Leaning Reverse Trike

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Abstract— Major problem for designer of an automobile is to obtain its utility & to enhance the value with development, so that product acceptability is maintained. Tilting trikes inherit leaning &dynamic stability characteristics of bicycles and static stability of trikes. Trikes can be better in cornering, stopping, handling & in stability than practical bicycles. Motorized and unmortised tilting reverse trikes are a new vehicle development. This project focuses on unmortised tilting recumbent trikes (tilters). They are part of the family of human powered cycles, which can have lower wind resistance and travel faster for the same effort than more conventional cycles.

Keywords: Three Wheeled Vehicle, Tadpole Trike, Reverse Trike

I. INTRODUCTION

Trike is a vehicle that contains three wheels. Some are battery operated tricycles, which may be classified as motorcycles, some of which are recumbent vehicles. Reverse trikes are the vehicles with two front wheels and single rear wheel with front suspension system. Trikes that are specially build for off the Road riding. Due to better safety while braking, a popular form is the "reverse trike". If one use a bicycle instead of a car than he can save the time in traffic, as the bicycle needs smaller space than a car.[3] Transport should be ecological not just from economic point of view, but also from a practical, personal perspective and enlarged use of cycles.[4] All types of cycles could be in plenteous use, and these include tilting trikes and can be enhanced than bicycles with combinations of developments such as having extra power available, more load capacity, extra stability when stopped.[5] While tilting trikes exist in the motorized transport system, this project concentrations on the small but increasing category of recumbent cycle, the Tilting Trike.

II. LITERATURE SURVEY

Transport needs to be sustainable not simply from a noble “use assets sparingly” point of view, yet in addition from a practical, personal perspective and increased use of cycles could help. All sorts of cycles could be in abundant use, and these include recumbent cycles, cargo bikes, velomobiles and electric bikes.[4] These comparatively new “improved cycles” include tilting trikes and can be “better-than-bicycle” with combinations of intensification such as having extra power available, good aerodynamics, larger load capacity, extra stability when stopped, and added weather protection. Leaning is synonymous with all two wheeled bicycles, but it is not standard on 3 or 4 wheel vehicles. So tilting in an NTV can be defined as “the ability of a vehicle with apparent static stability (three or more non-collinear wheels) to lean into corners and keep all wheels on the ground”.[6]

A. Aerodynamics and General Characteristics (Motion Physics and Control)

Recumbent cycles including tilters can have lower wind resistance and because of that they can travel much faster for the same energy input than more conventional cycles.

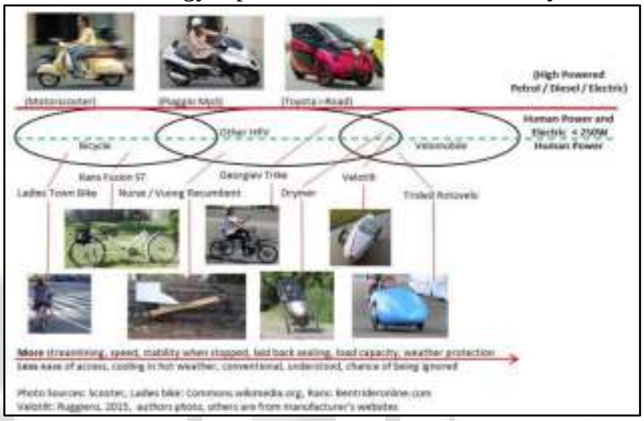

Fig. 1: Human powered tilters in context

They have achieved most records for cycling speed and distance travelled but was banned from UCI (Union Cyclist International, a cycling governing body) sanctioned cycle competitions in 1934, that ended up removing them from mainstream sports coverage.

Fig. 2: Aerodynamic / load carrying round Australia recumbent bike

Their main feature is many times aerodynamics but this does not undermine several other practical features.[7] Some specific events and advantages can be used to illustrate. Peter Heal holds the record for the fastest unsupported lap of Australia with 15000km covered in just 48 days on a very highly efficient recumbent bike that had built in luggage space (Oakman 2014). Recumbent trikes offer static stability that allow riders to go as slow as they want without losing balance. Commuting cycles can be compared with recumbents in quantitative terms when we use mathematical models. The scientific reason for the reduced effort while pedaling recumbents compared to other cycles is because of reduction in the drag coefficient (Cd) and frontal area (A). Both are really crucial elements of the equations governing cycle speed.

Drag coefficient and frontal are determined by using wind tunnel testing, but for a particular cycle, estimates of these values are made based on published tables.[8]

B. Technology Review (Motion Physics and Control) Tadpole trikes

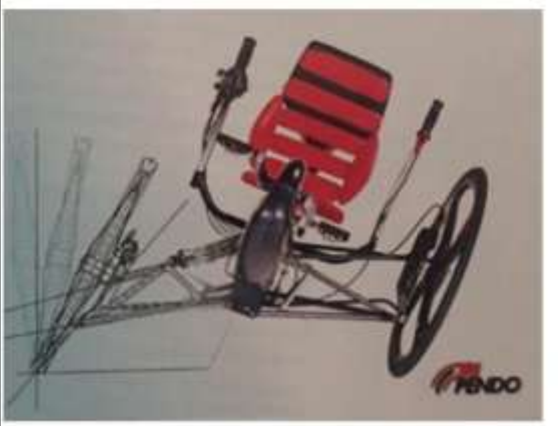

Fig. 3: Tripendo Tadpole Tilter

In 1995, US patent 5762351 was unsuccessful for a tilting tadpole trike. This "Aileron" trike failed to reach production. (Soohoo 1998) Several tadpole leaning trikes followed the "proposed manufacture stage", and the dominant configuration for 2F3T. Amongst them are the Tiefflieger from Germany (Kautt 2010) and FN trike (Fleiner 2011). Only few trikes in this category are able to reach full manufacture.

III. TILTING AND BALANCE

Two wheelers require more balance to ride and are dynamically stable. In a straight line, the rider keeps the vehicle's C.G. above the line in-between the two wheels by marginally steering inputs. Superimposed on this is leaning, i.e., keeping balanced when cornering by countering an outward centrifugal force with an inward gravitational force? The force on two wheeler's wheels is mainly close to right angle to the wheel axis. Non leaning trikes are statically stable. They will gradient when cornering shifts their C.G. outside of the "stability wedge" defined by the space above their tire contact points, but riders can forestall tipping by moving their C.G. and shifting body weight into the direction of a corner. Resultant forces on non-leaning trike wheels are not at 90 degrees to the wheel axis, and this increases the need for strength in trike wheels. For reasons of stability, non-tilting human powered trikes are often less ground clearance with a wide track, and their deficiency of height can make them hard to see in traffic. Adding tilting to a trike can make it revert to bike like handling, make simpler tight cornering and allowing a high, narrow vehicle to be dynamically stable.[1]

Fig. 4: Without tilting & with tilting

A. Two Wheels at back

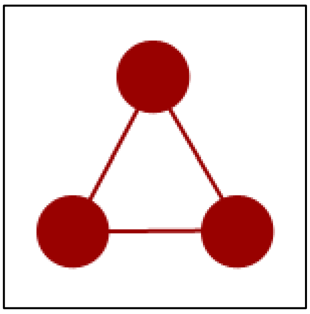

Fig. 5: Two wheels at back

A conventional wheels back trike has one wheel up front and two in the rear. Under normal riding the operational base footprint is the average of the width of the front tire and the width of the two rear tires. However braking or deceleration this footprints narrows significantly as the center of mass shift forward and if turning is involved with this deceleration then the triangle becomes unstable as the footprint narrows and inertial forces push outside of the lines of the triangle. Although under normal circumstances an ordinary trike is stable and safe.[2]

B. Two Wheels at front

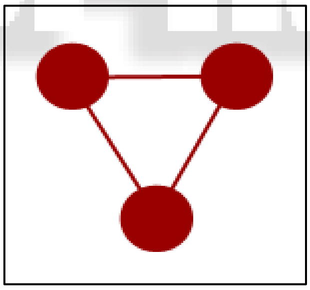

Fig. 6: Two wheels at front

In the reverse trike configuration the basic straight line base footprints is the about the same as a conventional trike. However during slowing and breaking the center of mass, now moves towards the much wider stance of the two front wheels. And now while engaged in slippery operations the center of mass stays inside the triangle which constitutes stability in design.[9] Also while cornering centrifugal force will shift weight to the outside wheel so traction is increased dramatically. And ground clearance is never a factor as the non-leaning trikes maintain full ground clearance at times. Also the yaw rate on this type of configuration is shorter so trike maintains a sporty quick feel.

IV. PROJECT SPECIFICATION

A three wheeled vehicle comprising:

– A right front steerable wheel and a left front steerable wheel inclined on respective sides of a central steering shaft having a handlebar attached there to wherein right and left front steerable wheels has a respective turning pivot;

– A rear wheel positioned on a rear axle and inclined aft of and between two front wheels;
– A front frame coupled to and supporting two front wheels, steering shaft, and steering linkage and handlebar;
– A rear frame supporting a rider, rear wheel, and a vehicle thrust arrangement.
– A hinged connection between front frame and rear frame.

Fig. 7: Reverse trike model

A. *Leaning trikes*

While tilting trikes do make use of correct configurations regarding wheels. great aerodynamics and enhanced braking there are two areas of concern.

Traction is not really improved as the motorcycle front end weight is distributed between two wheels so effectively each tire provides half the traction of a single wheel setup. This holds true even during cornering.

Ground clearance and cornering traction are still limiting factors. As the bike leans centrifugal force begins to offset gravitational force and traction is diminished and once things start to out tire traction ceases to exist. Because of all added hardware and masses yaw rate increased of leaning trike.

V. MATHEMATICAL CALCULATIONS

1) *Definitions:*

E: Modulus of Elasticity
I: Areal Moment of Inertia about the weakest axis

2) *Tubing Specification:*

Material: DUCTILE IRON
Diameter: 27mm
Wall Thickness: 1.5mm

3) *From Tubing Geometry:*

Modulus of elasticity, E= 165 GPa
Outer Diameter, D_o = 27mm
Thickness, t= 1.5mm
Inner Diameter, D_i = 24mm
Area Moment of Inertia, $I= [\pi * (D_o^4 – D_i^4)]/64 = 9801\ mm^4$
Yield Strength, S_y= 275 MPa
Distance from neutral axis to extreme fibre(C)= 13.5 mm
Bending Strength $\sigma_{bref}= S_y * I/C = 199$ Nm
Bending Stiffness= E* I = 1617 N m^2

4) *Material Specifications*

Material	DUCTILE IRON
Cross section of tube	Circular
Thickness	1.5 mm
Outer Dimension of tube	1"
Bending Strength	199 Nm
Bending Stiffness	1617 N m^2
Application in (SUSPENSION A ARMS)	WISHBONE A ARMS

Table 3: Dimensions for A-arms Members

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