

# Reciprocating Reversible Front Wheel Drive Incorporated in a Trike

Rishabh Jain , Shivam Setia , Aakash Handa

Department of Mechanical Engineering, College of Engineering Studies, University of Petroleum and Energy Studies,  
Dehradun, INDIA.

**Abstract**—With growing time, there are upcoming new technologies related to driving mechanisms but indeed led to massive emissions and violation of nature laws. Oil consumption is going high and nearly half of the world oil consumption is through automotive sector. Thus there is need for some source, by which we can prevent our nature. This could be done via various methods. One such is- encouraging the use of hybrid trikes. Generally tricycles are less preferred by humans because they require more human effort, they cannot be reversed, doesn't provide the comfortability, rollover stability is less and are slow in speed.

Thus this segment aims at developing a reciprocating reversible drive mechanism in a three wheeler trike which has not been incorporated till now and brings out various advantages. Viewing into the context of INDIA, one cannot drive any vehicle without reversing, thus this mechanism allows a vehicle to be reversed and further, it also reduces the human effort required for the vehicle to move (initial torque increases). This hybrid vehicle allows, increasing the speed of vehicle and making it an all- wheel drive. Further suspension system is incorporated such that the full frame is suspended and provides at-par comfortability and excellent rollover stability to the vehicle. Other advantages include low maintenance cost, always in running condition, cheap in price and one of its kinds when it comes to eco -friendly vehicles.

**Keywords**— *Hybrid, Reciprocating, Rollover, Suspension, Trike*

## I. INTRODUCTION

With the invention of bicycle, thereafter came rickshaws similar to that of bicycle which can carry more loads and are self-stabilized. Talking both about bicycle as well as rickshaws, with increasing load, human effort increased. After that came vehicles including 4 wheels but is not eco-friendly and are expensive too. There are always efforts to reduce the human power required, to increase the comfort zones which are leading to new developments in technology of automobiles.

Taking the view point of a cycle, if it is possible to convert rear wheel drive to front wheel the pedaling can be made easy

and less effortless and further effort can be reduced through reciprocating motion of the pedal. Since front axle has to steer plus power is also delivered to it plus suspension also needs to be taken care of and crank placement on it makes it complex and thus this paper provides a way of keeping all of them in a better way with proper installation. Also the reversible feature of this vehicle is one unique thing which has never been incorporated in any pedal driven vehicle and carries much of importance when it is a 2 seater.

## II. AIM OF THE RESEARCH

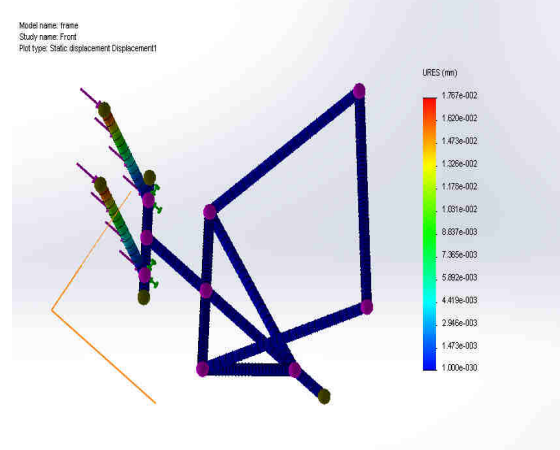
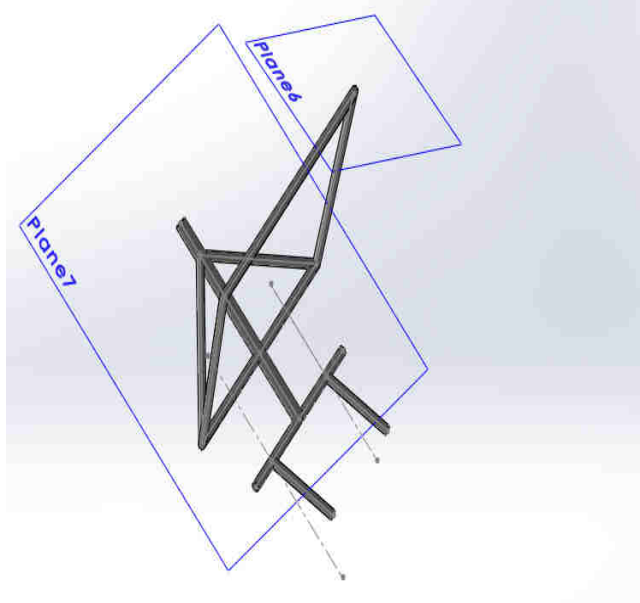
We are developing a technique of eliminating sprockets in a three wheeler, 2 seater, tadpole configured hybrid cycle and instead, using a reciprocating pedal drive on the front wheels to increase the starting torque or to decrease the human effort and to make the vehicle reversible.

## III. MECHANICAL DESIGN OF A MODEL

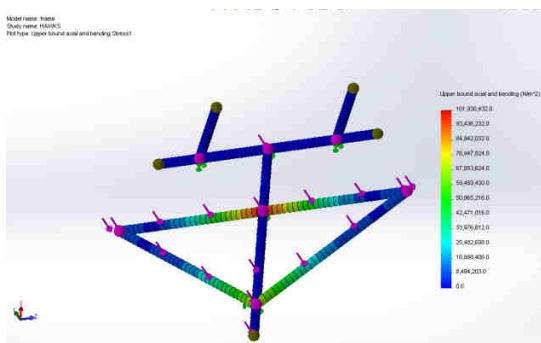
### 3.1 FRAME DESIGNING

It was done in consideration of force distribution, FOS (factor of safety) and Deflection of beam which thus gave rise to a fully triangulated frame with proper load distribution. Frame design was ideated from HAWK a nature bird and thus the vehicle was named HAWK.

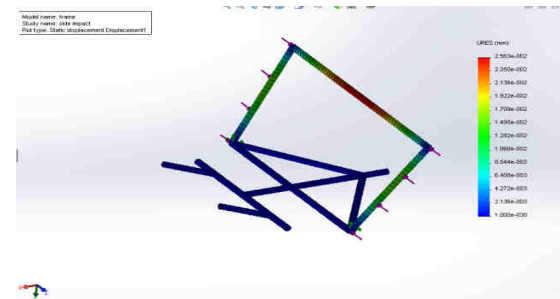
The results of stimulation gave a satisfactory value which is generally/ theoretically correct for further movement in respect to design procedure.



Front Impact Deflection = 1.767e-002



Yield stress = 350 Mpa. Deflection= 2.1mm

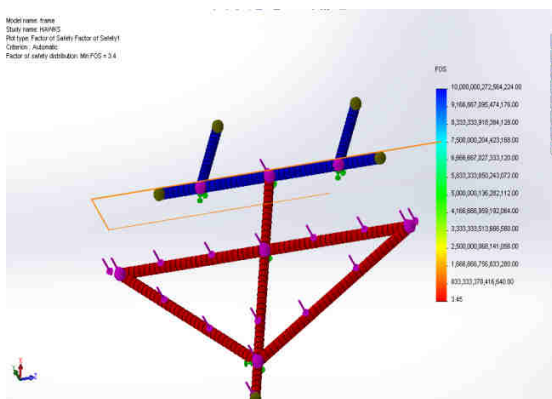


Side Impact deflection = 2.53e-002

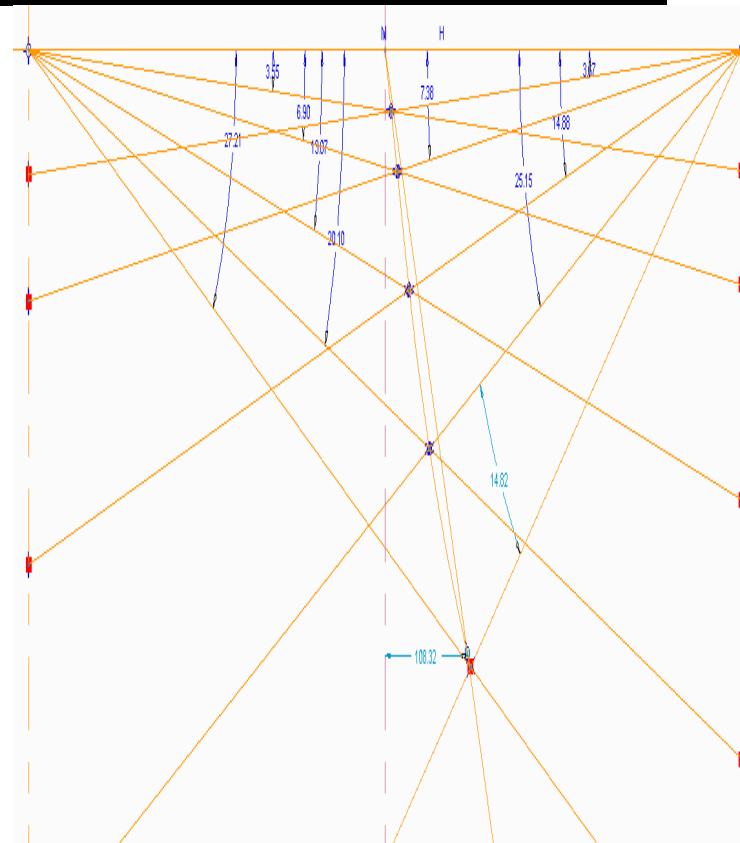
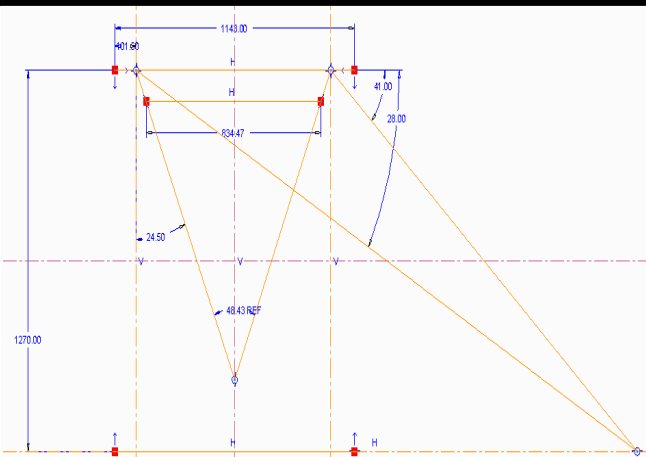
### 3.2 STEERING DESIGNING

It involved simple Ackermann Geometry with the use of tiller arm. This kind of handle bar provides less steering effort and thus is comfortable or the driver. Further calculations giving the following parameters:

- Turing Radius: 2.7 m
- Steering Arm: 127 mm
- Lock Angles: 28 deg. & 41 deg
- Tie Rod: 0.83 m
- Offset: 101.6 mm.



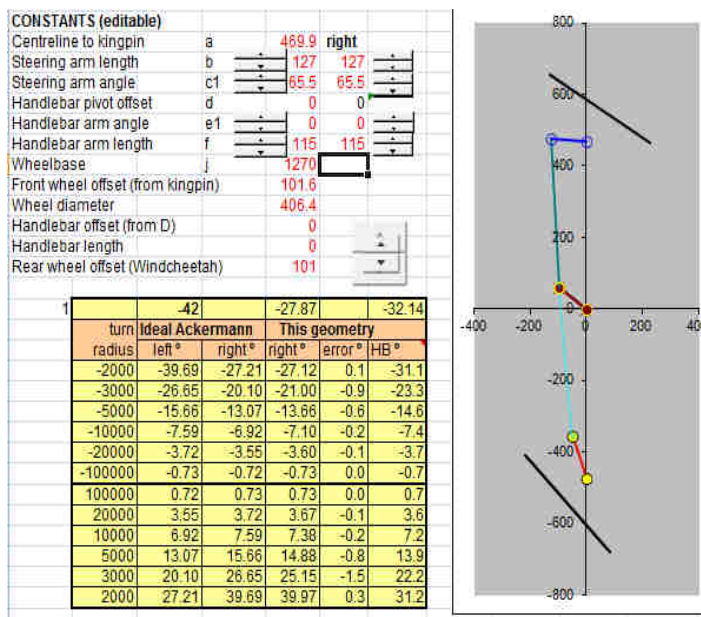
Induced stress = 101 MPa F.O.S.=3.5



Further the design also proved that the steering mechanism is very close running to pure rolling point at turning as the error produced is very less.

The method used the peter eland's spreadsheet which calculated the error (deviation from pure rolling curve).

The plot below shows the error shifting from negative to positive between 2m turn to 3m turn. Thus this proves that between these regions the vehicle is very close to pure rolling condition and also the turning radius of this vehicle is 2.7. Therefore this result proved very useful in context of this vehicle.



Also graphically it was proved, the same point as stated above and the curvature plot is shown below:

### 3.3 SUSPENSION DESIGNING

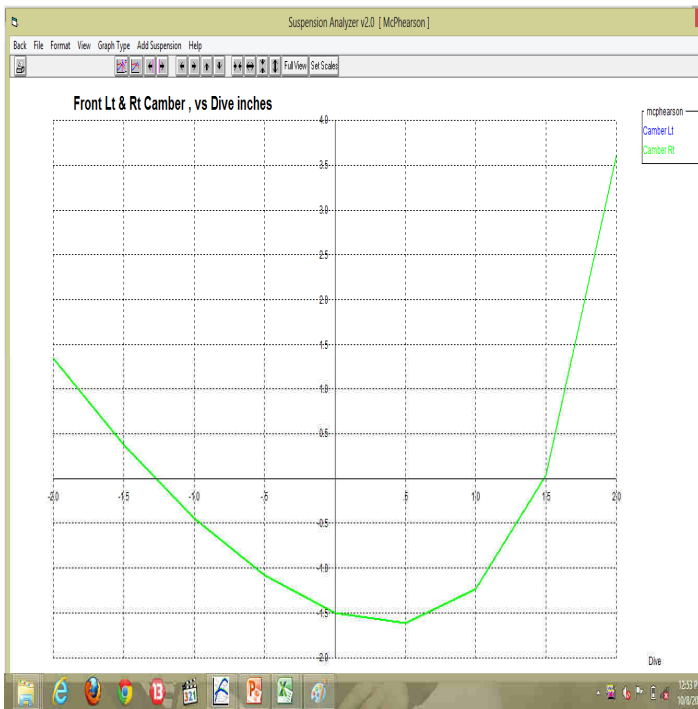
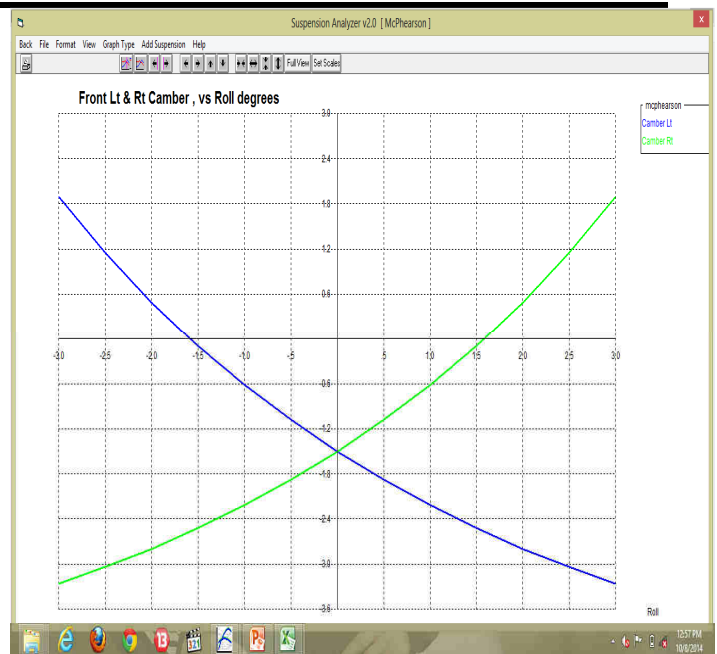
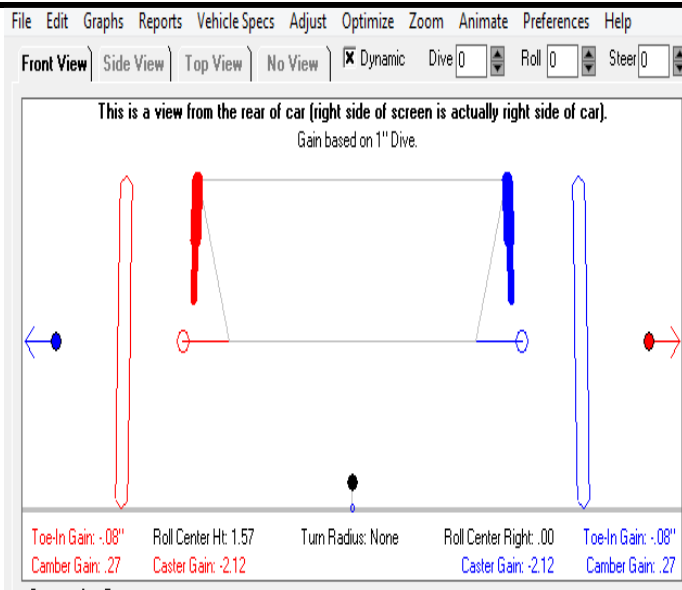
We used the Mac Pherson strut type suspension system for proper handling at comfort criterion. The results of the suspension calculations gave the following features:

1. Mac Pherson strut type
2. Diameter of coil spring-51 mm.
3. Diameter of spring wire-7.01 mm.
4. No of turns-11
5. Roll Centre Height = 39.87mm.
6. Deflection = 55.88 mm.
7. Camber = -1.5°

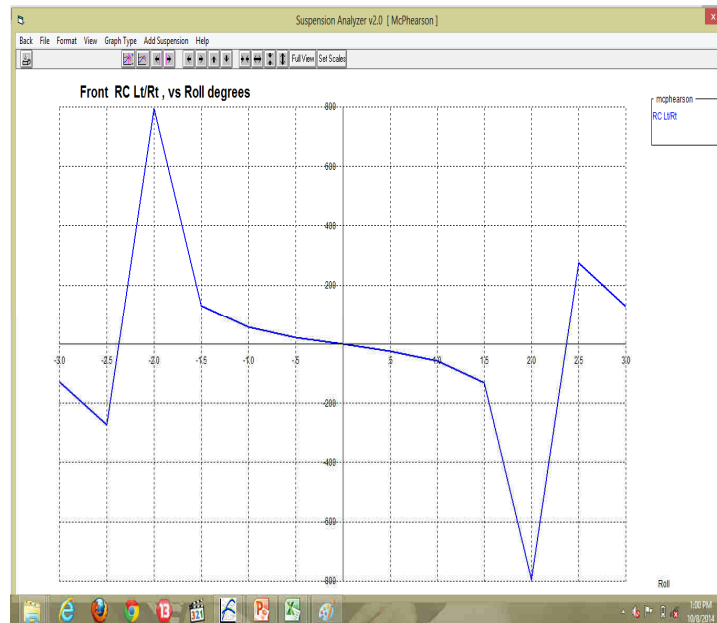
The results of the suspension also relates to an outcome which shows that the vehicle is very less prone to rollover because of less shift of roll centre horizontally. Also the camber is maintained negative while at cornering which is very much required for the stability of the vehicle.

Also various graphical plots have been shown for the justification of rollover and camber characteristics at cornering and dive nature.

For analysis of suspension, suspension analyzer v2.4 was used which showed the following results.



Camber characteristics for dive. (Negative up to +1.5inches)



Roll centre shift for vehicle roll

### 3.4 DRIVETRAIN DESIGNING

1. Material = AISI 1018
2. Pipe diameter = 1inches
3. Thickness = 2mm.
4. Front wheels = 20 inches diameter
5. Rear wheels = 26 inches diameter
6. Hub diameter= 5.5 inches
7. Guide= 6.4 cm.

Since being a front wheel drive both wheels needed to be free wheels. Therefore Universal Joints are incorporated in both front wheels for their separate motion.

Now, the design of reciprocating pedal drive includes one primary crank, one secondary crank and a U shaped crank. Primary crank is a pivoted crank whose pivot point allows the force to be multiplied at the other end. This crank allows the motion to be transferred from vertical plane to horizontal plane and the secondary crank function as way of transferring that horizontal force to the U shaped crank. This crank provides the multiplied efforts to the U crank and finally with this force, the U crank rotates converting linear motion into the rotatory motion of the front axle.

Specifications:

1<sup>st</sup> pivoted length = 240mm.

2<sup>nd</sup> pivoted length = 140mm.

Length of 1<sup>st</sup> crank = 380mm.

Length of 2<sup>nd</sup> crank = 265mm.

U crank (lxb) = 60x50 mm.

Stroke = 120mm.

Now, let us assume force applied at pedal by human =120N therefore, Force at the end of 2<sup>nd</sup> pivoted length=  $F = 120 \times 240 / 140 = 205.7N$

Torque at front axle =  $205.7 \times 0.06 = 12.34Nm$

Now for a normal cycle of sprocket ratio of 2.33 and stroke of 0.18m. So, Torque at 1<sup>st</sup> sprocket =  $120 \times 0.18 = 21.6Nm$  and thus Torque on 2<sup>nd</sup> sprocket=  $21.6 / 2.33 = 9.02Nm$ .

Thus the initial torque for starting is high with same human effort, in case of the reciprocating pedal drive.

Further, if the same amount of torque is required as that of cycle then the force reduction is about =  $(9.20/0.06) \times (140/240) = 89.44 N$  only. Percentage reduction in force = 25.46%.

Motor is also used for powering a rear wheel making it an all- wheel drive vehicle.

Motor and battery specifications:

1. Max. Power = 400watt
2. Max. Rpm = 1500
3. No. of batteries = 2
4. Current rating = 35 amph
5. Voltage =  $2 \times 12 = 24V$ .



#### IV. RESULT AND DISCUSSION

This vehicle is designed considering the environment point of view as eco-friendly is the word now-days and targets the vehicles for short distances with less attainable speeds. The vehicle is made considering the following aspects:

- 1) Comfort and ergonomics
- 2) Design and safety
- 3) Marketing Targets

The cost of vehicle is also reduced when manufactured in large quantities and also targets a large number of people to promote eco-friendly approach to set a trend for the future looking at the present status of environment and sustainability. The scope of the vehicle is not limited; the future target can be made to design the vehicle in all terrains to target the greater audience and facilities.

The design is also not constraint as it can be modified like on-board charging systems, higher utility and also different concepts and variants like side visors and different sensors and actuators

#### V. CONCLUSION

In this paper, the vehicle is designed considering the other designs .The vehicle is designed and tested in the national event SAE-Efficycle 2014 and won the prize for this reciprocating drive that we have incorporated in our vehicle as an innovative idea. The design was also appreciated in the Technical Paper event in the SAE- North India Convention and won the first prize .Further development can lead to the acceptance at the global level and manufacturing.

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## VI. ACKNOWLEDGEMENTS

**Rishabh Jain** is pursuing his B. Tech in Automotive Design Engineering from University of Petroleum and Energy Studies Dehradun, India and has represented the University in National event SAE-EFFICYCLE 2014, BAJA SAE INDIA 2015 virtuals and International Event Formula Student 2015 virtuals .He is also involved in the International project ROLL ON/ROLL OFF University payload Design Challenge for C130J super Hercules under Lockheed Martin Corporation, USA. He has been selected for the SAE Foundation awards-SAE student of the year award (3<sup>rd</sup> position) for excellent academic year 2014-2015.

**Shivam Setia** is pursuing his B. Tech in Automotive Design Engineering from University of Petroleum and Energy Studies Dehradun, India and has represented the University in various national events like SAE-EFFICYCLE 2014, ECO-KART-2015, BAJA SAE INDIA 2015 virtuals and International Event Formula Student 2015 virtuals .He is currently doing International Cancat Project.

**Aakash Handa** is pursuing his B. Tech in Automotive Design Engineering from University of Petroleum and Energy Studies Dehradun, India and has represented the University in National event SAE-EFFICYCLE 2014, BAJA SAE INDIA 2015 virtuals and International Event Formula Student 2015 virtuals.

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