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Design and Fabrication of Hand Operated Reverse Gear Mechanism in Two - Wheelers for Physically Challenged People

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Abstract – *This paper has been conceived having observed the difficulty faced by physically handicapped persons riding a two-wheeler. At times when the front wheel gets into a trench it is very difficult to take the vehicle from parking. Even normal people face much problem to take the vehicle out of the parking at that time. In order to take the vehicle out of the parking they need to seek others help or they should push it out of the parking. Also, for physically handicapped people it is impossible to take reverse from the parking. As a help to them we have designed a gear position which will be fit to the vehicle without altering the existing gear. This paper deals with the design of such a gear position and the assembly process of the gear to the vehicle.*

This chassis containing the additional two wheels are carved out of steel pipes. The additional chassis has been attached with the body of scooter with two shock absorbers. An external gearbox has been coupled to the output shaft of the motor. The output shaft of the gearbox is acting as the input shaft for the gearbox and output shaft of the gearbox is connected with a gear which is further connected to the rear wheel with the help of yoke rods. For changing the mode (forward/reverse), a lever is placed on the right side of the scooter, conveniently placed for a person to engage the reverse mode. Through this paper we have shown that a physically handicapped person can use a motorcycle easily if it is converted into a specialized vehicle properly. The vehicle was specially fabricated and a lot of work has been put into the fabrication of the frame. The directional stability of the vehicle is not at all affected and another mentionable fact is that the ride quality has improved with the addition of the extra shock absorbers in the frame. The vehicle is able to travel over undulated roads with aplomb and without stability problem.

Key Words: *(Chassis, External gear box, shock absorbers, Directional stability & yoke rod)*

1. INTRODUCTION

A motorcycle transmission is a transmission created for motorcycle applications. They may also be found in use on other light vehicles such as motor tricycles and quad bikes, off-road buggies, mowers and other utility vehicles, micro cars, and even some superlight sports cars. At present, there is no system available to back the vehicle. At times when the front wheel gets into a trench it is very difficult to take the vehicle from parking. Even normal people face much problem to take the vehicle out of the parking at that time. In case of the physically handicapped people who drive two wheelers with extra support wheels, face much problem to take the vehicle out of the parking by pushing the vehicle with legs as we do. In order to take the vehicle out of the parking they need to seek others help or they should push it out of the parking.

The aim of the paper is to describe a "Two- Wheeler with Reverse Gear for Physically Challenged People". Since most handicapped persons do not possess the ability to balance the weight of a two- wheeler on their own, a sturdy and light weight side wheels setup have been fabricated. Also, since a handicapped person has some difficulty in changing gears using the foot, a gear change mechanism has been devised by using hands.

Another major difficulty faced by a handicapped person is the inability to reverse or push the vehicle out of a parking spot in the side of the road due to the slight slope or camber present in the roads to provide drainage of water during rain. This problem has also solved by using a separate drive mechanism to help in reversing the vehicle.

By implementing the above in a two-wheeler, the motorcycle can be made an efficient and user-friendly vehicle for the use of a handicapped person. This has the potential to transform the commuting on a motorcycle from being tedious and straining to a comfortable and hassle – free ride. By using this vehicle, they can easily move the vehicle towards back and front easily. By using the lever, they can change the direction of the vehicle. Using this physically challenged people gets more confidence by driving this vehicle. When they struck at any position they can easily change the direction by moving the lever.

2. LITERATURE REVIEW

G. Hari Prasad, S. Marurthi, R. Ganapathi, M. Janardhan, M. P. Madhu sudhan *et al* discussed in detail in the International Journal of Emerging Engineering Research and Technology Volume 2, Issue 2, May 2014 about the reverse mechanism for a two-wheeler using propeller shaft. Usually in two wheelers, chain and sprocket method is used to drive the back wheel. But in this project, the Engine is connected at the front part of the vehicle. The shaft of the engine is connected with a long rod. The other side of the long rod is connected with a set of bevel gears. The bevel gears are used to rotate the shaft in 90 ^{o} angle. The back wheel of the vehicle is connected with the bevel gear (driven). Thus, the back wheel is rotated in perpendicular to

the engine shaft. Thus, two-wheeler will move forward. According to the direction of motion of the engine, the wheel will be moved forward or reverse. This avoids the usage of chain and sprocket method.

S. Vanangamudi, S. Prabhakar, C. Thamotharan and R. Anbazhagan et al investigated in detail in the Middle-East Journal of Scientific Research, IDOSI Publications, 2014 about the design for suitable propeller shaft and replacement of chain drive smoothly to transmit power from the engine to the wheel without slip. It needs only a less maintenance because it will not get worn out during service as compared to chain drive. It is cost effective. Propeller shaft strength is more and also propeller shaft diameter is less. It absorbs the shock. Because the propeller shaft center is fitted with the universal joint is a flexible joint. It turns into any angular position. The both end of the shaft are fitted with the bevel pinion, the bevel pinion engaged with the crown and power is transmitted to the rear wheel through the propeller shaft and gear box.

Sathish kumar, J. Jerris, J. Purushothaman, J. Jude Shelley, A. Abdul khadeer, Ranjeet Pokharel, J. Arshad Basha, P. Saravanan et al discussed about the design of a gear box

which will be fit to the vehicle without altering the existing gear box. The paper deals with the design of such a gear box and the assembly process of the gear box to the vehicle. The design deals with the conditions of the gear box operation, and the design of the gear box based on easy assembly and easy manufacturing at low cost. The reverse gear on the manual transmission system typically uses an Idler Gear Idler gear is an intermediate gear which does not drive a shaft to perform any work. Sometimes, a single idler gear is used to reverse the direction, in which case it may be referred to as a reverse idler. In our system we are going to use the compound idler gear. The input gear is connected with the crank shaft and output gear is connected with the flywheel. During forward gear the input gear is directly meshed with the output gear. If the input gear rotates in clockwise direction, the output gear will rotate in anticlockwise direction. So, the vehicle moves in the forward direction. During reverse gear the idler gear is meshed in between the input and output gear. Idler gear here using is a compound gear, so smaller gear in compound gear is meshed with input gear and larger gear is meshed with output gear. When the input gear rotates in clockwise direction the idler gear rotates in anticlockwise direction. Also, the output gear meshed with idler gear rotates in clockwise direction. So, the vehicle moves in reverse direction. The disadvantage is that sometimes the chain gets loosened easily and need to maintain frequently.

Kenneth S. Keyes et al investigated about the design of an improved three-speed or coaster bicycle having a driver bevel gear connected to the pedals, a driven bevel gear at the hub of the rear wheel, one or more drive shafts having beveled gears at each end and capable of transmitting the rotation of the driver gear to the driven gear. This invention relates to coaster and three-speed bicycles, and in particular, to bicycles having bevel gears and one or more drive shafts that replace the traditional spur gears and chain.

3. PROBLEM IDENTIFICATION

From the literature review, it is observed that there are many limitations of the existing methods for reversing a two-wheeler. After further investigation of reverse mechanism of two wheelers, the following conclusions were drawn.

3.1 Two Wheelers with Side Cars

The below picture shows a scooter with side car fittings a shell capable of holding one extra passenger is fitted on the side of the vehicle which provides extra balance for the driver. Adding the sidecar turns the bike from a symmetrical, balance-steered vehicle into an asymmetrical, actively-steered one. Most of the weight is on the motorcycle. The drive and braking forces are now offset- power is applied only to the bike's rear wheel, and there may or may not be a separate brake on the sidecar's wheel. With the sidecar on the left, accelerating will tend to turn the combination to the left, and braking will induce a right-hand turn. Both of these need to be countered by the rider.

Fig. 1: Two wheelers with side cars

3.2 Vehicle with Side Support Wheels

Fig. 2 shows a two-wheeler with side support wheels and being offered in many design these days and some local as well as companies are creating such contraptions to be used by the physically disadvantaged people.

Fig. 2: Vehicle with side support wheels

3.3 Drawbacks

A. Problems Listed by Users

a. Steering problems.
b. Abnormal tire wear.
c. Brake inefficient since the support wheels do not have brakes.
d. Traction problems in non-paved surfaces.
e. Suspensions either being too hard or too soft resulting in body pain
f. poor mileage characteristics of both engine and fuel
g. no reverse gear option making it difficult to use with people having disadvantaged leg functions

B. Problems Listed by Technicians.

a. The fitting not easy for technicians to enable access to vehicle engine and transmission parts.
b. Imperfect design of suspensions resulting in engine foundation damage.
c. Tendency to lose alignment perfection which causes steering system damage.
d. Extra fitting supports gets welded on sensitive chassis portion resulting in loss of chassis flexibility and results in breakage of the same.

In order to resolve all the above problems with the existing methods for reversing a two-wheeler, we introduced a new reverse mechanism for two wheelers which would be useful for the physically handicapped people.

4. METHODOLOGY

Main components used in construction of this vehicle are:

a. Wheels
b. Bearings
c. Axle
d. Gear box
e. Lever

Since a motorcycle is heavier and taller than a scooter, the extra wheels which are required for construction of the side support wheel arrangement have to be sturdy. The wheels used are of the size 2.75×10 in. nylon cross – ply wheels used commonly on Bajaj Spirit. 2.75 in. specifies the cross section of the tyre which is 2.75 inches wide. 10 in. specifies the diameter of the wheel rim. The rim used is also of the Bajaj Spirit. The hub for the wheels is of the front wheels which is suitable for being installed on the side setup with an ordinary axle.

4.1. Working of a Three Wheeled Scooter

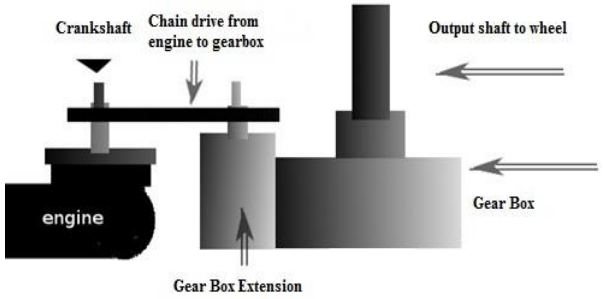

Fig. 3: Working and construction

We decided to create a three-wheeler from a non-geared two-wheeler. And traction is provided on both the rear wheels. We designed and fabricated a reverse forward selection gear box which helps to reverse the vehicle.

The rear wheel which is connected to the engine is removed and a sprocket is connected. Using a chain drive input is given to the gear box from the engine's shaft. The design of gear box and chain drive will be explained later. Spur gear is provided on the gear box which gives traction to both the rear wheels. For this we selected a 75 cc, 4.5 Bhp non-geared scooter, Honda spirit.

4.2. Working of gear box

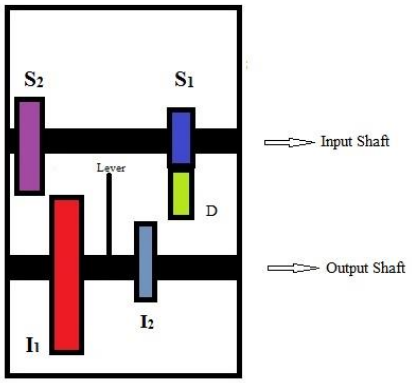

Fig. 4: Gear box sketch

Figure 4 shows the working of a gear box

Where,

D	- Crown wheel
S_1 and S_2	- Stationary gears
I_1& I_2	– Sliding gears

The gear box consists of four gears. S_1 and S_2 are stationary gears which are mounted on a stationary shaft. The gears I_1 & I_2 are sliding gears which are mounted on the output shaft. A lever is attached to these gears which help to slide the gear to different positions. D is the crown gear. The gear S_1 will always engaged with gear D. Since S_1 and S_2 are in same direction they will rotate in same direction and same

rpm. Bearings are provided to place the shaft in position. The position of the sliding gear will change with respect to the needed mode. A sprocket is attached to the input shaft. And input is given to the gear box with a chain drive.

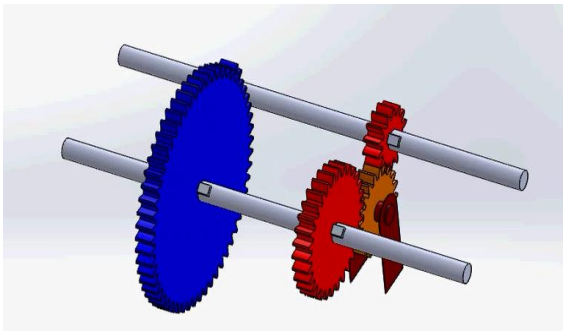

Fig. 5: Gear Arrangement

4.2.1. Reverse Mode

During reversing, the gear I_1 will slide and engage with gear S_2. Gear S_2 always rotates in forward direction. So, gear I_1 will rotate in the opposite direction as that of gear S_2.

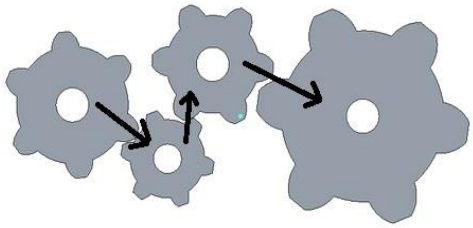

Fig. 6: Reverse motion gears

4.2.2. Forward Mode

During forward mode gear I_2 will slide and engage with gear D with the help of lever. S_1& S_2 rotate in the same direction (i.e. forward) since they are in the same shaft. S_1 rotates the gear D in opposite direction. So, after the engagement of I_2 with gear D, gear I_2 rotates in the same direction as that of the input.

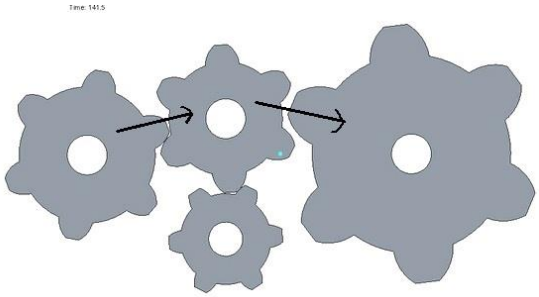

Fig. 7: Forward Motion of gears

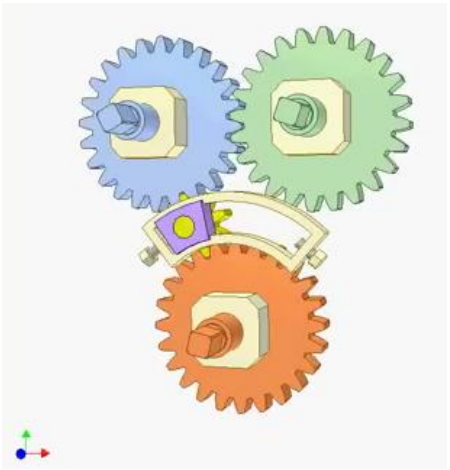

Fig. 8: 3D rendering of reverse mechanism

4.3. Vehicle Specifications:

Item	Bajaj Spirit
Type	Scooter
Engine Displacement	60 cc
Engine Type	2-Stroke
Transmission	Automatic
Front Suspension	Hydraulic Damped Telescopic
Rear Suspension	Hydraulic Damper with co-axial spring
Front Tyre	2.75 x 10 inches
Rear Tyre	2.75 x 10 inches
Wheelbase	1165 mm
Weight	72kg
Petrol Tank Capacity	3.5 liters

Table 1: Specification of the vehicle selected

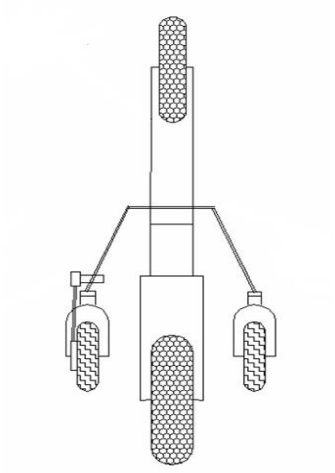

Fig.9: The three-wheeler configuration using AUTOCAD

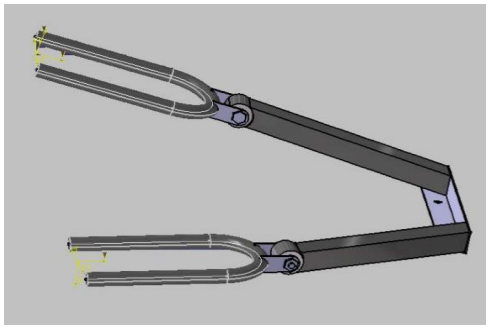

Fig. 10: Drawing of Frame for side wheel

5. DESIGN

5.1 Design of Gearbox

5.1.1. Reverse Condition

From the gear box sketch, we know Gear S_2 and Gear I_1 are engaged. The two gears are made of Cast iron grade 25. So, gear S_2 is the pinion. For gear I_1, we know, the values of diameter of the gear (D_g), Number of teeth, Zg

So, we can calculate the module of the gear

Module of gear, $m_g = \frac{Dg}{Zg}$

The rpm of the input shaft is assumed as 1500,
Pitch Line Velocity, V = π DpNp / 60
Where,

D_p – Diameter of the pinion
N_p – Speed of the pinion in rpm
Z_p – No: of teeth of the pinion

From data book

$$c_v = \frac{3.05}{3.05+v}$$

Where,

c_v – Velocity factor
y - Lewis form factor
y = 0.154 – (0.912/Z_p)

Where,

Zp – Number of teeth on the pinion

Assure 20^0 Involutes systems

Assuming breadth, b = 8 × module

Tangential tooth load $f_t = \pi\sigma_d c_v$ b y m
Where,

σ_d - Dynamic stress
C_v - Velocity factor
b - Breadth
y - Lewis form factor
m - Module

We know load factor, K = 0.814

The ratio factor, $Q = \frac{2Z_2}{Z_2+Z_1}$

Where,

Z_2 – No: of teeth of the gear
Z_1 – No: of teeth of the pinion

Wear load, $f_w = d_1$ b Q K

Where;

D_1 –Diameter of the pinion
b – Breadth
Q – Ratio factor
K – Load factor

If $F_w > F_t$, the design is safe

Gear Terms	Proportions of Machine Cut Teeth	Values
Addendum	M	2.5
Dedendum	1.25m	3.125
Tooth thickness	1.5708m	3.927
Tooth space	1.5708m	3.927
Working depth	2m	5
Whole depth	2.25m	5.625
Clearance	0.25 m	.625
The pitch diameter	Z m	25
Outside diameter	(z+2) m	30
Root diameter	(z — 2.5) m	18.75
Fillet radius	0.4 m	1

Table.2: Gear terms

5.1.2 Forward Condition

Gear S_1 and D is engaged. Since both are of same material S_1 is considered as pinion and gear D is the driver gear. S_1 and S_2 is rotating on the same shaft, so they both have the same rpm.

For the gear we know, number of teeth on the gear, Z_g, Diameter of the gear, D_g, Module, m Speed of the pinion, N_p, Diameter of the pinion, D_p

$Z_p = D_p / m$

Where,

D_g - Diameter of the gear
m – Module

We can find the speed of the gear using

$$\frac{N_p}{N_g} = \frac{Z_g}{Z_p}$$

Where,

N_P - Speed of the pinion in rpm
N_g - Speed of the gear in rpm
Z_P - Number of teeth on the pinion
Z_g - Number of teeth on the gear

Velocity coefficient, $c_v = \frac{3.5}{3.5+v}$

Where,

Tangential Velocity, v = $\pi D_p N_p /60$
Lewis form factor, y = $0.154 - (.912 / Z_P)$
Tangential tooth load, f_t = $\pi \sigma_d c_v b y m$
Wear load, f_w = $d_1 b Q K$

Where,

The ratio factor, Q = $\frac{2Z_2}{Z_1+Z_2}$

If $F_w > F_t$, the design is safe

Gear D and I_2 are engaged. Since both gears are of same material we choose I_2 as gear and D as pinion.

We know the values of, Speed of pinion, N_p, No. Of teeth in gear, Zg, Module, m, Diameter of the gear, Dg, Diameter of the pinion D_p, Number of teeth in pinion, Z_p

Pitch line velocity, $v = \pi D_p N_p / 60$
Where,

D_p - Diameter of the pinion
N_p - Speed of the pinion in rpm
Z_p - No: of teeth of the pinion

Velocity coefficient, $c_v = \frac{3.5}{3.5+v}$

Where,

Pitch line velocity, v = $\pi D_p N_p /60$

Lewis form factor, y = $0.154 - (.912 / Z_P)$

Tangential tooth load, f_t = $\pi \sigma_d c_v b y m$

Wear load, f_w = $d_1 b Q K$

Where,

The ratio factor, Q = $\frac{2Z_2}{Z_1+Z_2}$

If $F_w > F_t$, the design is safe

5.2. CHAIN DRIVE DESIGN

5.2.1 Roller Chain Construction

Roller chains are assembled using link plates, pins and rollers and connecting them in an endless chain using a connecting link

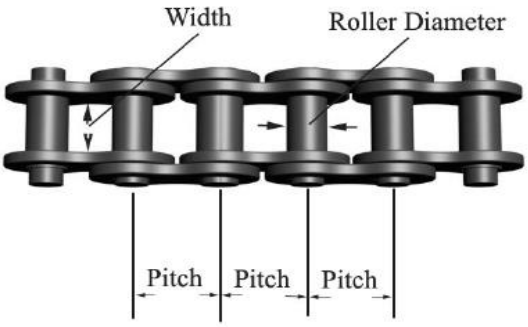

Fig.11: Roller chain

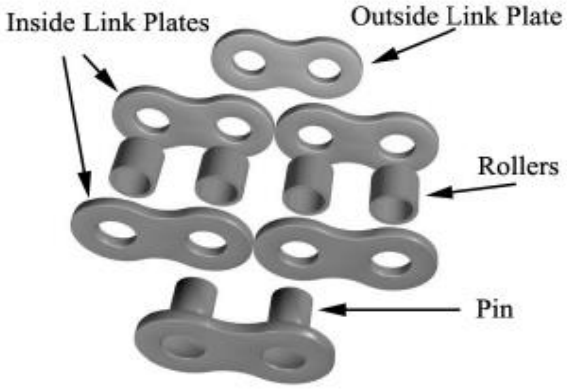

Fig. 12: Roller chain link

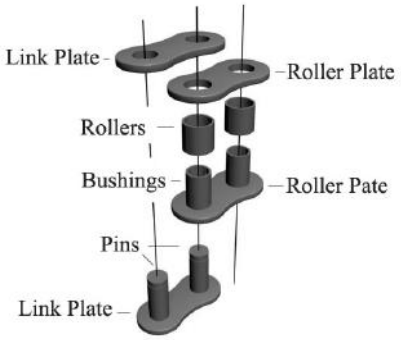

Fig. 13: Roller chain pin

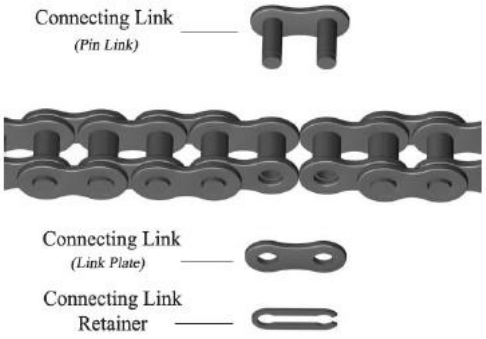

Fig.14: Connecting link

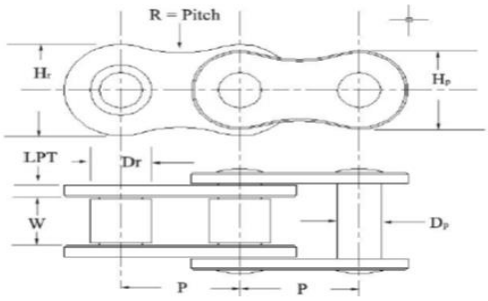

Fig. 15: Pitch

Chain dimension	Symbol
Roller diameter	D_r
Chain width	W
Pin Diameter	p
Link plate Thickness	LPT
Roller Link Plate Height(Maximum)	H_r
Pin Link Plate Height(Maximum)	H_p

Table 3: Chain Dimension

5.2.2. Sprocket Pitch Diameter

The sprocket pitch diameter is an imaginary circle through which the chain pin centers move on the sprocket. The pitch diameter is the fundamental design geometry that determines the size shape and form of the sprocket teeth dimensions.

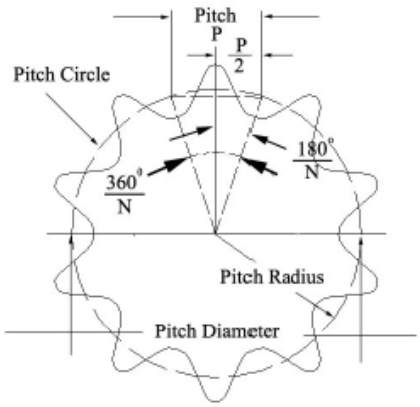

Fig. 16: Sprocket

Sprocket pitch Diameter calculation

$$PD = \frac{p}{\sin[\frac{180}{N}]}$$

PD = Pitch diameter
P = Chain pitch in inches
N = Number teeth on the sprocket

We know,

No of teeth on driven sprocket
No of teeth on driver sprocket

$$\text{Drive ratio} = \frac{\text{driven sprocket}}{\text{driver sprocket}}$$

$$\text{Pitch diameter, PD} = \frac{p}{\frac{\sin 180}{N}}$$

From the above equation we get the value of pitch diameter of driver and driven sprocket

We selected 428 chains (½" pitch, .335-inch roller diameter, 5/16" roller width)

5.2.3. Chain Length

The chain length for a given drive is determined by:

1. The number of teeth in the drive sprocket
2. The number of teeth in the driven sprocket
3. The pitch diameter (PD) of the drive sprocket
4. The pitch diameter (PD) of the driven sprocket
5. The center to center distances between the sprockets (C)

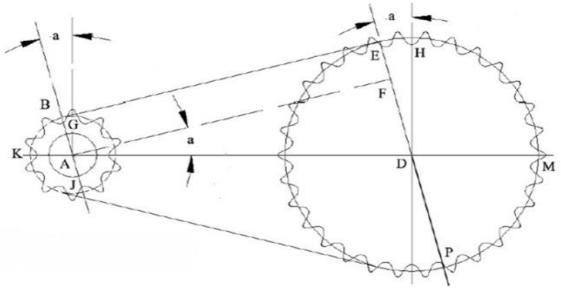

Fig. 17: Chain length

Design Procedure:

1. Calculate the pitch circle radius for the drive sprocket, AB
2. Calculate the pitch circle radius for driver sprocket, DE
3. Calculate the length of side DF

a. Line AF is parallel to line BE and perpendicular to AB and DE
b. Line BE is tangent to circles K and M
c. Line DF = DE — AB

4. Calculate angle a.
a. Triangle AFD is a right triangle
b. sin a = $\frac{DF}{AD}$

5. BE = AF = AD $\cos a$

6. Find the pitch lengths of chain wrapped around each of the sprockets.

ME = MH + HE = (N/4) + (Na/ 360)

KB = KG – 3.8082BG = (n/4) – (Na /360)

Using the information from the 6 preceding steps, we can find the chain length (In pitch units) for these 2 sprockets.

Let L represent the chain length in pitches. L = 2 [BE + ME + KB] Pitch units.

6. FABRICATION

Gears, Frame for supporting side wheels, Chain drive, lever for actuating the reverse gear mechanism etc were designed and fabricated. The assembled mechanism is installed in a two-stroke automatic scooter.

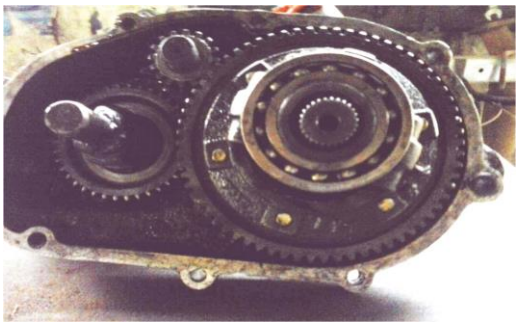

Fig. 18: Gear box used in the vehicle

Fig. 19: Chain drive used in the vehicle

Fig. 20: Top view of additional gear box

Fig. 21: Modified vehicle installed with reverse gear mechanism

7. CONCLUSIONS

Reverse gear mechanism for a two-wheeler is designed and fabricated and installed in two stroke automatic transmission scooter. After analyzing performance of the mechanism, following conclusions were drawn.

Through this project we have shown that a handicapped person can use a motorcycle easily if it is converted into a specialized vehicle properly. The vehicle was specially fabricated and a lot of work has been put into the fabrication of the frame. The directional stability of the vehicle is not at all affected and another mentionable fact is that the ride quality has improved with the addition of the extra shock absorbers in the frame. The vehicle is able to travel over undulated roads with aplomb and without stability problems. The project designed and fabricated by us is aimed for modification of two wheelers for handicapped vehicles. And we successfully overcome some of the problems present in the existing vehicles such as steering problem, tire wear, traction, etc. Also, we provided a reversing mechanism which can be actuate with the help of a lever, this will help the physically handicapped persons to reverse the vehicle without any help. The vehicle has proved its capability and we hope that it will be able to set a benchmark in the handling and comfort factors for the physically challenged people.

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