International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 04, April-2019

LEANING REVERSE TRIKE WITH DOUBLE WISHBONE SUSPENSION SYSTEM

Jayvish Jani[1], Prof. Devang Patel[2], Prof. Ajay Solanki[3]

[1]*Mechanical Engineering Department & SVIT-Vasad,*
[2]*Mechanical Engineering Department & SVIT-Vasad,*
[3]*Mechanical Engineering Department & SVIT-Vasad,*

Abstract— ***A leaning vehicle has a frame that pivots relative to a pivotable frame member about a pivot axis. A preferably Three wheeled vehicle having tilting characteristics that allows the vehicle to have substantial leaning properties similar to those offered by an inline two wheel vehicles, but that does not require complex linkages or control system to operate effectively. Purpose of designing this mechanism in order to increase the cornering safety and stability of the vehicle at high speeds also for person with disabilities. For demonstration, this mechanism is installed in Honda Activa model 2004 because it is gear less vehicle, so person with physical disabilities able to drive it. Independent Double Wishbone Suspension system in front two wheels is used to get good steering and lean property. Leaning mechanism is carried out for a normal reverse trike to give it the flexibility of a two wheeled motor cycle. Leaning a vehicle can provide many performance and design advantages including greater stability while turning as well as reduced probability of roll over while taking a turn.***

Keywords— ***Leaning mechanism, Independent suspension, Reverse trike, Wishbone suspension, Stability***

I. INTRODUCTION

Leaning vehicles possess the ability to lean the body frame about a pivot axis in the particular direction of making turn. This system provides better mobility and stability with more traction while cornering at optimal speed, this helps the rider to maintain proper balance on vehicle. Reverse trike is simply the reverse design of presently available Trike. Unlike trike the reverse trike possess two wheels at front and one wheel at rear which is generally driven by mechanical means such as engine or electric motor. The idea behind using reverse trike design is to optimize the design of trike by proper weight distribution, proper cornering and stability at normal speed. Though there are two wheels at front, the steering mechanism is a bit difficult to handle because the leaning effect and turning of the vehicle depends on these front two wheels. The Wishbone suspension has two shock absorbers and control arms on each side of the vehicle. These arms are like the two legs of chicken wishbone or letter V. These wishbones are connected with chassis frame on the open end one arm is below whereas the other is above the frame. This helps to keep the wheel track constant, so avoid the tyre scrub and thus reduces the tyre wear. This suspension is popularly known to tackle irregular surfaces without giving a jerk to the rider and thus makes the ride smooth. The centre of gravity of bike moves out from the vehicle body while making a turn due to angle of heel which may lead to an accidental situation, while in leaning mechanism reverse trike has centre of gravity within the body frame of the vehicle which provides more stability and appropriate lean angle to the rider with negligible accidental possibilities.

II. PROBLEM IDENTIFICATION & SOLUTION

Presently available vehicle design for handicapped person requires proper balancing also stability of such vehicle is difficult due to those rigidly supported wheels on either side of the vehicle and this is the main reason for improper overall weight distribution of vehicle. The worst thing about those wheels is they do not posses any kind of suspension system. In case vehicle is stuck in a pothole in such a manner that the driving wheel loses its traction from road surface and freely rotates on accelerating, the vehicle requires external effort to move from such situation and ultimately this is a huge headache for a physically challenged person.

Fig. 1 Loss of Traction on uneven surface

Fig. 2 Presently available vehicle design for handicapped person

To overcome this problem, these rigidly supported wheels should be eliminated and a leaning mechanism is to be introduced which would provide better mobility and stability of the vehicle with proper overall weight distribution.
The professional bike racers need to lean at appropriate angle in order to make turn, this action requires proper balance and stability or else it may result in an accident. Where if leaning mechanism is introduced in such bikes, it provides better stability while turning, by which chances of accident becomes negligible. Also it provides smooth and secure turn at optimal speed.

Fig. 3 Angle of heel for racing bike at turning

III. MATERIAL PROPERTIES

Out of many materials like aluminium, mild steel, etc., The mild steel is the correct option for manufacturing as its mechanical properties are favourable and it possess better strength and machinability.
Following are the raw material dimensions,
1.) Rectangular cross section pipe: 50mm x 25mm x 3.5mm.
2.) Circular pipe: OD 21mm, ID 16mm.

TABLE I
MECHANICAL PROPERTIES OF MILD STEEL

Mechanical properties	Metric
Hardness, Brinell	126
Hardness, knoop (converted from barinell hardness)	145
Hardness, Rockwell B (Converted from brinell hardness)	71
Hardness, Vickers (Converted from brinell hardness)	131
Tensile strength, Ultimate	440 Mpa
Tensile strength, Yield	370 Mpa
Elongation at Break(in 50 mm)	15.0 %
Reduction of Area	40.0 %
Modulus of Elasticity (Typical for steel)	205 Gpa
Bulk Modulus (Typical for steel)	140 Gpa
Machinability (Based on AISI 1212 steel as 100% machinability)	70 %
Shear modulus(Typical for steel)	80.0 Gpa

IV. DESIGN METHODOLOGY AND SIMULATION

Following are the list of components along with its design model and required simulation for individual components and assembly.

TABLE III
COMPONENTS

Sr. No.	Name of Component	Material
1	Body Frame	Mild Steel
2	Upper Control arm	Mild Steel
3	Lower Control arm	Mild Steel
4	Shock absorber stand	Mild Steel
5	Wheel hub/C - arm	Mild Steel

A. Body Frame

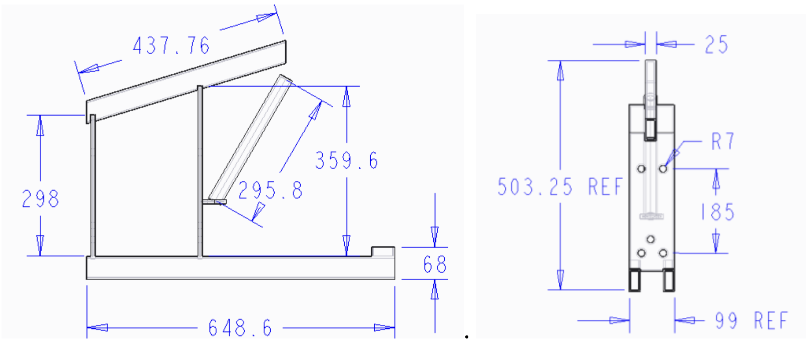

Fig. 4 Front view and Side view of Body Frame

Volume = 1.5941445e+06 mm^3
Surface Area = 7.8947552e+05 mm^2
Density = 7.8700000e-06 kg / mm^3
Mass = 12.545917 kg

B. Upper control arm

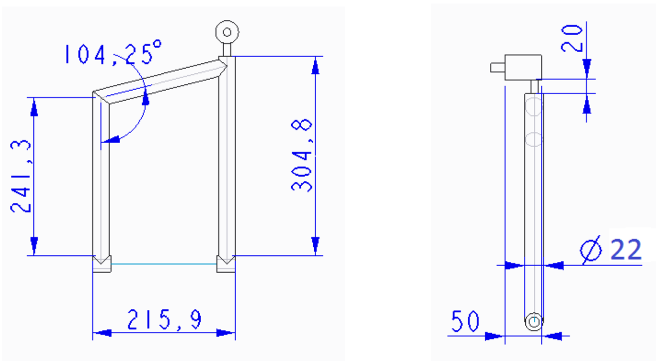

Fig. 5 Front view and Side view of Upper control arm

Volume = 4.3163634e+05 mm^3
Surface Area = 7.3737598e+04 mm^2
Density = 7.8700000e-06 kg / mm^3
Mass = 3.1969780 kg

C. Lower left control arm

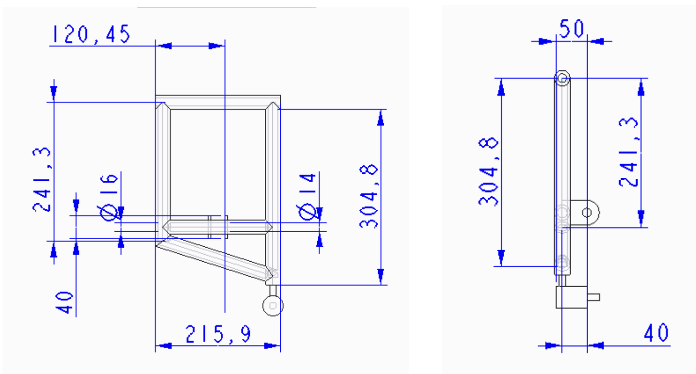

Fig. 6 Front view and Side vide of Lower left control arm

Volume = 4.0311172e+05 mm^3
Surface Area = 1.5923570e+05 mm^2
Density = 7.8700000e-06 kg / mm^3
Mass = 3.7724892 kg

D. Lower right control arm

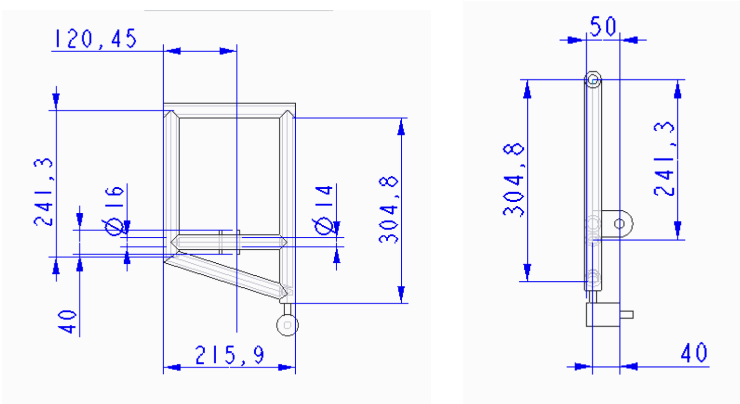

Fig. 7 Front view and Side vide of Lower right control arm

Volume = 4.0521938e+05 mm^3
Surface Area = 1.5915015e+05 mm^2
Density = 7.8700000e-06 kg / mm^3
Mass = 3.7890765 kg

E. Shock absorber Stand

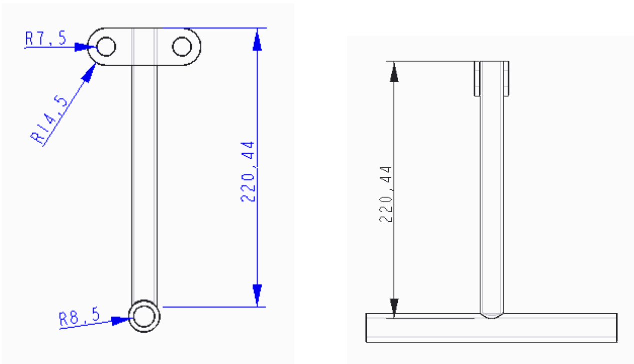

Fig. 8 Front view and Side view of Shock absorber stand

Volume = 1.0913350e+05 mm^3
Surface Area = 6.4472123e+04 mm^2
Density = 7.8700000e-06 kg / mm^3
Mass = 0.85888063 kg

F. Wheel hub or C arm

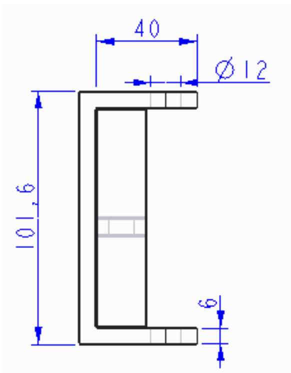

Fig. 9 Front view of C arm

Volume = 5.0408914e+04 mm^3
Surface Area = 1.8205012e+04 mm^2
Density = 7.8700000e-06 kg / mm^3
Mass = 0.39671815 kg

G. Assembly

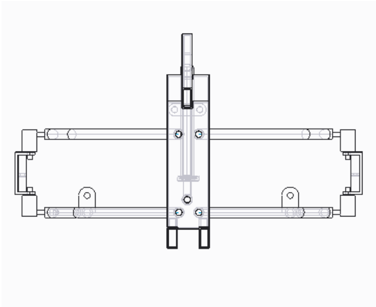

Fig. 10 Front view

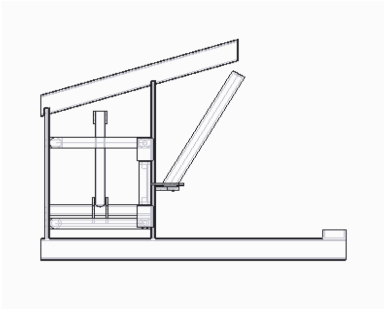

Fig. 11 Side view

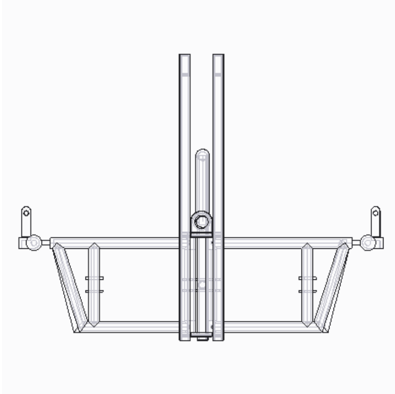

Fig. 12 Top view

Volume = 3.4731423e+06 mm^3
Surface Area = 1.3558931e+06 mm^2
Average Density = 7.8700000e-06 kg / mm^3
Mass = 27.333630 kg

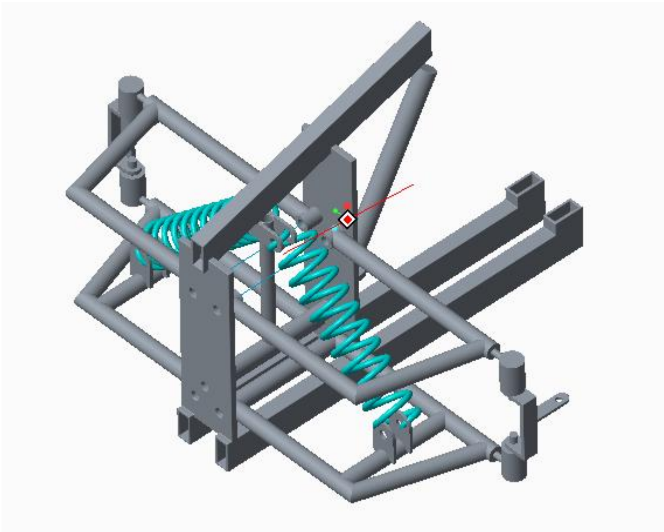

Fig. 13 CAD Model Assembly

V. SIMULATION

As the main portion on which whole assembly is mounted is body frame though need to simulate it to find out its Stress, Strain and Displacement distribution.
Maximum Load: 2500 N

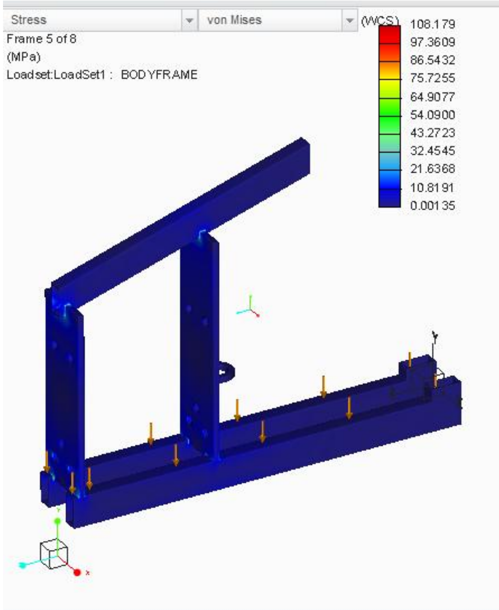

Fig.14 Stress distribution of body frame

Maximum Stress (σ max): 109 MPa
Tensile Yield Strength of MS (Syt): 370 MPa
Factor of Safety (Syt / σ max): 3.39

Since the stress induced is well within the yield strength of the selected material and the factor of safety was found to be 3.39, hence the design is safe for the applied load.

VI. Specifications

A. Front Suspension

Suspension type: Double Wishbone spring for 7610-1298 series shocks.

TABLE IIIII
SUSPENSION SPECIFICATIONS

Description	Values
Part No.	250-19/29/42CH
Lo (Free Length of spring)	250 mm
Di (Inner Diameter)	42 mm
d (Wire Diameter)	8 mm
C (Spring Rate)	19-42 N/mm
Lbi (Minimum Spring Length)	110 mm
S (Length In-between the spring seat)	235 mm

B. Wheels Specification

Front two wheels should be selected in such a manner that it should provide proper ground clearance.

TABLE IVV
WHEELS SPECIFICATION

Description	Values
Tyre Size (Front)	16 Inch
Tyre Size (Rear)	12 Inch (default)
Tyre type	Tube
Wheel type (Pressed Steel/Alloy)	Spoke 32nos.
Tyre width	60mm
Tyre height	42mm

C. Overall Vehicle Dimensions and Weight

After applying this system to Activa model: 2004 following are the new modified dimension of the vehicle,

Overall vehicle span: 1770 mm
Overall wheel width: 865 mm
Overall height: 1130 mm
Overall weight: 126 Kg
Maximum tilt angle: 28° - 35°
Ground clearance: 135 mm

VII. IMPLEMENTATION

A. STAGE 1

Eliminating the default front wheel of Activa Model 2004 and removal of fibre body to get sufficient space for welding and fabrication work.

Fig. 15 Stage 1

B. STAGE 2

Manufacturing of body frame, shock absorber stand, lower and upper control arms. TIG welding process is used with mild steel electrode of diameter 4mm.

Fig.16 Welding process of control arms

After manufactured these components, it is required to be installed on main body frame of the vehicle,

Fig. 17 Installation of control arms, suspension stand and shock absorbers on body frame

C. STAGE 3

Installation of wheels by calibrating the control arms with respect to tie rods and steering rod.

Fig. 18 Installation of tie rods, steering rod and wheels

D. STAGE 4

Installation of battery and fibre body to the vehicle and paint with proper colour to avoid corrosion.

Fig. 19 Final model after paint

VIII. EXPERIMENTAL ANALYSIS

TABLE V
TEST REPORT

Sr. No.	Testing Subject	Testing Outcomes
1	Frame Static Loading test	Frame successfully takes 2500N load without failure
2	Shock absorbers compressibility test	It takes required amount of load, hence supports the vehicle while leaning
3	Steering mechanism alignment test	Mechanism is properly aligned and provides good turning in both static and dynamic conditions
4	Wheel traction test	All three wheels have perfect traction to road without being slip
5	Cornering and Turning test	Vehicle remains stable in both the conditions, though steering is hard to handle
6	Leaning test	Vehicle provides good leaning range between 15° to 35°

IX. Cost Estimation

Following is the cost estimation table which includes cost of various components and other necessary details,

TABLE VI
COST ESTIMATION

Sr. No.	Description	Cost (Rs.)
1	Activa Model: 2004	8500
2	Mild Steel Raw material (50*25mm) (OD:22mm, ID: 16mm) Total weight: 24.1Kg (Rs55 per Kg)	1450
3	Shock absorbers Qty:2	500
4	Wheels Qty:2	800
5	Fabrication work	1000
6	Welding work	8000
7	Axle bolts, Nut bolts, washers, bushes,	300
8	Tie rods Qty: 4	1200
9	Spray paint	400
Total		**22150/-**

X. Conclusions

It is very economical and fairly simple to drive. The performance, handling and safety of the reverse trike with leaning mechanism are much better than others commercially available vehicle for handicapped person. The Centre of Gravity of the vehicle remains within the body of vehicle which provides safe and secure lean to professional bike racers while making a turn.

REFERENCES

[1] S Tonoli Andrea “Suspension Tilting Module for a Wheeled Vehicle” 2007, Avigliana, Italy.
[2] Fecteau Berthold “Suspension including wheel tilting system” 2004, Richmond, Virginia, U.S
[3] Lawayne Matthies “Tilting independent Suspension system for motorcycle trike” 2008, Dallas,Texas.
[4] Eshaan Ayyar “Selection, Modification and Analysis of Suspension System for an All-Terrain Vehicle” Volume-2, Issue-4, 2013.
[5] Tamide Venkata Ramana “Modeling and Evaluation of a Two Wheeler Suspension System for Different Loads and Materials” Volume-3, Issue-8, 2016. Sri Sunflower College of Engineering & Technology, Lankapalli.
[6] Subhash N “Design of leaning attachment” Volume-5, Issue-6, Jun-2017.
[7] Hardik Parmar “Leaning Mechanism” Issue-7-ICEMTE, March-2017.
[8] Chandresh P. Rana “A review-Leaning reverse trike”, Volume-3, Issue-6, 2017 Vadodara Institute of Engineering, Gujarat, India.
[9] Shubham N. Raut “Design, Modification & Implementation of Tilting Steering System”, Volume-7, Issue-3, May-June 2017 Sanjay Ghodawat Institute, Atigre, Maharashtra, India.
[10] Atheender A “Tilt Suspension system for the three wheelers and reverse trike”, Volume-3, Issue-1, Jan-2018 Saveetha Engineering College, Thandalam.
[11] Abhijit M. Mane “ Design and Fabrication of Universal tilting three wheeler mechanism”, special issue, ISSN 2395-1621, May-2017 ArvindGavali College of Engineering, Panmalewadi, Varye, Satara-415015, Maharashtra, India.
[12] Jawwad A. K. Lodhi “ Performance Evaluation of Leaning Reverse tirke”, Volume-02, Issue-10, ISSN 2395-7549, December-2016, Anjuman College of Engineering & Technology, Nagpur, Maharashtra.
[13] Meng Chen “ Project Proposal and Feasible Study”, Calvin College December-2012.
[14] V.B.Bhandari “Design of Machine Element” Edition-2, 2014.