COMPOUND CHAIN BICYCLE

T. Jashwanth[1], V. Arun kumar[2], G. Vamshi Krishna[3], P. Sai Sharan[4], B. Laxmi Narayana[5]

[1,2,3,4] (students, IV yr – II semester, B.Tech), Mechanical Engineering, Vaageswari College of Engineering, karimnagar – 505481 (Telangana) (India)
Email: ([1] jashuadi005@gmail.com, [2] vodnalaarunkumar0@gmail.com, [3]vamshi316krishna@gmail.com, [4] saisharan167@gmail.com)

[5] Asst. Professor, Department of Mechanical Engineering, Vaageswari College of Engineering, karimnagar – 505481 (Telangana) (India)
Email: ([5] narayana.mech444@gmail.com)

ABSTRACT: This paper mainly focuses on the concept of COMPOUND CHAIN BICYCLE (CCB) and the modifications to be done for making it suitable for a common man to use. Generally, such bicycles are very few in no. & are used for racing & only to create world records of about 200 kmph till date.

This paper shows the arrangement of chain drive in compound form, speed calculations and the bicycle frame design. Speed is the important difference between the conventional bicycle & CCB. The former one, under a normal adult effort, goes around 15 kmph but CCB under the same effort goes around 50 kmph, even 60 kmph if higher toothed sprockets are employed.

Keywords: *bicycles, chain drive, compound chain, CCB, high speed bicycles.*

INTRODUCTION: In the very beginning of human evolution, we used wooden logs to carry goods (wood). They were replaced by bullock carts with wooden wheels. Later, with the invention of petrol & diesel engines, motor vehicles changed the pace of transportation. From then, we've been using different types of vehicles for our comfort & faster transportation. They run on fossil fuels like coal, petrol, diesel, etc. They cause lot of pollution by releasing micro pollutants, HC, greenhouse gases like CO, CO_2, NO_x, SO_2, etc., into the atmosphere thereby increasing global - warming.

The only vehicle invented by man which is eco-friendly is BICYCLE. Hence, for a greener planet we need to raise its use. The only drawback of bicycle is its low speed as it is directly driven mechanically by the rider. This project is our little contribution to increase the bicycle speed relatively only by mechanical means using compound chain drive mechanism. This is different from e-bikes as they use electric alternator, battery and motor to run the bicycle at high speed.

CHAIN DRIVE: Generally, chains can be used for centre distance upto 8 metres, velocities upto 25 m/s (90 kmph) and for power upto 110kW.

No slip takes place and gives fewer loads on shafts. Transmission efficiency is upto 98 % i.e., transmits more power than belts.

The fig.4 below shows the diagram of concept of simple chain drive.

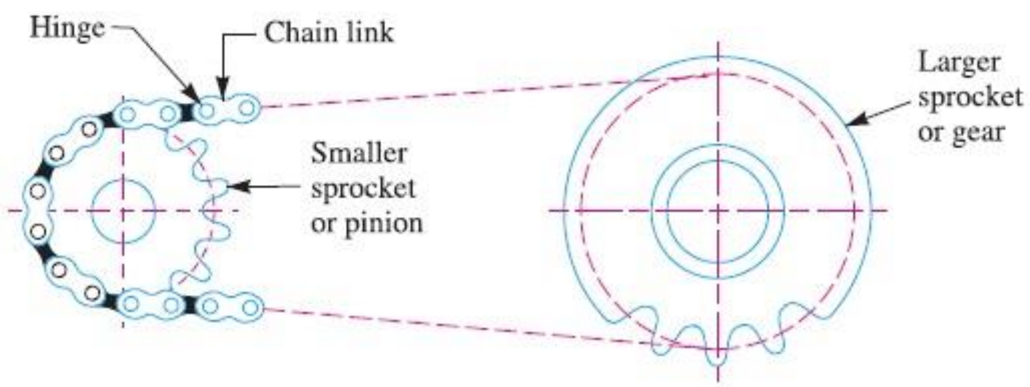

Fig.4 Simple chain drive

The concept of compound chain drive is shown in fig.5 below. It is generally used for belts in flour mills.

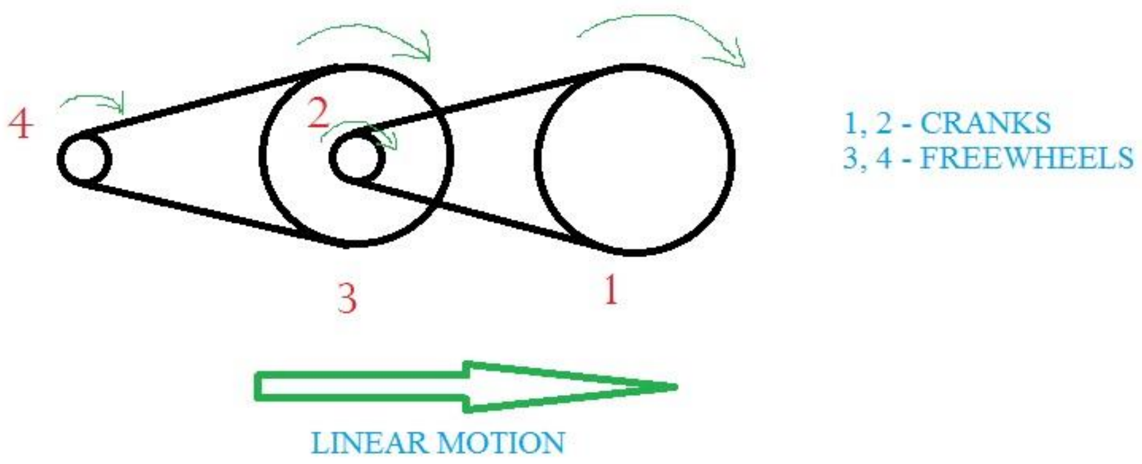

Fig.5 Compound Chain Drive

(**All the cranks and freewheels mentioned below are based on above fig.)

There are two possible designs for this type bikes. They are:

1. Linear arrangement and
2. Angular arrangement.

The linear arrangement has an advantage that uniform stress concentration takes place as both the drives are in-line i.e., 180°. But the complexity here is we must design the whole new frame which is lengthier than traditional bikes. It is shown in fig.6 below.

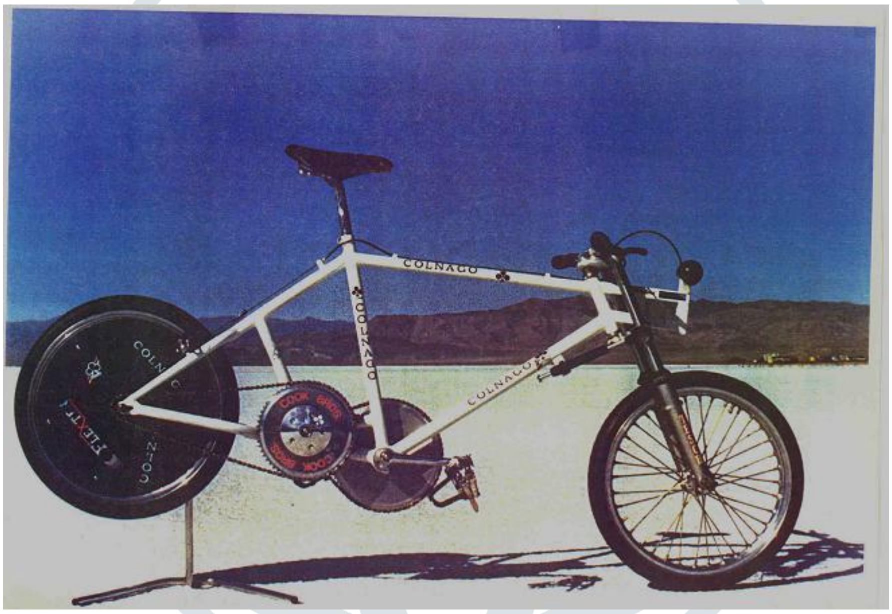

Fig.6 Linear arrangement of chain drives

Inertia forces also may act on freewheel 2 but those are negligible.

On the other hand, angular arrangement type has the advantage of having same length as that of a conventional bike. But, as the two drives are at an angle, the stress or load concentration is relatively more on the freewheel 2 as it has to overcome the inertia of whole bicycle and turn the crank 3 connected to freewheel 4 thereby moving the bicycle. It is shown in fig.7 below.

Fig.7 Angular arrangement of chain drives

A traditional bike with straight seat tube can easily be altered into our type using angular arrangement.

BUSH: While mounting the freewheel 2 and crank 3 on the same shaft, a bush is made on lathe. The 3D model designed using CATIA is shown in the fig.8 below.

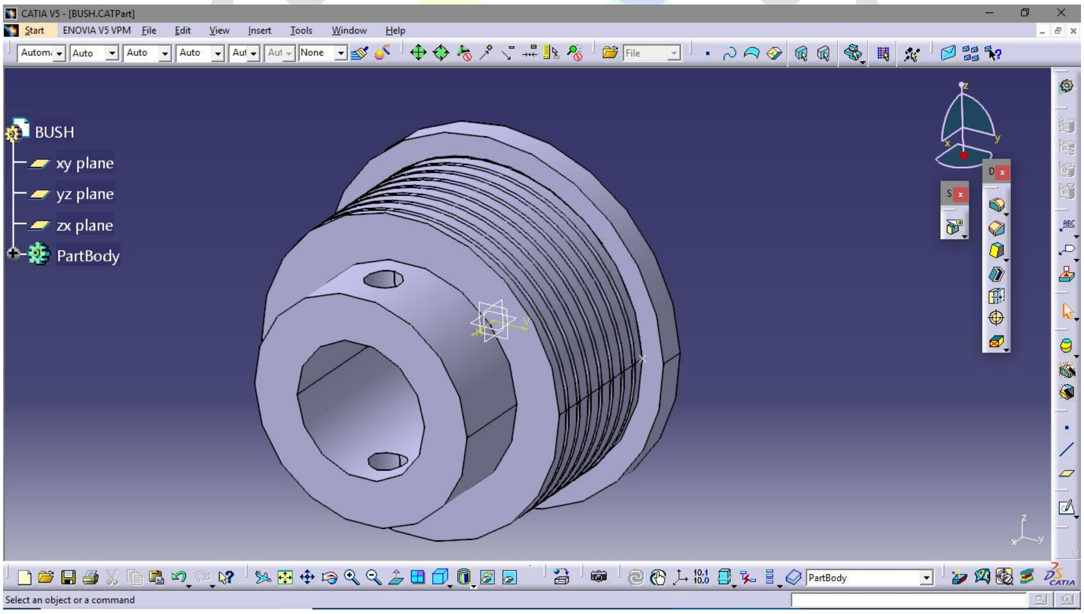

Fig.8 Bush prepared for freewheel designed using CATIA

This bush provides flexibility that even if freewheel 2 has failed, it can be easily replaced by the other. In the bush, hole is provided for pin arrangement and also thin wall on opposite side to prevent freewheel from slipping inwards. All other sprockets available in market can be usually replaced. In fact, allen key nut is to be used instead of bolt used. The figures 9(a), 9(b), 9(c) below represent different views of the bush (with freewheel) we made.

Fig.9(a)Bush with Freewheel

Fig.9(b)Top view of bush with freewheel

Fig.9(c) Side view of bush with freewheel

SPEED CALCULATIONS: First, we calculated our own bicycle "Atlas Vortex" which has 44 T crank and 18 T freewheel. Let crank be numbered 1 and freewheel as 2. Assuming 80 kg of rider and around 18 kg of bicycle, normal air speed and 26' (or D = 0.66 metre) outer diameter of wheel (with tyre),

Angular velocity of crank, $N_1 = 46$ rpm

Speed ratio, $N_2/N_1 = T_1/T_2 = 44/18 = 2.44$

Angular velocity of freewheel, $N_2 = N_1 \times 2.44 = 46 \times 2.44 = 112.44$ rpm

Linear speed of rear wheel, $V_2 = \pi DN_2 / 60$ m/s $= \pi \times 0.66 \times 112.44 / 60$

$= 3.89$ m/s $= 3.89 \times 18/5$

$V_2 = 13.99 = 14$ kmph.

But practically, we reached 12 kmph showing that loss of 2 kmph in speed.

Applying same calculation for CCB with same specifications (cranks 44 T, freewheels 18 T),

Angular velocity of crank 1, $N_1 = 46$ rpm; $N_2 = N_3$

Speed ratio, $N_4/N_1 = (T_1 \times T_3) / (T_2 \times T_4) = (44 \times 44) / (18 \times 18) = 5.975$

Angular velocity of final freewheel, $N_4 = 46 \times 5.975 = 274.86$ rpm

Linear speed of rear wheel, $V_4 = \pi DN_4 / 60$ m/s $= \pi \times 0.66 \times 274.86 / 60$

$= 9.5$ m/s $= 9.5 \times 18/5$

$V_4 = 34.2$ kmph

In our project, we used 2 cranks of 60 T each and 2 freewheels of 18 T each, applying above calculation for this,

Angular velocity of crank 1, $N_1 = 46$ rpm; $N_2 = N_3$

Speed ratio, $N_4/N_1 = (T_1 \times T_3) / (T_2 \times T_4) = (60 \times 60) / (18 \times 18) = 11.11$

Angular velocity of final freewheel, $N_4 = 46 \times 11.11 = 511.11$ rpm

Linear speed of rear wheel, $V_4 = \pi D N_4 / 60$ m/s $= \pi \times 0.66 \times 511.11 / 60$

$= 17.66$ m/s $= 17.66 \times 18/5$

$V_4 = 63.59$ kmph*

*Theoretical speed, changes with total weight (bicycle + rider's), air flow, road friction, steepness, etc., and coefficient of friction of road (BT or CC), $\mu = 0.7$

FRAME DESIGN: We went through the papers and reports mentioned under reference and obtained with some solutions. We applied them for our model. Solutions are:

- Von mises stresses occur at junctions and at head and chain stays.
- All the stresses, strains and displacements are below the maximum limit.
- Chain stays and seat stays must be of larger diameter than the conventional bicycles to have more strength.
- Tubes of frame when left straight (not even having one bend) have relatively low stresses.

The figures 1 and 2 below show the frame design done using CATIA.

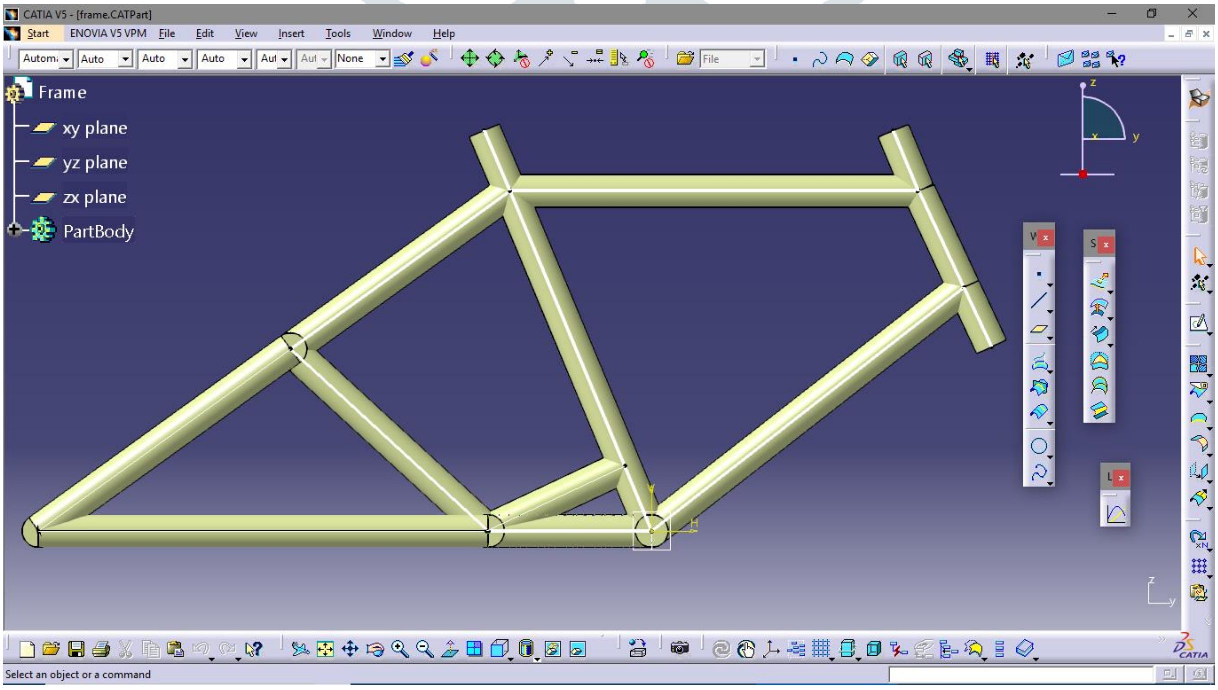

Fig.1 Frame designed using CATIA

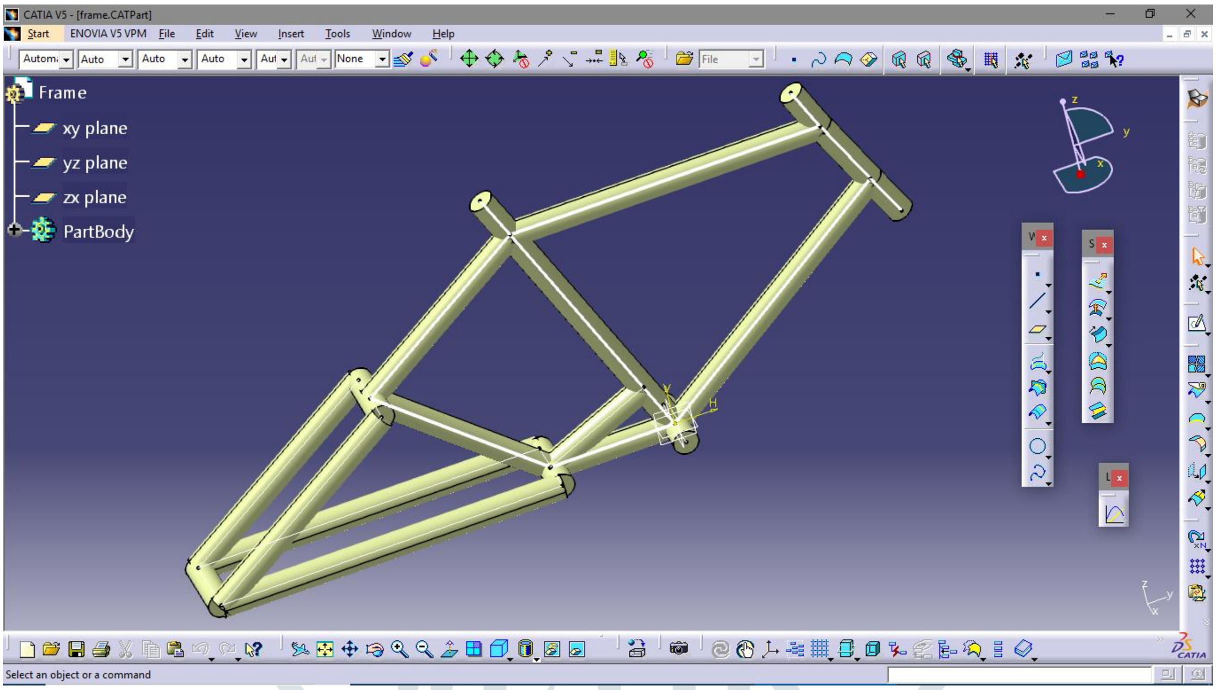

Fig.2 Frame design in other view

We used Mild Steel tubes of outer diameter 3.2 cm and thickness 2 mm for the frame.

Saddle is placed almost at equal height so that air resistance is reduced while riding as it passes over the rider's back.

Our frame design is adopted from COLNAGO bicycle (fig.6) and dimensions are changed according to the requirement. The fig.3 below shows our final frame.

Fig.3 Our final frame

AUXILIARIES: A suspension fork has replaced the normal fork in our design as it prevents the shocks (due to uneven roads or braking, etc) reaching the rider. It is available in the market. It is shown in fig.10 below.

Fig.10 Suspension Fork

Disc brake is provided to the front wheel whereas traditional brake is used for rear wheel to control the bicycle at higher speeds. It is shown in fig. 11 below.

Fig.11 Disc brake equipment

The saddle is preferably chosen to be well cushioned and having required suspension providing springs.

A carriage arrangement is also to be made as this bicycle is to be used by a common man for his daily activities.

Mobile charging point can also be provided.

ADVANTAGES OF CCB: The following are few advantages observed,

- Can reach the constant speed of around 60 kmph almost with the same effort which is applied on traditional bicycle is enough.
- Bicycle is however eco – friendly.
- Relatively simpler in design and operation than those of a sports bicycle.
- No need of changing gears to increase or decrease speed like sports cycle.
- Almost of same cost as MTB.
- No need of electric motors, batteries, etc to increase bicycle speed.
- Can be used for medium distances like 30 km, instead of using motorcycles.
- Saves lot of journey time when compared to conventional bicycle.
- Saves fuel even. It uses only mechanical energy.
- Cycling is healthy. Regular cycling keeps us fit.

CONCLUSION: Based on the project activity, this paper concludes the following,

- Compound Chain Bicycle (CCB) can successfully replace the traditional bicycle for daily use.
- Designing the CCB must be carefully done and body must be pleasing.
- A traditional bicycle can be modified into a CCB by making minor alterations.
- Effort applied by rider is almost same as that for conventional cycle. Cycling is also the same as there is no need to chain gears (sprockets).
- All the stresses, strains and displacements of frame are under below maximum limit.
- Speed calculations provided above proved that the constant higher speeds can be achieved with CCB.
- All frame tubes having same diameter, thickness and also having no bends in design and carbon steel metal yields better results.

- Two possible arrangements of chain drives are learned.
- It partially looks like conventional bicycle but few parameters like length, width, etc. must be carefully decided.
- Different auxiliaries can be employed for our comfort.

We are still working on the design and development of CCB to make it more reliable and comfortable.

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