

Design, Fabrication and Analysis of Reverse Gearbox in Three Wheeler Car by Using Bike Engine

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Abstract

This paper presents the design of an eco-friendly human powered vehicle with a compounded electric drive system. The focus has been laid on the simplicity in design, high performance, easy maintenance and safety at very reasonable prices. Most of the components have been chosen keeping in mind the easy availability and reliability. This paper provides the details of components used, and performance parameters taken into consideration while designing the vehicle. Due to rapid industrialization and development of the economy the expectation of the customer and their ability and willingness to pay for the product has changed drastically.

Everyday new products are being launched and new niche markets are developing. To meet out this change and expectation and to maintain the value of the product the companies has to undergo continues process of product upgradation incorporating both technical and cosmetic changes. Major problem for the designer of the automobile is to retain its utility and continue to enhance the value, so that the product acceptability and prefer ability to competitor's product is maintained.

Automobiles now – a – days doesn't means simply as a mode of transport but also the comfort, performance and durability contribute to its value. As the world moved into the 20th century, three-wheelers gained in popularity as low-cost, lightweight vehicles -- that is, until about the late 1920s, when cars

generally started going more along the four-wheel track. A three-wheel car is, by design, basically a triangle shape. Depending on where the passengers sit, the location of the engine, and the placement of other critical mechanical components, this means the car either has two wheels up front and one in the rear – Tadpole Design or two wheels in the rear and one up front – Delta Design.

Keywords: *Automobile, Three – Wheelers, Design, Tadpole Design, Delta Design*

EXECUTIVE SUMMARY

Three-wheel vehicles have existed since the earliest days of the motor vehicle. They include varied configurations, including the trike, reverse trike, sidecar motorcycle, and what the Three-Wheel Vehicle Working Group (3WVWG) has defined as the “auto cycle,” which operates much like a passenger vehicle. These vehicles can vary drastically in price, performance, and design.

Manufacturers’ desire to create fuel-efficient vehicles and to cater to people who want to ride a motorcycle but don’t want the worry of the instability of a two-wheel motorcycle have led to a proliferation of three-wheel vehicles on the market. Jurisdictions are faced with complex and evolving issues regulating the operation and registration of three-wheel vehicles. As a result, the AAMVA formed

the 3WVWG and tasked it with the development of best practices and recommendations for regulating or restricting on-highway operation and registration of three-wheel vehicles. The group focused on creating guidelines that adequately identify the different vehicles in production today but that are broad enough to accommodate emerging vehicle technology.

Most three-wheel vehicles clearly meet the definition of a motorcycle in United States code 49 CFR 571.3(b) and should be regulated as motorcycles. However, two-wheel motorcycles and three-wheel vehicles operate very differently. This document provides guidelines to help jurisdictions determine the type of knowledge and skills testing required for the operation of each type of three-wheel vehicle and the type of driving privilege

the operator should obtain. It also offers recommendations for identifying the different types of three-wheel vehicles for registration and crash reporting purposes, which will also help law enforcement easily, determine which laws to enforce for the different types of three-wheel vehicles. Many jurisdictions allow operators of two-wheel motorcycles (tested or trained on a two-wheel motorcycle) to operate any motorcycle yet restrict three-wheel motorcycle operators (tested or trained on a three-wheel motorcycle) to only operating three wheel motorcycles. The 3WVWG recognizes that this practice needs to change and addresses it in the recommended best practices.

Some information about three-wheel motorcycles was determined to be outside the scope of this project, including motive power, weight, safety and inspection concerns, helmet use, safety belt use, and enclosures. The National Highway Traffic Safety Administration (NHTSA) has identified issues with vehicles such as Auto cycles. Auto cycles may have bodies that surround the operator, and their overall appearance is similar to that of passenger cars. Passenger cars have to meet crash tests and provide an established level of safety to occupants. Auto cycles do not have to meet these standards

because they are motorcycles and must meet the safety standards established for motorcycles. The public may not be aware of these differences and may have a false sense of safety when choosing a vehicle. It is our understanding that the NHTSA is reviewing the safety standards and definitions of certain three wheel vehicles. If new rules are established, jurisdictions will need to adjust their definitions and procedures as appropriate.

The purpose of this guide is to aid jurisdictions in adhering to a consistent method of defining and identifying three-wheel vehicles. This can be accomplished by implementing the best practices developed by the 3WVWG to regulate on-highway operation and registration of three-wheel vehicles. AAMVA strongly encourages jurisdictions to use these best practices to promote uniformity. This will facilitate the movement of these vehicles from one jurisdiction to another. These best practices have the capability to grow, change, and evolve as new three wheel vehicle types continue to be introduced.

For purposes of these best practices, the following definitions and acronyms shall be used:

AAMVA- American Association of Motor Vehicle Administrators

Auto cycle- A three-wheel motorcycle that has a steering wheel and seating that does not require the operator to straddle or sit astride it.

Instruction permit A permit issued for the purpose of learning to operate a motor vehicle; it may also be called a learner's permit

Motorcycle- A motor vehicle with motive power having a seat or saddle for the use of the rider and designed to travel on not more than three wheels in contact with the ground 49 CFR 571.3(b)

Motor vehicle a vehicle driven or drawn by mechanical power and manufactured primarily for use on public streets, roads, and highways but does not include a vehicle operated only on a rail line (49 CFR 30102).

NHTSA- National Highway Traffic Safety Administration

Registration- Documentary proof of authority to operate a motor vehicle on a public road or the process of issuing such proof

INTRODUCTION

A three wheeled car, also known as a Tricar or tri-car, is an automobile having either one wheel in the front for steering and two at the rear for power, two in the front for steering and one in the rear for power, or any other combination of layouts. Due to its handling superiority, an increasingly popular form is the front-steering "Tadpole" or "reverse trike" sometimes with front drive but usually with rear drive.

A three-wheel car is, by design, basically a triangle shape. Depending on where the passengers sit, the location of the engine, and the placement of other critical mechanical components, this means the car either has two wheels up front and one in the rear or two wheels in the rear and one up front.

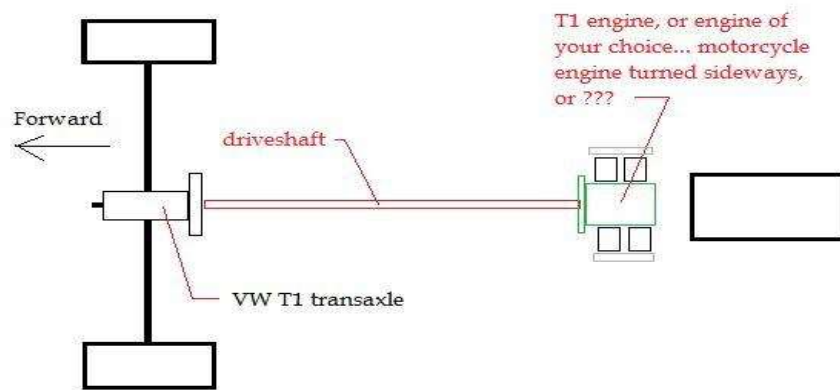


Fig.1.1: Principle of Tricar with Reverse Gear

The engine can drive the single rear wheel or the two rear wheels, and the steering can be done either way as well. Having one wheel up front and two in the back is known as the delta configuration. Karl Benz's creation followed this setup, as did the Reliant Robin. The original three-wheeled Mazda automobile, the Mazda-Go, was configured this way to allow for a pickup truck bed in the back. The benefit to the delta setup is its inherent low cost. Most cars set up this way have the engine driving the rear wheels and leave steering to the front one. It's relatively easy (and inexpensive) to build a steering setup with only one wheel. The second type of three-wheeler setup is called the tadpole or reverse trike. The opposite of the delta, this formation has two wheels up front and one in the back. All around the globe there are people who enjoy riding tricycles.

Tricycles come in many different styles and designs. The three most common designs are the upright style, recumbent delta, and the recumbent tadpole. The upright style is the original design with the diamond frame and the two wide spaced wheels in the back. The Recumbent delta design resembles the upright design in that it has one wheel in front and two in the back. The features that separate the recumbent delta from the upright are the overall length, seating, and steering. With the recumbent delta design the driver sits at a much lower distance from the ground and pedals with his or her feet in front of them, making the trike longer in length.

A lot of the recumbent delta steering designs stray away from the traditional handle bars and replace them with two separate handles that are located on both sides of the driver. The other design of a

tricycle is the recumbent tadpole. The recumbent tadpole resembles the recumbent delta in that they both have a low stance and require the driver to pedal with his or feet in front of themselves. The difference with the tadpole design is that there are two wheels in front and one wheel in the back. This design allows for a more stable design when turning. There are plenty of styles of each design; the problem is that the tricycles tend to be heavy and very expensive. The purpose of this report is to compare current trike designs and their subsystems to analyze and design a trike which is less burdensome to the costumer's wallet and lighter on the legs. Analysis of subsystems will include frame design, steering, drive train, component materials, suspension, brakes, and wheel design. This setup is the basis for the speedy Campagna Motors T-Rex, as well as the exciting Volkswagen GX-3 concept vehicle. Tadpole designs are much more stable than the delta setup because the back wheel drives the vehicle while the two wheels up front are responsible for steering.

This allows air to flow easily over the vehicle's bodywork. The tadpole design is becoming more and more favored among auto designers for its stability,

aerodynamics and ability to house a fuel-efficient engine. In fact, a number of current hybrid and electric concept vehicles use a three-wheel setup along these lines.

LITERATURE REVIEW

Having one wheel in front and two in the rear for power reduces the cost of the steering mechanism, but greatly decreases stability. However, a configuration of two wheels in the front and one wheel at the back has many strong proponents among automotive designers and enthusiasts. Two advantages are its improved aerodynamics, and that it readily enables small lightweight motorcycle power plants and rear wheels to be used. Alternatively, a more conventional front-engine, front wheel drive layout as is common in four-wheeled cars can be used, with subsequent advantages for stability and traction.

For the lowest wind resistance (which increases fuel efficiency), a teardrop shape is desirable. A tear drop is wide and round at the front, tapering to a point at the back. The three wheel configuration allows the two front wheels to create the wide round surface of the vehicle. The single rear wheel allows the vehicle to taper at the back. Having one less wheel

also increases fuel efficiency because of decreased rolling resistance. To improve stability some three wheelers are designed as tilting three wheelers so that they lean while cornering like a motorcyclist would do. The tilt may be controlled manually or by computer.



Fig.2.1:- Tadpole Design

In postwar England, Bond Cars Ltd. found success in making small, three-wheel

Cars powered by single-cylinder motorcycle engines. These small cars proved popular

Among motorcyclists looking to protect themselves from the elements, and as an added benefit, the car didn't require an automobile driver's license. In addition, their ability to achieve more than 100 miles per gallon (42.5 kilometers per liter) was extremely helpful at a time when fuel was expensive and supplies were scarce.

DISTINGUISHING THREE-WHEEL MOTORCYCLES FROM AUTO CYCLES

In recent years, there has been an increase in new motorcycle designs. Some of the new designs are challenging the existing rules and procedures for dealing with motorcycles. Some of the newly designed motorcycles have three wheels, a steering wheel, and full or partial enclosures and do not have typical motorcycle controls. Because these motorcycles are so different, a new term is needed to identify them; auto cycle is the new term to refer to these motorcycles. Three-wheel motorcycles and auto cycles are types of motorcycles, but each requires different driver skills for operation. The key aspect that separates these vehicles is how similar or different they are from traditional motorcycles with two wheels. Three-wheel motorcycles share some characteristics with traditional motorcycles, but auto cycles are fundamentally different.

The characteristics that distinguish these vehicles are based on the operation and handling of the vehicles. To verify that operators have the necessary skills to safely operate each type of vehicle, specific testing is required.

Key Three-Wheel Motorcycle

Characteristics

- Handlebars
- Straddle or sit astride

Key Autocycle Characteristics

- Steering wheel
- Operator sits in a seat

The mass of a three-wheel motorcycle is beneath the operator and therefore has a direct connection to the way the vehicle handles. This is a break-point between Three-wheel vehicles and auto cycles because the mass of an auto cycle is spread out either above or at the same height as the operator. Auto cycle operators are within the vehicle they are operating and do not have to worry about their location on the vehicle or positioning themselves when cornering or stopping.

Auto cycles share more characteristics with passenger cars; the operator remains in a seated position at all times, and the vehicle has a steering wheel. Auto cycles may have side-by-side seating that places a passenger next to the driver. Operating an auto cycle may require braking and acceleration mechanics similar to a passenger car.

Three-wheel motorcycles also have some minor characteristics that separate them from auto cycles. In general, three-wheel motorcycles have less mass, and the driver has more of an influence on the stability of the vehicle. Some three-wheel motorcycles can be quite large, and the driver does not have much influence on the balance, but handlebars are typically used to operate the vehicle.

The differences between these types of vehicles mean they should have different operator licensing requirements. A regular passenger car license should be required to operate an auto cycle, and the operator of three-wheel motorcycle should continue to have a motorcycle endorsement or license.

With auto cycles being a new type of vehicle, detailed information on their safety record is needed. A way to uniquely register auto cycles is needed to allow specific safety statistics on auto cycles to be collected. This provides a method of identifying unique issues and concerns with auto cycles. It also provides law enforcement with a method of identifying these vehicles and determining the required operator license and endorsement. The following pictures show examples of three-wheel

motorcycles and auto cycles. The pictures illustrate the different characteristics between these vehicles.

METHODOLOGY

Working Principle

The gears in most modern differentials are hypoid, which means they are cut to run mainly in one direction and pull themselves into mesh. Which is why when you drive? Your car quickly in reverse it whines. Imagine that whine happening while going forwards and that's what you end up with.



Fig.4.1.1:-Design of Reverse Gear for Trike in Design Software

It is NOT a reverse gear, i.e. to cause the Trike to move backwards. This gearbox is designed to reverse the props haft rotation of a shaft drive bike to enable the use of a differential or axle mounted the right way up. As a rule of thumb, if the shaft is on the up. As a rule of thumb, if the shaft is on the left-hand side of the bike the axle must be mounted upside down or a reverse rotation.



Fig.4.1.2:-Reverse Gear Rotation

Reverse rotation Trike Gear box

For dissatisfaction of customer but, to improve service quality level it is must, to first resolve problem of delay. So we concluded that delay is the most influencing factor of dissatisfaction and is adversely affecting the reliability of the dealership.



Fig.4.2.1:-Reverse Rotation Trike Gearbox

If the driveshaft is on the right-hand side of the bike then you should be ok to use the axle the right way up. Always check

as there are so many possible combinations. Although other factors are also responsible further research was concentrated for finding out the reasons of delay. A root cause analysis was carried out. Fishbone diagram for delay is shown in Figure. Data taken for free service vehicles were again analyzed.

The shafts were machined up so that the gears were a shrink fit. This helps to keep everything running true. The gears were welded to the shaft as shown. Taken from the input side. Not all the screws are in and the oil seals are still to be fitted. The output flange can just be seen. The bearing covers and oil seal holders are machined so that a spigot enters the gearbox. This spigot is made so that the bearings are held in position. Care must be taken to ensure that the bearings are not pre loaded.

Design Calculation

A. Design of Gear

Diameter of Gear (Standard)

Outer Diameter of Gear= 56mm

Inner Diameter of Gear= 48mm

Pitch Diameter of Gear= $(56+48)/2$
=52mm

Teeth of gear=29 teeth

Pitch Diameter of Gear= $m \times t$
 $52 = m \times 29$

$m = 1.799\text{mm}$

Where, $m = \text{Module}$

$t = \text{No. of Teeth on Gear}$

Standard Module=2mm

1) Face width (b) = $8.5 \times m$
= 8.5×2

$b = 17\text{mm}$

2) Pitch line velocity (V_p) = $(\pi \times m \times t \times N_p) / 60$

= $(\pi \times 2 \times 29 \times 8600) / 60$

$V_p = 25.8\text{m/s}$

3) Tooth load (F_t) = P_d / V_p

$F_t = 12.05 / 25.81$

$F_t = 466.87\text{N}$

4) Design power (P_d) = $P_r \times K_1$

= 9.64×1.25

$P_d = 12.05\text{kw}$

5) Bending strength (F_b) = $S_o \times y \times C_v \times m \times B$

Where,

$Y = \text{Lewis form-XVI-5 (Data book)} = 20$
degree depth

$Y = (0.485) - (2.87) / 29$

$Y = 0.386$

$C_v = \text{T XV-10 CI medium grade} = 70\text{MPa}$

$C_v = 0.519$

6) Bending strength $(F_b) = 164.95 = 29 \times 2 \times 17 \times k \times 1$

$S_o \times y \times C_v \times m \times B$ $k = 0.16$

$F_b = 70 \times 0.368 \times 0.519 \times 2 \times 17$

$F_b = 476.69 \text{ N}$

$F_t < F_b$ Hence design is safe.

7) Dynamic load $(F_d) = F_t + 21 \times V_p \times$
 $(c \times e \times b + F_t) / 21 V_p + (c \times e \times b \times t \times F_t)$

Where,

$c = 8100$

$e =$ error in pinion

Probable error = 0.05 (class 1 Gear)

Permissible gear = 0.018

$e_{per} < e_{prob}$

Choosing permissible error

Dynamic load $(F_d) = F_t + 21 \times V_p \times$
 $(c \times e \times b + F_t) / 21 V_p + (c \times e \times b \times t \times F_t)$

$= 466.87 + 2125.8 \times$

$(8100 \times 0.018 \times 17 + 466.67) / 21 \times 25.8 \times (\sqrt{8100 \times 0.018 \times 17 + 466.67})$

$F_d = 164.95 \text{ N}$

8) Limiting wear strength $(F_w) =$

$D_p \times b \times k \times Q$

$F_w = 29 \times 2 \times 17 \times k \times 1$

Where,

Size factor $(Q) = (2 \times 29) / (29 + 25)$

$Q = 1$

Limiting condition: - $F_w = F_d$

Where,

$k = 0.421$ CI-T XVI-6 (Data Book)

(G) BHN = 180 BHN

(P) BHN = 180 BHN

$F_w = 29 \times 2 \times 17 \times 0.421 \times 1$

$F_w = 415.106 \text{ N}$

$F_w > F_d$ Hence design is safe.

9) Endurance strength $(f_{en}) = S_{eb} \times y \times b \times m$

Where,

$S_{eb} = 126$ Endurance Strength, Table XVI-

9

$= 126 \times 17 \times 0.386 \times 2$

$= 1653.62 \text{ N}$

$F_{en} > F_d$ Hence design is safe

B. Design of Chain Drive

1) Design power $(P_d) = P_r \times K_1$

$= 9.64 \times 1.2$

$= 11.58 \text{ KW}$

2) Pitch line velocity $(V_p) =$

$(\pi \times m \times t \times N_p) / 60$

$= (\pi \times 2 \times 29 \times 8600) / 60$

$V_p = 25.8 \text{ m/s}$

3) Tooth load $(F_t) = P_d / V$

$$=11.58/25.8$$

$$=448.83\text{N}$$

4) Power capacity of roller chain

As per A.S.A. in KW (P)

$$=p^2[V/104-V1.41/526(26$$

$$25 \times \cos 180/T)] \times K_c$$

Where,

P=Chain Pitch, mm

T=No. of teeth=29

K_c= capacity factor for No. of stand

Refer Fig. 14.1 Shows 15.73HP VS
8600R.P.M.

Chain No. =25

Pitch=6.25m

5) Pitch diameter of Sprocket ,(D_p)=

$$P/\sin \times (180/T)$$

$$=6.25/\sin \times (180/29)$$

$$=57.60\text{mm}$$

6) Power capacity per stand(P)=

$$p^2[V/104-V1.41/526(26-$$

$$25 \times \cos 180/T)] \times K_c$$

$$11.58= (6.25)^2[25.8/104-25.8 \times 1.41/526 \times$$

$$(26-25 \times \cos 180/29)] \times K_c$$

K_c=1.31 Single Strand Chain

Design is Safe

7) Length of chain in pitches,

$$L_p=T_1+T_2/2+2C/P+P \times (T_1-T_2)^2/40C$$

$$=29+29/2+2 \times 140/6.25+6.25 \times (29-$$

$$29)^2/40 \times 140$$

$$=73.8 \text{ in pitches}=73.8 \times 6.25=461.25\text{mm}$$

Where,

C= Centre Distance=140mm

T₁, T₂=No. of Teeth on Sprocket

C. Standard Chain Sprocket Dimensions

1) Width of Sprocket Teeth ,mm (t_o)

For Single Strand Chain=0.58P-0.15

$$=0.58 \times 6.25-0.15$$

$$=3.745\text{mm}$$

2) Outside Diameter, mm

$$(D_o)=P[0.6+\cot(180/T)]$$

$$=6.25[0.6+\cot(180/29)]$$

$$=61.21\text{mm}$$

3) Root Bottom Diameter, mm(D_r)=D_p

$$0.625 \times P$$

$$=57.60-0.625 \times 6.2$$

$$=53.69\text{mm}$$

D. Design Of Shaft

1) Power Transmitted By Shaft =2 π

$$N \times T/60$$

$$11.58 = 2\pi \times 8600 \times T/60$$

$$T=12.85\text{Nm}$$

2) Torque transmitted by shaft(T) =

$$\pi/16 \times \sigma \times d^3$$

Where,

σ =Shear Stress Induced in Shaft
 $=136/2.5=0.25 \times 54.5=40.87 \text{ N/mm}^2$

from Table II-7 (Data Book)

d= Diameter of Shaft

$$(T) = \pi / 16 \times \sigma \times d^3$$

$$12.85 \times 10^3 = \pi / 16 \times 40.87 \times d^3$$

$$d = 13.41 \text{ mm} = 16 \text{ mm take as a Standard}$$

From

Appendix-II (Data Book)

Hence Design is safe.

CONCLUSION

Having one wheel in front and two in the rear for power reduces the cost of the steering mechanism, but greatly decreases stability. However, a configuration of two wheels in the front and one wheel at the back has many strong proponents among automotive designers and enthusiasts. Two advantages are its improved aerodynamics, and that it readily enables small lightweight motorcycle power plants and rear wheels to be used. Alternatively, a more conventional front-engine, front wheel drive layout as is common in four-wheeled cars can be used, with subsequent advantages for stability and traction.

For the lowest wind resistance (which

increases fuel efficiency), a teardrop shape is desirable. A tear drop is wide and round at the front, tapering to a point at the back. The three wheel configuration allows the two front wheels to create the wide round surface of the vehicle. The single rear wheel allows the vehicle to taper at the back. Having one less wheel also increases fuel efficiency because of decreased rolling resistance.

The disadvantage of a rear drive, non-tilting three wheel configuration is instability - the car will tip over in a turn before it will slide, unless the centre of mass is much closer to the ground or the wheelbase is much wider than a similar four wheel vehicle. To improve stability some three wheelers are designed as tilting three wheelers so that they lean while cornering like a motorcyclist would do. The tilt may be controlled manually or by computer. Electric three-wheelers often lower the center of gravity by placing the heavy battery pack at the base of the vehicle.

This conclusion is easily understandable if a 3-Wheeler with two front wheels is considered. If the center of gravity of the vehicle-occupants assembly is sufficiently low to be under the pyramid, the vehicle will not roll sideways in a curve and will

not tip backward when accelerating or tip forward when braking.

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