Design of Tilting Reverse Trike

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Abstract - *The safety of the passenger is the first and most important thing to be considered, but the normal trike and vehicle for handicapped people are highly unstable during cornering, which results in an increase in rate of accidents due to slippage and roll over of the vehicle. The use of a tilting mechanism in three wheel vehicles will reduce the rate of accidents caused due to slippage and rollover. The tilting mechanism provides directional as well as dynamic stability and also increases the ride comfort and braking performance. In our project work we have created a tilting three wheel vehicle by adding a tilting mechanism in a normal motorcycle.We have designed the tilting mechanism using a solidworks software, we have tried to keep the design simple. The tilting mechanism can be easily joined to the main frame of the motorcycle. We have used a double wishbone type suspension system in our project which helps in making the design simple and also it increases the traction , braking performance, passenger comfort and their safety.*

***Key Words*: Tilting trike, Tilting mechanism, Reverse trike.**

1. INTRODUCTION

1.1 Normal Trike

Trike is a three wheel vehicle having one wheel in front and two wheels at rear or two wheels in front and one wheel at rear. The trike with one wheel in front and two wheels in rear is called Delta trike, where the trike with two wheels in front and one wheel at rear is called tadpole Trike. The delta trikes are more maneuverable than tadpole trikes; also the turning radius is equal to their wheelbase.

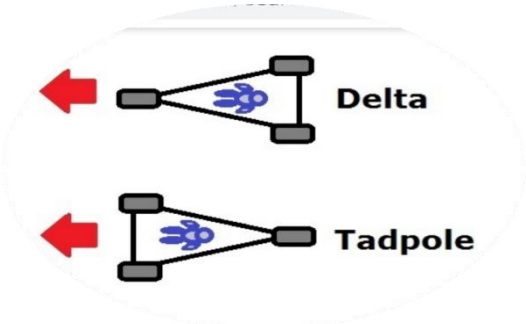

Fig. no.1 Delta trike & Tadpole trike[12]

The tadpole trike are considered more stable than delta trike, Also the construction of tadpole trike are simple as compared to delta trike.

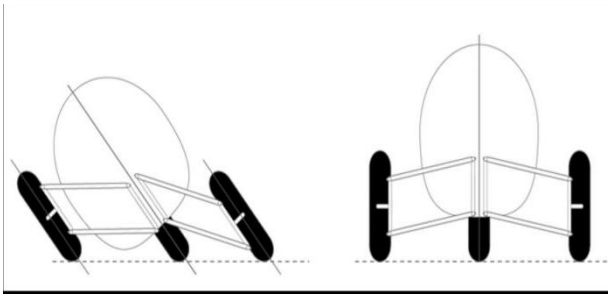

Fig. no. 2 Tilting trike[4]

1.2 Tilting Trike

Tilting trike is a three wheel vehicle which is able to tilt like inline two wheel vehicles such as motorcycles and mopeds. The tilting provides greater stability during cornering and straight line condition. The construction of the tilting mechanism is like a double wishbone suspension system which makes construction simple and also it makes the ride more comfortable and increases the braking performance.

2. PROBLEM ANALYSIS

2.1 Cornering Instability

When the vehicle is turning around the corners, the centrifugal force acts on the center of gravity of the vehicle tangentially to the curve. In case of motorcycle and mopeds the centrifugal force is balanced by leaning the motorcycle. But the normal trike is not able to tilting like motorcycle and mopeds, the centrifugal force tends to lift the inner wheel results in rolling out of the vehicle.

2.2 Larger turning radius

When the vehicle is turning at a speed of 30kmph, due to the centrifugal force that acts on the vehicle it tends to lift the inner wheel and the chance of rolling out of vehicle arsis. To avoid this situation larger turning radius is required but it is limited to the certain speed limit.

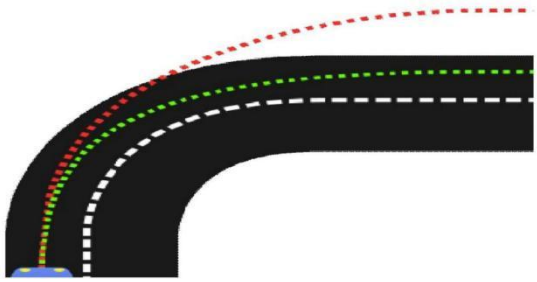

Fig. no.3 Turning radius with or without tilting[7]

2.3 Uncomfortable Ride

The vehicle used by the handicapped people has two supporting wheels joined rigidly to the main vehicle body.

Fig. no. 4 Handicapped vehicle

Due to the supporting wheels the rear suspension becomes ineffective due to which the road shocks are directly transmitted to the main body through these supporting wheels. This results in discomfort for passengers.

2.4 Poor braking efficiency and performance

This problem mainly arises in handicapped vehicles due to the supporting wheels not having brakes in them, those supporting wheels increase the weight of the vehicle. Due to which the loads on brake is increased results in reduced brake life and performance.

2.5 Poor engine performance

When the supporting wheels of the handicapped vehicle is not fitted properly, it creates misalignment with the rear wheel, this causes the loss of traction and this results in poor engine performance.

3. OBJECTIVE

The main objective of our project is to create a tilting trike for handicapped people and old age people by adding a tilting mechanism in normal motorcycles and mopeds with better stability, comfort and good braking and engine performance.

4. METHODOLOGY

For the designing of our trike we make use of three principle such as,

1. The center of gravity should be mounted as close to the two wheel axle to maximize the roll over stability of the vehicle.[11}

2. The Height of the center of Gravity should be less than the half of track width and less than distance to front axle.[11]

3. If the center of gravity is in the front of the vehicle, the vehicle will be stable at all speeds.[11]

5. DESIGN

For designing the tilting mechanism of tilting trike we have considered Tadpole(Reverse) type as the construction is simple and it is more stable than the Delta type.

For designing the trike we first need to find the track width and wheelbase of the vehicle. The wheelbase of the vehicle is kept the same as the 1230mm of the motorcycle for which the tilting mechanism is designed.

5.1 Finding the track width

According to the first point of three principles that “For rollover stability the height of center of gravity from ground is to be less than half of the track width “.

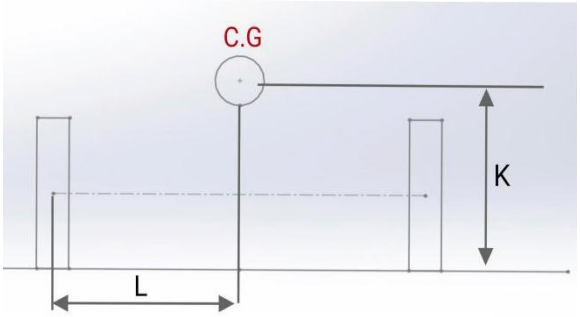

Fig. no.5 Front view of trike

5.1.1 Height of C.G from the ground

The Center of Gravity can be easily found by simple static analysis: force and moment balances.

The Free Body Diagram of a two wheeled vehicle on a horizontal surface.

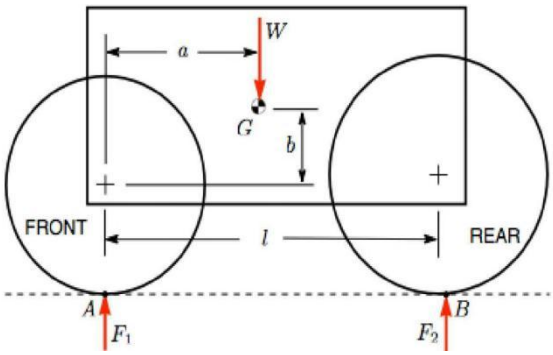

Fig. No. 6 Free Body Diagram of Motorcycle on Horizontal Surface[10]

The notations in fig.

- F1= weight on front wheel
- F2= weight on rear wheel
- W = Total weight of motorcycle
- A = front wheel contact point
- B = rear wheel contact point
- G = center of mass of vehicle
- l = wheelbase of vehicle
- a - horizontal distance from front wheel to C.G
- b = vertical distance from front axle to C.G

Weight on front wheel *F1 = 54.486N.*
Weight on front wheel *F2 = 60.314N*.
Total weight *W = 114.8N.*

Horizontal Analysis

The procedure is to first perform a force balance in the vertical direction, thus

$$\sum Fv = F1 = F2 - W = 0$$

then a moment balance around point A:
$\sum M(A) = F2l - Wa$ (1.0)
$W = 114.8N$ (1.1)
$F1 = 54.486N$ (1.2)
$F2 = 60.314N$ (1.3)
Wheelbase l = 1230mm. (1.4)

Taking moment moment balance around point A:
$Wa = F2l$ (1.5)
Substituting the values of "(1.1), (1.3), (1.4)" in "(1.5)" we get,

a = 651.9mm

Inclined Analysis

The motorcycle is placed on the inclined surface having height(h) of 146mm.

Angled Free Body Diagram

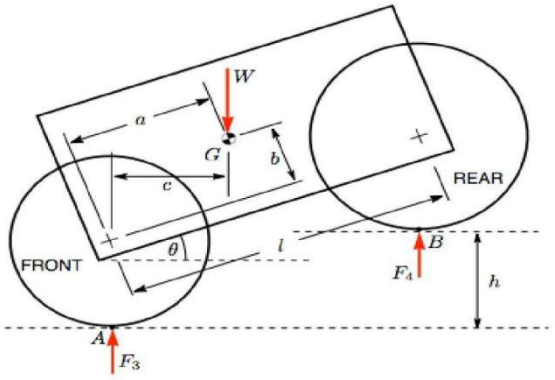

Fig. No. 7 Free Body Diagram of Motorcycle on Inclined Surface[10]

Weight on front wheel *F3 = 56.10N.*
Weight on front wheel *F4 = 58.70N.*

Balancing the moment at point A,
$\sum M(A) = F4l\cos\theta - Wc = 0$ (2.0)
$c = a\cos\theta - b\sin\theta$ (2.1)

By substituting the "(2.1)" in "(2.0)" we get,

$b = (Wa - F4l\cos\theta)/W\sin\theta$ (2.2)
F4 = 58.70N

By substituting the numeric value we get,

b = 146mm

The ground clearance of the vehicle is 159mm.

Hence total height of C.G from the ground(K) is,

K =146 + 159

K = 305mm

This height of center of gravity of motorcycle is used for reference purpose for finding the track width of tilting trike and from this value we can say that the minimum on half track width is to be more than 305mm.

5.1.2 Centroid of triangle

According to the third principle, the half of the track width is more than the distance of center of gravity from the front axle. This distance can be found by using the theory of centroid of triangles.

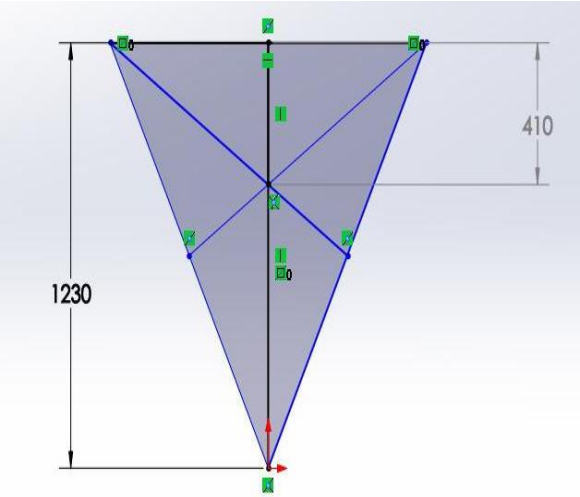

Fig. no.8 Centroid of triangle

Here we have considered the equal weight distribution which means 33% on each wheel. Due to the equal weight distribution the distance on center of gravity does not depend upon track width. For creating the triangle we use track width same as wheelbase which is 1230mm.

From Fig. 8 we find that the half track width of the vehicle is to be more than 410mm. Thus we have kept the track width of around 900mm.

6. STEERING GEOMETRY

In our tilting trike, there are two wheels in front which means during turning the inner wheel turns at a greater angle than the outer wheel for correct steering.

6.1 Ackerman Angle

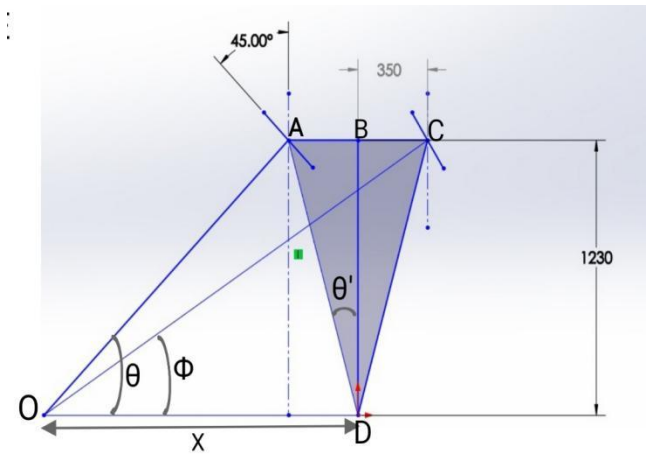

Fig. no.9 Steering Geometry

AB = King pin distance
BD = Wheelbase
Θ = Maximum turning angle of inner wheel
Φ = Maximum turning angle of outer wheel
Θ' = Ackerman Angle

From above Fig. we can find the ackermann angle,
$tan\theta' = AB/BD$
$tan\theta' = 350/1230$
$\theta' = 14°$
Ackerman angle $\theta' = 14°$

6.2 True Rolling

For true rolling condition, the inner wheel has to turn at a greater angle than the outer wheel.

The maximum turning angle of inner wheel Θ is 45°.
From Fig. no.9 we say that,
$cot\Phi - cot\theta = AB/BD$
$cot\Phi - cot45 = 350/1230$
$cot\Phi - cot45 = 0.2486$
$cot\Phi - 1 = 0.2486$
$\Phi = 37.90°$

Thus for true rolling, maximum turning angle of outer wheel is $\Phi = 37.90°$

6.3 Turning Radius

The theoretical turning radius of the vehicle can be found by using trigonometry law.

From Fig. no.8 we get,

$tan\Phi = BD/(OD + 350)$
$tan\Phi = 1230/(x + 350)$
$\tan 37.90° = 1230/(x + 350)$

$0.7785 = 1230/(x + 350)$

$x = 1579.96 - 350$
$x = 1229.96mm$

$x = 1230mm$

The Turning radius of the tilting trike is $x = 1230mm$.

7.0 3D MODEL

7.1 When the tilting mechanism hits bumps and potholes

The construction of tilting mechanism in tilting trikes is like a double wishbone suspension system.

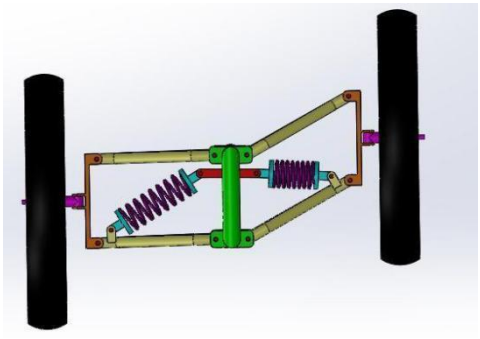

Fig. no.10 During Bump or Potholes

Thus the wheel under bump and potholes only experience roadshock and this shock is not transmitted to the other wheel.

7.2 Tilting mechanism during turning

During turning the tilting mechanism of the trike helps in tilting the vehicle like an inline two wheel motorcycle.

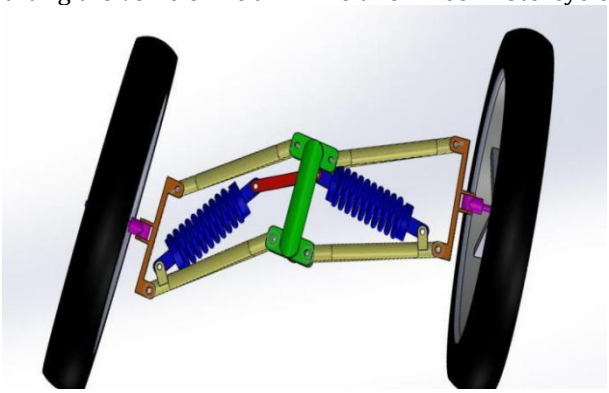

Fig. no.11 During turning

7.3 During straight road conditions

During straight road conditions the tilting mechanism provides better traction, stability, braking performance with comfortable ride condition.

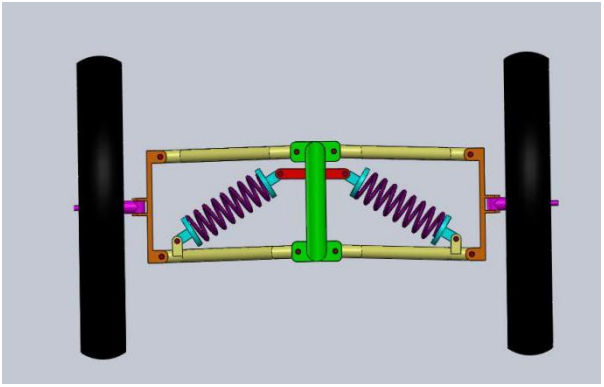

Fig. no.12 During straight road condition

7.4 Components of tilting mechanism

Center Frame

Center frame is the main component of the tilting mechanism which is directly attached to the main frame of the motorcycle or mopeds. Both Upper and Lower wishbones are attached to the center frame.

As it is directly joined to the main frame of the motorcycle it transfers the tilting motion to the wheels through wishbones.

Wishbones

The wishbone type suspension is an independent suspension system which consists of upper and lower wishbones connected to the main frame and they are mainly parallel to each other to locate the wheel.

The lower wishbone used in tilting trikes have mounting in which shock absorbers and coil springs are attached. In tilting trike these wishbones transfer the motion of leaning to the wheels such that the wheels tilt at the same angle as of the main frame.

Hubplate

The hub plate is also known as a steering knuckle which connects the wheel and the wishbones of the suspension system. The hub consists of a spindle on which the wheel rotates freely.

Shock absorber and coil spring

The suspension of the tilting trike consists of a shock absorber and coil spring just like a normal suspension system. The suspension system is such that it does not block the tilting mechanism. One end of the shock absorber is connected to the hinge point on the lower wishbone while the other end is connected to the end of the other shock absorber such that it is not connected to the center frame as shown in Fig.11.

8. ADVANTAGES, LIMITATIONS & APPLICATIONS

8.1 Advantages of tilting trike

- The stability of the vehicle is increased due to the double wishbone type independent suspension system.
- The rate of accidents reduces causes due to skidding and rolling out.
- The vehicle will be useful on highways as well as on off roads.
- Provide higher vehicle stability during cornering.

- Load carrying capacity increase.
- Both the front wheels of the vehicle have brakes resulting in higher braking efficiency and performance.
- The engine efficiency of the vehicle with a tilting mechanism is better.
- The ride quality of the vehicle is better.

8.2 Limitations of tilting trike

- The weight of the tilting trike is increased due to addition of wheel, wishbones, center frame, wheel hub, etc.
- As compared to motorcycles and mopeds, the engine efficiency is reduced due to increased weight.
- For tilting of trike weight shifting is required.

8.3 Applications of tilting trike

- Tilting trike is mainly for handicapped and old age people.
- The vehicle can be used in both ON road and OFF road conditions.
- Due to increased straight line and cornering stability the tilting trike can be used in wet road conditions.

9. CONCLUSIONS & FUTURE SCOPE

9.1 Conclusion

This project report includes the Designing process of the tilting mechanism which is used in normal trike and for handicaped vehicle.

By implementing the tilting mechanism in three wheel vehicles, it is able to tilt at an angle of approximately 30°.

Due to tilting of the vehicle the stability is increased during cornering at different speeds, also their double wishbone suspension system provides greater traction to wheels which results in better braking performance. The double wishbone suspension system also provides comfortable ride conditions.

9.2 Future scope

An Advanced tilting mechanism can be implemented along with an advanced lean lock which can be controlled by use of ECU by calculating the speed, acceleration or braking and load on the vehicle.

The tilting mechanism can also be implemented on the four wheel vehicle having higher ground clearance such as ATV, LMV, which helps in providing Roll Over stability to the vehicle during cornering at high speeds.

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