DESIGN AND FABRICATION OF 180^0 WHEEL ROTATION VEHICLE

[1]V MALLIKARJUNA, [2]Dr. A. HEMANTH KUMAR, [3]S MD JAMEEL BASHA
[1]Assistant Professor, [2] Professor, [3] Assistant Professor
[1]Department of Mechanical Engineering
[1]Annamacharya Institute of Technology & Sciences, Rajampet, INDIA.

***ABSTRACT*:** The design and fabrication of 180 degree wheel rotation vehicle using DC motor and steering is done to reduce time to turn from one direction to other direction. This vehicle can move in all direction at a same position by used of steering, sprocket, DC motor, bearing and chain drive. Main function of this vehicle is easy to move from one direction to other direction. Modern development and economical progression of Indian society resulted in increase of people on railway platform, increase of vehicle on the road, due to space constraints, in hospital is major problem of the country. Present study aims for development of a system to reduce the turning radius of vehicle. In this system at first vehicle is stopped and wheels are then turned in the required direction with help of steering system and DC motor. It has turning radius nearly equal to negligible of length of the vehicle itself. This vehicle used to carry the goods in various areas such as, railway platform, hospital, industries and market.

Keywords: Bearing, Chain drive, DC motor, Sprocket, Steering and wheel.

INTRODUCTION:

Four wheel steering is a method developed in automobile industry for the effective turning of the vehicle and to increase the manoeuvrability. In a typical front wheel steering system the rear wheels do not turn in the direction of the curve and thus curb on the efficiency of the steering. In four wheels steering the rear wheels turn with the front wheels thus increasing the efficiency of the vehicle. The direction of steering the rear wheels relative to the front wheels depends on the operating conditions. At low speed wheel movement is pronounced, so that rear wheels are steered in the opposite direction to that of front wheels. At high speed, when steering adjustments are subtle, the front wheels and the rear wheels turn in the same direction.

Many modern cars use rack and pinion steering mechanisms, where the steering wheel turns the pinion gear; the pinion moves the rack, which is a linear gear that meshes with the pinion, converting circular motion into linear motion along the transverse axis of the car (side to side motion). This motion applies steering torque to the swivel pin ball joints that replaced previously used kingpins of the stub axle of the steered wheels via tie rods and a short lever arm called the steering arm. The rack and pinion design has the advantages of a large degree of feedback and direct steering "feel". A disadvantage is that it is not adjustable, so that when it does wear and develop lash, the only cure is replacement. A rack and pinion is commonly found in the steering mechanism of cars or other wheeled, steered vehicles. Rack and pinion provides a less efficient mechanical advantage than other mechanisms such as recirculating ball, but less backlash and greater feedback, or steering "feel". The mechanism may be power-assisted, usually by hydraulic or electrical means. A rack and pinion is a type of linear actuator that comprises a pair of gears which convert rotational motion into linear motion. A circular gear called "the pinion" engages teeth on a linear "gear" bar called "the rack"; rotational motion applied to the pinion causes the rack to move relative to the pinion, thereby translating the rotational motion of the pinion into linear motion.

OBJECTIVE:

Modern development and economical progression of Indian society resulted in increase of factories and industries . Due to space constraints material handling is the main problem is the major problem faced in most parts of the country. Present study aims for development of a system to reduce the turning radius of a vehicle. The indigenously developed system consists of Ackerman steering and various mechanism with arrangement of the various kinematics links. In this system at first vehicle is stopped and wheels are then turned in the required direction with the help of steering system. It has turning radius nearly equal to negligible of the length of car itself.

MECHANISAMS:

i) Mechanisms and Simple Machines

1. **Mechanism**: the fundamental physical or chemical processes involved in or responsible for an action, reaction or other natural phenomenon.

2. **Machine:** an assemblage of parts that transmit forces, motion and energy in a predetermined manner.

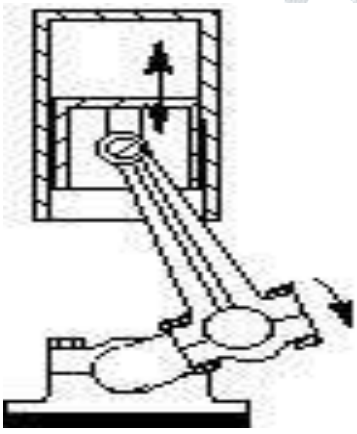
3. **Simple Machine**: any of various elementary mechanisms having the elements of which all machines are composed. Included in this category are the lever, wheel and axle, pulley, inclined plane, wedge and the screw.

The word mechanism has many meanings. In kinematics, a mechanism is a means of transmitting, controlling, or constraining relative movement (Hunt 78). Movements which are electrically, magnetically, pneumatically operated are excluded from the concept of mechanism. The central theme for mechanisms is rigid bodies connected together by joints.

A machine is a combination of rigid or resistant bodies, formed and connected do that they move with definite relative motions and transmit force from the source of power to the resistance to be overcome. A machine has two functions: transmitting definite relative motion and transmitting force. These functions require strength and rigidity to transmit the forces.
The term mechanism is applied to the combination of geometrical bodies which constitute a machine or part of a machine. A mechanism may therefore be defined as a combination of rigid or resistant bodies, formed and connected so that they move with definite relative motions with respect to one another.

Although a truly rigid body does not exist, many engineering components are rigid because their deformations and distortions are negligible in comparison with their relative movements.

The difference between machine and mechanism is that machines transform energy to do work, while mechanisms so not necessarily perform this function. The term machinery generally means machines and mechanisms. Figure 2-1 shows a picture of the main part of a diesel engine. The mechanism of its cylinder-link-crank parts is a slider-crank mechanism.



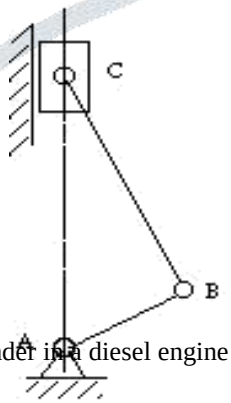


Fig 3.1: Cross section of a power cylinder in a diesel engine

Fig : Skeleton outline

ii) The Inclined Plane

Figure 2-3a shows an inclined plane, AB is the base, BC is the height and AC the inclined plane. With the use of the inclined plane a given resistance can be overcome with a smaller force than if the plane is not used. For example, in Figure 2-

3b, suppose we wish to raise a weight of 1000 lb. through the vertical distance BC = 2 ft. If this weight were raised vertically and without the use of the inclined plane the force 1000 lb. would have to be exerted through the distance BC. If, however, the inclined plane is used and the weight is moved over its inclined plane AC, a force of only 2/3 of 1000 lb. or 667 lb. is necessary, although this force is exerted through a distance AC which is greater than distance BC.

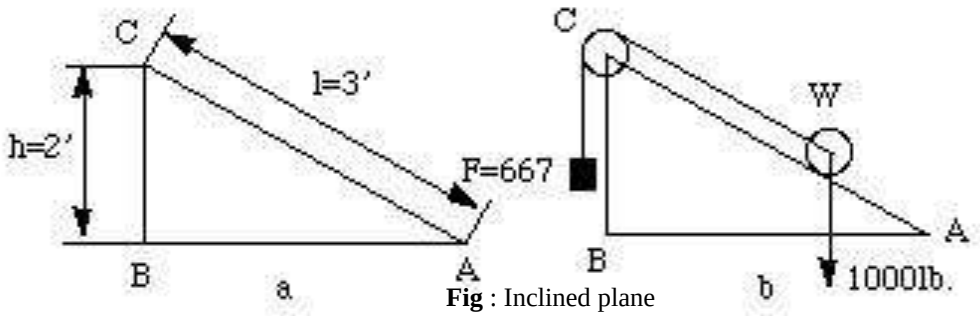


Fig : Inclined plane

Using an inclined plane requires a smaller force exerted through a greater distance to do a certain amount of work.

Letting F represent the force required to raise a given weight on the inclined plane, and W the weight to be raised, we have the proportion:

$$\frac{F}{W} = \frac{h}{l}$$

Neglecting the friction the following rule is used: The force F multiplied by the distance through which it moves in one complete turn is equal to the weight lifted times the distance through which it is lifted in the same time. In one complete turn the end of the handle describes a circle of circumference 2πR. This is the distance through which the force F is exerted.

Therefore from the rule above

$$F \times 2\pi R = W \times P$$

And

$$F = \frac{W \times P}{2\pi R}$$

Suppose R equals 18 in., P equals 1/8 in. and the weight to be lifted equals 100,000 lb., then the force required at F is then 110 lb. This means that, neglecting friction, 110 lb. at F will raise 100,000 lb. at W, but the weight lifted moves much slower than the force applied at F.

SPARE PARTS

SPROKETS:

A sprocket is a profiled wheel with teeth, cogs, or even sprockets that mesh with a chain. The sprockets are used for the power transmission between steering and wheel through the roller chain drive. A sprocket is a profiled wheel with teeth that meshes with a chain, track or other perforated or indented material. Chain sprocket is a part this vehicle. Chain sprocket are used to provide the clockwise or anticlockwise direction to front wheel and rear wheel through the chain drive. Sprockets are used in bicycles, motorcycles, cars, tracked vehicles, and other machinery either to transmit rotary motion between two shafts where gears are unsuitable or to impart linear motion to a track, tape etc.

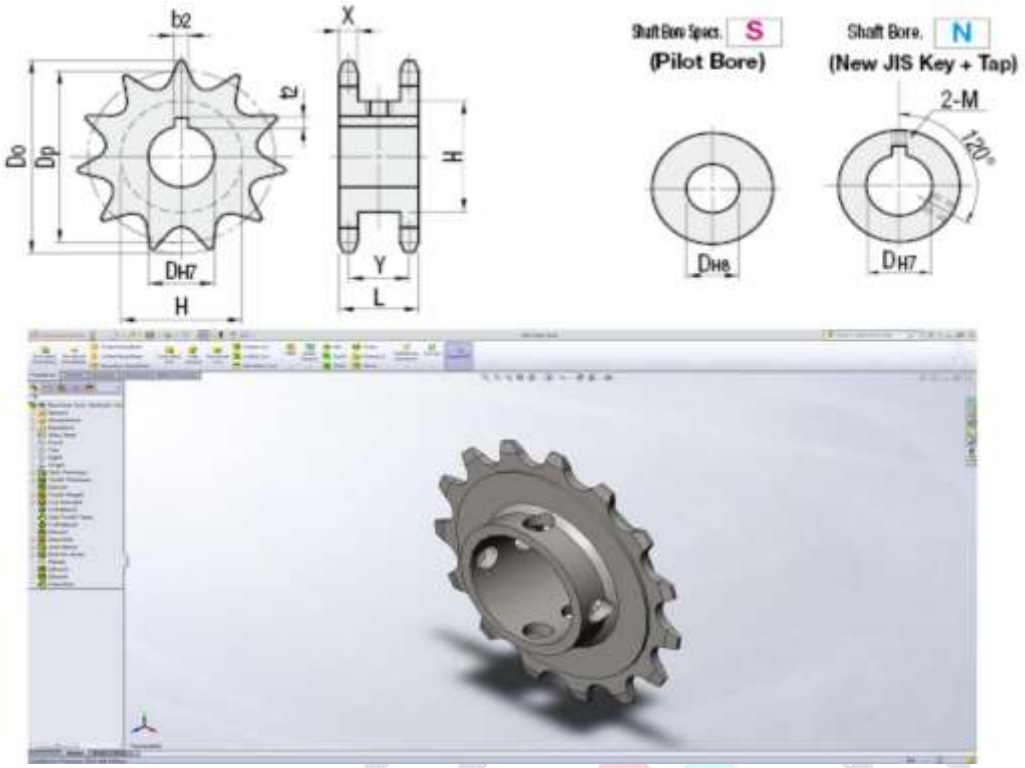


Fig : sprocket CAD and SOLID WORKS design

HEAD SPROKET:

Fig : Head sprocket

Sprockets are of various designs, a maximum of efficiency being claimed for each by its originator. Sprockets typically do not have a flange. Some sprockets used with timing belts have flanges to keep the timing belt centered.. They can be run at high speed and some forms of chain are so constructed as to be noiseless even at high speed.

ROLLER CHAIN:

A roller chain is the type of chain driven most commonly used for transmission of mechanical power between two sprockets. It consists of a series of short cylindrical rollers held together by side links. It is driven by a toothed wheel called a sprocket. It is often used to convey power to the wheels of a vehicle, particularly bicycles and motorcycles. It is also used in a wide variety of machines besides vehicles. In this vehicle first chain drive connected with sprocket of front wheel and sprocket of steering and second chain drive is connected with sprocket of rear wheel.

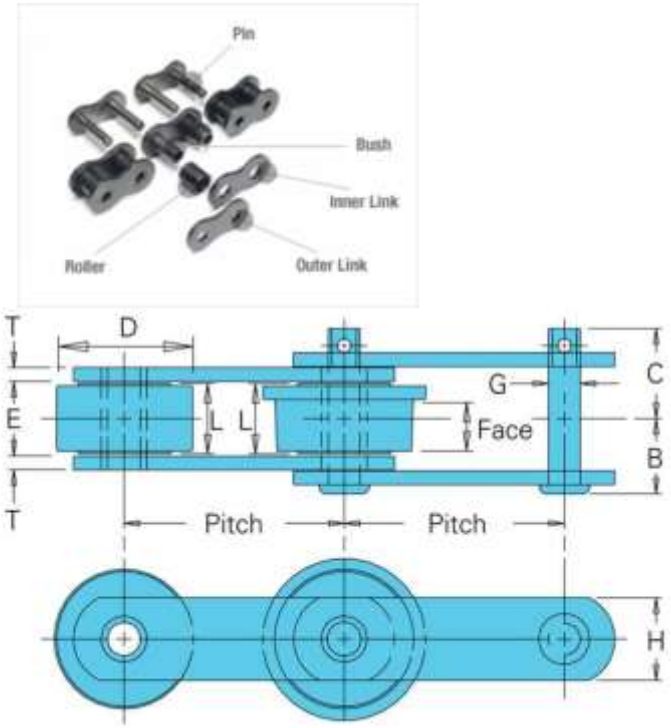


Fig 4.3: roller chain assembly and CAD design

4.4 ELECTRICALLY POWERED WHEELS (INWHEEL MOTOR):

Fig4.4 : In wheel motor assembly

The basic principle behind a vehicle equipped with in-wheel electric motors is simple. The internal combustion engine normally found under the hood is simply not necessary. It's replaced with at least two motors located in the hub of the

wheels. These wheels contain not only the braking components, but also all of the functionality that was formerly performed by the engine, transmission, clutch, suspension and other related parts.

LINKAGE HUB:

Fig 4.5: Linkage hub

It is one of the most important part which links the wheel to the sprocket and frame which all make a rigid link and rotates all together

BEARING:

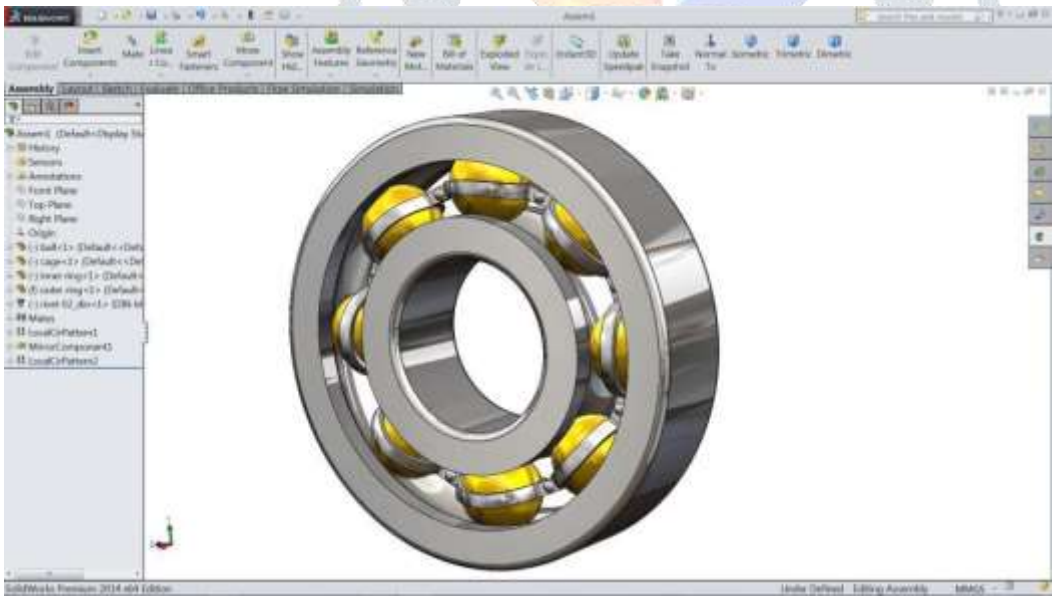


Fig 4.6: Bearing

In this vehicle bearing is use easy to move wheel from one direction to other direction, each bearing is connected with each wheel with the help of sprocket and iron pipe.A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Most bearings facilitate the desired motion by minimizing friction.

DC SPEED CONTROLLER:

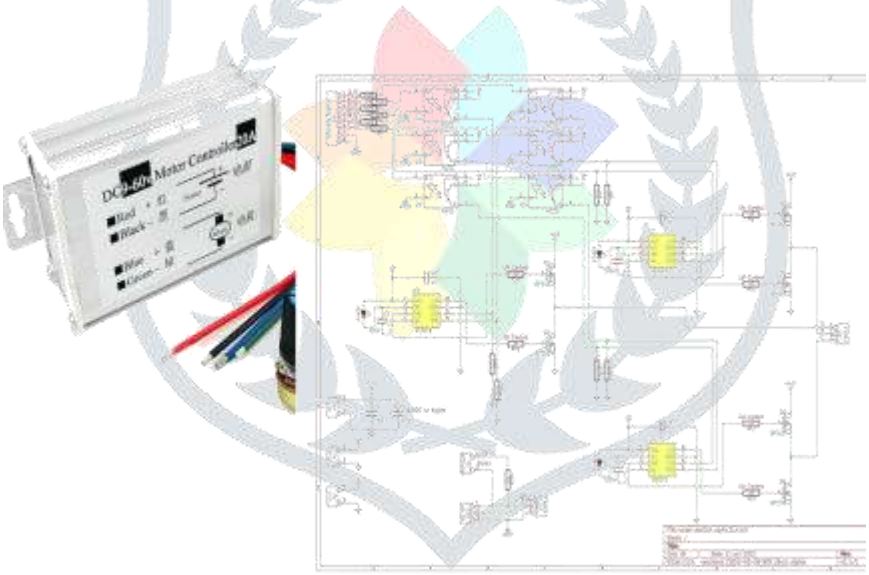


Fig 4.7: BLDC speed controller and schematic

An electronic speed control follows a speed reference signal (derived from a throttle lever, joystick, or other manual input) and varies the switching rate of a network of field effect transistors (FETs) By adjusting the duty cycle or switching frequency of the transistors, the speed of the motor is changed. The rapid switching of the transistors is what causes the motor itself to emit its characteristic high-pitched whine, especially noticeable at lower speeds.

Different types of speed controls are required for brushed DC motors and brushless DC motors. A brushed motor can have its speed controlled by varying the voltage on its armature. (Industrially, motors with electromagnet field windings instead of permanent magnets can also have their speed controlled by adjusting the strength of the motor field current.) A brushless motor requires a different operating principle. The speed of the motor is varied by adjusting the timing of pulses of current delivered to the several windings of the motor.

4.8 BATTERY:

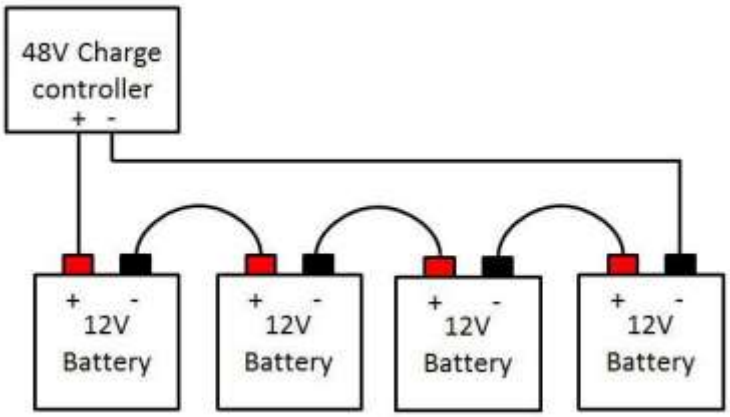


Fig 4.8 Battery connection schematic

A 48V 40 Ah battery is used to rotate the wheels .

In order to get 48V voltage 4 12V batteries are to be connected in series which fulfills the requirement .

MECHANISM:

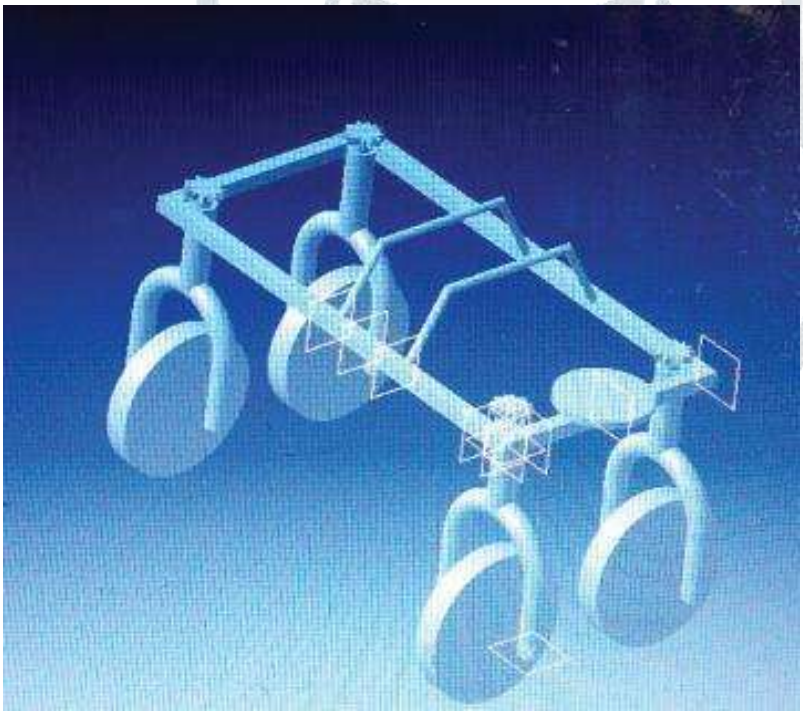


Fig 5.1: Design of used mechanism

WORKING PRINCIPLE:

This paper consist of steering, chain sprocket,DC motor, wheel, bearing, iron pipe, battery and chain drive. In this system first the vehicle is stopped and wheels are then turned in the required direction with help of steering system and DC motor. Teeth of sprocket are completely mesh with chain drive which has used to provide rotary motion to rear wheels by help of DC motor. Steering is used to provide direction of rotation to front wheels by help of sprocket and chain drive arrangement. DC motors are used in each wheel to provide forward and backward movement of this vehicle, also a battery is

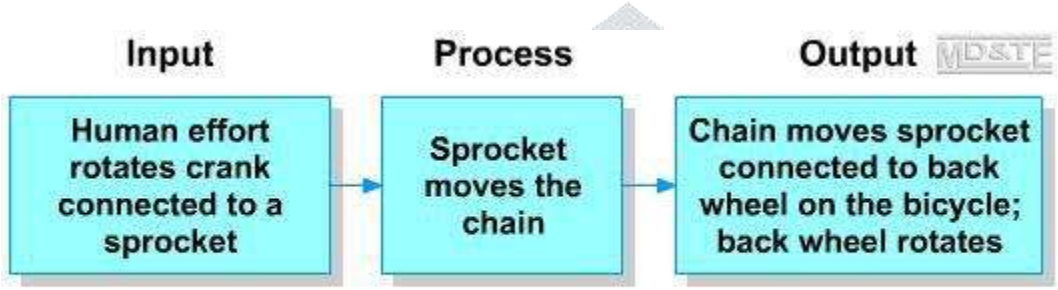
used to provide electrical energy of each DC motor. It has turning radius nearly equal to negligible of length of the vehicle itself. This system is to be useful in hospitals, small industries and also on railway platforms.

WORKING OF MECHANISM:

The output from power sources such as electric motors, car engines and wind generators is rotary motion of a drive shaft. The output rotary motion and force must be transmitted from the power source to a mechanism that will use the energy in some way. The usual ways of transmitting motion and force from the output drive shaft to a shaft in a mechanism is through: gears belt and pulleys chain and sprockets a crank couplings.

This section will explain how motion and force is transmitted from the output shaft of a power source through a chain and sprocket to other parts of a mechanism.

Example: the chain and sprocket drive on a bicycle



Process diagram for a chain drive system on a bicycle

Chain and Sprocket:

A **sprocket** is a toothed wheel that fits onto a shaft. It is prevented from rotating on the shaft by a key that fits into keyways in the sprocket and shaft.

A **chain** is used to connect two sprockets. One sprocket is the driver sprocket. The other sprocket is the driven sprocket. Motion and force can be transmitted via the chain from one sprocket to another, therefore from one shaft to another. Chains that are used to transmit motion and force from one sprocket to another are called **power transmission chains.**

There are 6 major groups of power transmission chains standard general purpose **roller chains,** widel used in industry high performance roller chains, these roller chains are stronger than general purpose roller chains lube-free chains, these chains can be used without lubrication environmentally resistant chains with special corrosion resistance specialty chains, Type 1. used as bicycle chains, motor cycle chains, automotive chain specialty chains, Type 2. including miniature chains, leaf chains and inverted tooth chain, i.e. silent chains.

Most of these chains are the roller type, i.e. they are composed of link plates, pins that join the link plates and also rollers and bushes.

STEP BY STEP DETAILED DESCRIPTION:

1. First steering is rotated
2. Then the head sprocket directs other sprockets and take a turn in the same angle
3. The sprocket is connected to wheel by the means of a connecting hub
4. That mean total sprocket is one link including wheels
5. All 4 wheels take turn

POWER CALCULATIONS:

Torque required on a flat surface

Normal force (Fn) = force applied = mg

= 100*9.81

= 981N

= 0.2*981

= 196.2 N

Torque required = Ff*rw

= 196.2*0.18

= 35.316 N-m

Torque required on slope

Stair dimensions

Land: 254.0 mm

Rise: 177.8 mm

Slope of stair = tan-1(177.8/254)= 35o

Total mass acting (including setup) = 100kg = 100*9.8 = 981N Normal force acting (Fn) = mgcos =100*9.81*cos (35o)

= 803.58 N

= 0.2*803.58

= 160.7 N

= 100*9.81*sin (35o)

= 562.67 N

= (160.7+562.67) 0.18

= 130.20 N-m

Motor torque generated

Power of motor (P) =2 NT60

180 =2 1.5T60 *0.6 (i.e., 0.6 = efficiency of the motor gear box)

Torque at the mid-shaft Tmid = 687.54N-m

Torque generated at wheels = Tmid / 1 (1:1 ratio sprocket arrangement)

= 687.5 / 1

= 687.5 N-m

The following formulae were used to determine the radius and the chain length P = 2 r2 sin(180/Z2)

Lp = 2*c/15 + (Z1+Z2)/2 + P(Z1-Z2)/(4π2*c)

L = Lp*P

Cactual = P/4[Lp - (Z1+Z2)/2 +√{((Lp-(Z1+Z2)/2)2 – 8(20/2)2}]

Where, P = Pitch of chain

Lp = Pitch length of chain

L = Length of chain

c = center distance

Z1 = no. of teeth on driver

Z2 = no. of teeth on driven

Cactual = actual centre distance

Centre distance 426 mm

Pitch of chain 15 mm

Radius of driven sprocket 78.9 mm

Radius of driver sprocket 78.9 mm

Pitch length of chain 90 mm

Length of chain 1350 mm

Actual centre distance 424.81mm

No of teeth on driver 33

5.5 chain drive calculations

Assumed breaking load = 6810kgf

Pitch, p = 15.875

Teeth number, z1 = 16 z2 =45

Transmission ratio, i = z2 /z1 =45/16 =2.8125

Weight of car = 80kg

Total estimated weight = 200kg

Breaking load = 200*9.81=**1962kgf**

Hence designed chain is safe.

Motor calculation:

60 rpm 12 V 18 W

Torque of motor: ζ =P × 602 × 3.14 × N (1) =18 × 602 × 3.14 × 60 = 2.866 Nm =2.866× 10^3 N-mm.
The motor shaft is made of MS and its allowable shear stress (Fd) = 42 MPa Torque:ζ = 3.14 ×Fd× d^3 16 (2)

Calculation of position of center of gravity with respect to the rear axle

We know that turning Radius of vehicle (R) = 1500 mm.

Also we know that,

Turning radius of vehicle: R= a2 2 + R1 2

Where, a2 = Distance of CG from rear axis.

R1= Distance between instantaneous center and the axis of the vehicle.

To find a2 Load on front axel: Wf=W× a2L

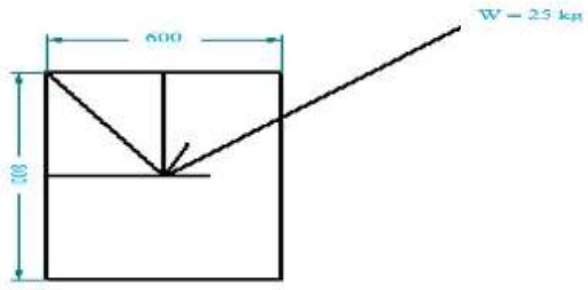
Where, Wf = Load on front axle = 17kg (On basis weight distribution)

Total weight of vehicle (W) = 30kg Wheel base (L) = 2669 mm

Therefore, a2 = 1200 mm Substituting the value of a2 in the above equation R1 = 2010 mm

If load apply on the vehicle is 25kg and length 600 mm, width of vehicle 800 mm.Find the reaction force developed by each wheel and also find torque of each wheel?

Here Given Data W=25kg



Length=600 mm

Width=800 mm

To find reaction force on each wheel (F),

torque (T) r= ((a 2)2+ (2)2)0.5

r= ((6002)2 + (8002)2)0.5

r=500 mm

Now W= 25kg = 25 × 9.81 = 245.25N

Now Force on each wheel =W4 =61.32N According to Newton's 3rd law of motion Reaction Force developed by each wheel: F =W4 = 61.32N Now Torque on each wheel: T=W4×r = 30660 N-mm.

DESIGN OF FRAME

Material used –mild steel, square pipe

Area=1*1inch=25.4*25.4=645.16 mm2

Length of link=48" = 1220 mm

Weight of project=10 kg= 10*9.81 =98.1N

Weight of human being 75 Kg = 75*9.81 = 735.75N Total load = 833.85 N

Young's modulus=E=210GPa

1) Solution

1) Effective Length

Effective length, when both end fixed,

Le= 2=12202= 610 mm

2) Internal Area

Internal width and depth, which have 3 mm thickness,

d=b=25.4-2*3 =19.4 mm

3) Moment of Inertia

I= 3− 312=25.4∗25.43−19.4∗19.4312=22882.048mm4 4) Crippling load by Euler's formula

Pc=127442.8251 KN

Pc = 127442.8251 KN > Total load = 833.85 N

Hence design safe.

RESULTS AND DISCUSSIONS

The performance analysis of the 360 degree wheel rotation vehicle has clearly shown that it is more efficient, economical and effective. In this paper forward and backward movement of vehicle and turning of rear wheel of the vehicle are getting power from the battery in the form of an electrical energy. This energy is has stored into a 12V battery and then supplied to the components. As the electrical power is used and transmitted to components by the use of electrical wires in place of any mechanical arrangement, this results in less noise, less wear of components and less vibration. Use of battery provides a smooth flow of current toward the components. Most of time people are facing problem in parking and railway platform because other vehicle are taking more space to move from one direction to other direction. But developed 360 degree wheel rotation vehicle this problem easily solved. Because this vehicle has capability to move from one direction to other direction in very less space. In this project a DC motor and battery are used according to load carry capacity which is of 5 kg, but vehicle able to carry more load if use more than 12V of battery.

Front wheel steering mode

1. Turning angle of front wheels = 23°
2. Turning radius calculated = 3.503 m

Shorter radius turning mode

1. Turning angle of front wheels = 22°
2. Turning angle of rear wheels = -17°
3. Turning radius calculated = 2.779m

Parallel parking mode

1 Turning angle of front wheels = 22°

2 Turning angle of rear wheels = 19°

3 Turning radius calculated = infinity

Zero degree rotation mode

1. Turning angle of front wheels = 41°
2. Turning angle of rear wheels = 37°
3. Turning radius calculated = 0m

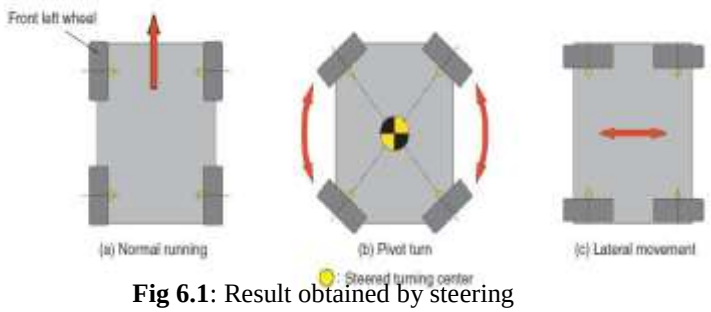


Fig 6.1: Result obtained by steering

CONCLUSION:

This paper focused on a steering mechanism which offers feasible solutions to a number of current maneuvering limitations. A prototype for the proposed approach was developed by introducing separate mechanism for normal steering purpose and 180 degree steering purpose. This prototype was found to be able to be maneuvered very easily in tight spaces, also making 90 degree steering possible. Different mechanisms were adopted by trial and error method, in order to facilitate the engagement of the wheels in the required direction, and the most convenient method was adopted. The time analysis, for the time required to perform a parallel parking maneuver and a 90 degree. Turn was carried out, and it was established that the implementation of the modification, led to decrease in the time required for the performance of the above operations. The prototype was tested to ensure the conformity with Ackermann' s steering condition, and it complied with the same .The forces acting on each wheel was obtained and the force that required to be applied on the steering wheel, in order to engage the wheels in the required direction was calculated. The features that enhanced the prototype were the increase in maneuverability in limited space, and the parallel parking ability.

REFERENCES:

1. J. Uicker, G. R. Pennock, and J. E. Shigley, 2003, Theory of Machines and Mechanisms, Oxford University Press, New York.
2. Reuleaux, F., 1876 'The Kinematics of Machinery,' (trans. and annotated by A. B. W. Kennedy), reprinted by Dover, New York (1963)
3. Eckhart, Homer. Kinematic Design of Machines and Mechanisms. McGraw Hill. ISBN 0-07-018953-6.
4. J. Phillips, Freedom in Machinery, Cambridge University Press, 2006
5. theory of machines and mechanisms by Joseph E. Shingle
6. "1988 Peugeot 405 T16 GR Pikes Peak". Retrieved 16 March 2015.
7. Murphy, Tom; Corbett, Brian (2005-03-01). "Quadra steer Off Course". Wards Auto World. Retrieved 2010-06-11.
8. "2009 BMW 750Li and 750i Technology - Inside the 2009 BMW 7 Series". Motor Trend. Retrieved 2011-11-13.
9. Johnson, Erik (June 2007). "2008 Infiniti G37 Sport Coupe - Suspension, Handling, and Four-Wheel Steering".
10. "Turbo Terror: New Porsche 911 Turbo Announced". Automoblog.net. 2013-05-06. Retrieved 2013-05-13.
11. "Toyota Camry Catalog".
12. http://www.porsche.com/usa/models/911/911-turbo/chassis/rear-axle-steering/
13. "Thrust SSC - Engineering". Retrieved 2010-05-26.
14. Smart, Jim. "Collapsible Steering Column Installation".
15. Gear Nomenclature, Definition of Terms withSymbols. American gear Manufacturers Association. p. 72. ISBN 1-55589-846-7.OCLC 65562739.ANSI/AGMA 1012- G05.
16. "Rack and pinion variable ratio steering gear". Google Patent Search. Retrieved 2007-03-22.

17. "The Role of Rack and Pinion Actuators in On-Off & Modulating Controls". Valve Magazine (Valve Manufacturers Association) (Spring 2010).

18. "AutomaxSuperNova Series Pneumatic Rack & Pinion Actuators" (PDF). Flowserve Corporation. Retrieved 7 July 2014.

19. Jaishnu Moudgil, Shubhankar Mengi and Mudit Chopra, 360 Degree Rotating Vehicle to Overcome the Problem of Parking Space, International Journal of Research in Mechanical Engineering and Technology, 5(2), 2015, 22-25.

20. Sudip kachhia, Design of 360 Degree Rotating Car, International Journal of Advance Research and Innovative Ideas In Education, 2(5), 2016, 15–16.

21. K. Lohith, K. Lohith, Dr. S. R. Shankapal, M. H. Monish Gowda, Development of Four Wheel,Scholars Journal of Engineering and Technology,12(1), 2013, 52-53.

22. Er. Amitesh Kumar, Dr.Dinesh.N.Kamble, Zero Turn Four Wheel Steering System, International Journal of Scientific & Engineering Research,5(12), 2014, 22-24.

23. Mr. Sharad P. Mali, Mr. Sagar Jadhav, Prof. D.U.Patil, Zero Turn Four Wheel Mechanism, International Engineering Research Journal,2(2), 2016, 484-486.