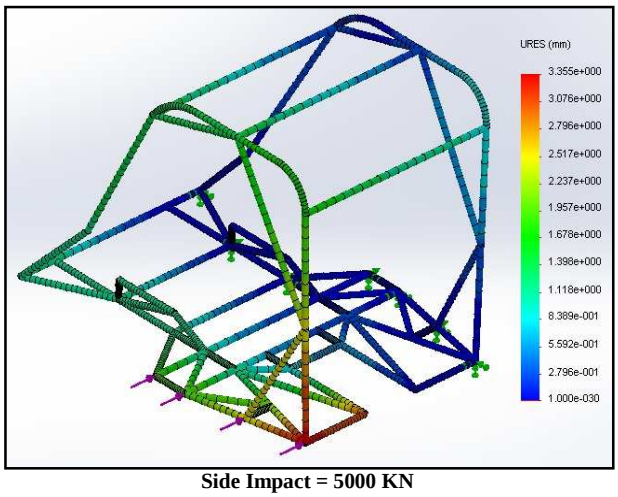


Front View Side View

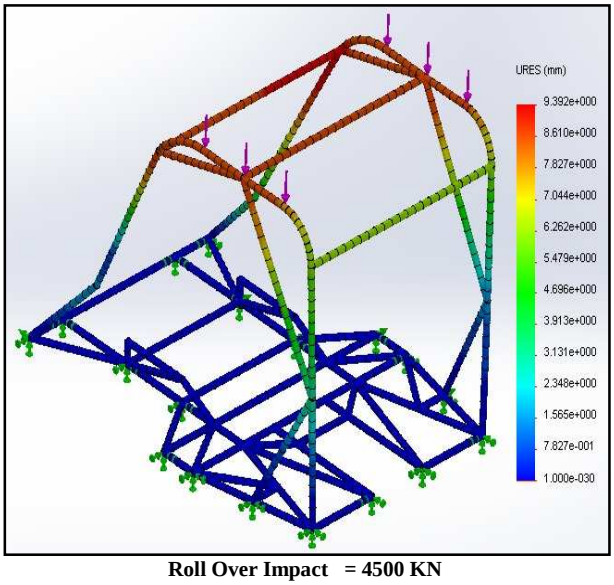
Fig. 4 ANSYS model



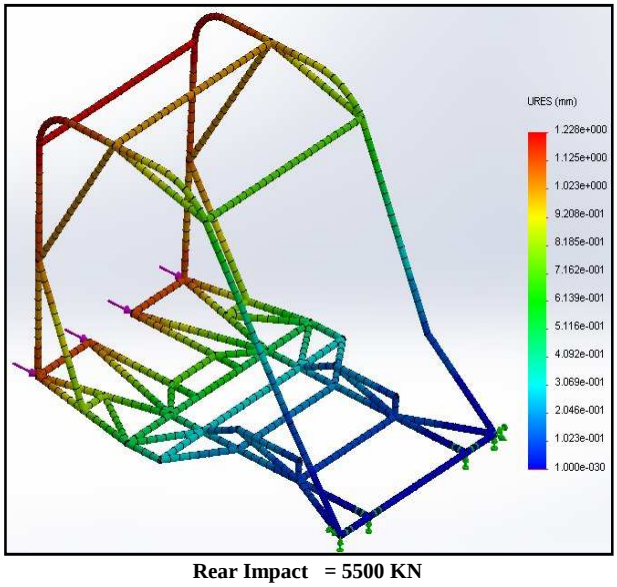
Front Impact = 5500 KN



Side Impact = 5000 KN



Roll Over Impact = 4500 KN



Rear Impact = 5500 KN

Fig. 5

Fig. 6 Final Vehicle design

CONCLUSION

This vehicle is completely with the new concept and changes the automobile industry in the future. We tested all the parameters of the vehicle like

- Designing test in ANSYS – 5500 KN
- Front Impact test – 5000 KN
- Suspension test – OK
- Brake Test – OK
- Acceleration Test – OK
- Steering Geometry – OK

To conclude the new pedal kart has achieved reducing rolling resistance by reducing the weight dramatically [from 42 to25kg]. The weight decrease is mainly due to the design of the kart and use of material. The wheel alignment of the kart was also well position in order to minimize the effect of welding deflection.
Things such as the rotation of the wheels and parts, steering and further weight reduction can achieve a higher performance kart. These measures can be implemented to the kart in near future.
In addition, further testing of the kart and fine tune will be needed in order to find the best setting. Hopefully, the new kart can bring pedal kart technology into a new lever of playing ground and produce flying colors in the future. This vehicle is may be called as Future of New World

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