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Design and Fabrication of Hybrid Torque Bicycle

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Abstract

Hybrid Torque Bicycle work on the concept of KERS which is a collection of parts which takes some of the kinetic energy of a vehicle under deceleration, stores this energy and then releases this stored energy back into the drive train of the vehicle, providing a power boost to that vehicle. For the driver, it is like having two power sources at his disposal, one of the power sources is the engine while the other is the stored kinetic energy which justifies the concept of hybrid power source from flywheel
Keywords: KERS (kinetic energy recovery system), etc

I. Introduction

A flywheel is an energy storage device that uses its significant moment of inertia to store energy by rotating. Flywheels have long been used to generate or maintain power and are most identified with the industrial age and the steam engine. In one sense it can be thought of as a rechargeable battery that store energy in the form of mechanical energy instead of electrochemical. Flywheels have been gaining popularity as a possible replacement for chemical batteries in vehicles, but until last year there was no record of a flywheels being used to increase the efficiency of a bicycle.

II. Literature review

Gao Y., Chen L., Ehsani M. The possibility of recovering vehicle kinetic energy is one inherent advantage of electric and hybrid electric vehicles. When a vehicle drives in heavy traffic, for example in New York City, more than half of the total energy is dissipated in the brakes. Therefore, recovering braking energy is an effective approach for improving the driving range of EV and the energy efficiency of HEV. In this paper, three different braking patterns are investigated for evaluating the availability of braking energy recovery. The results indicate that even without active braking control, a significant amount of braking energy can be recovered, and the brake system does not need much changing from the brake systems of conventional passenger cars.

Chibulka J. New advancement of technology and never satisfying demands of the civilization are putting huge pressure on the natural fuel resources and these resources are at a constant threat to its sustainability. To get the best out of the automobile, the optimum balance between performance and fuel economy is important. In the present state of art, either of the above two aspects are taken into mind while designing and development process which puts the other in the loss as increase in fuel economy leads to decrement in performance and vice-versa. In-depth observation of the vehicle dynamics apparently shows that large amount of energy is lost during braking and likewise large amount of fuel is consumed to reclaim the initial state, this leads to lower fuel efficiency to gain the same performance. Current use of Kinetic Energy Recovery System is only limited to sports vehicles only because of the higher cost of this system. They are also temporary in nature as power can be squeezed only during a small time duration and use of superior parts leads to high cost, which results on concentration on performance only and neglecting the fuel economy. In this paper Kinetic Energy Recovery System for storing the power and then using the same while accelerating has been discussed. The major storing element in this system is a Flat Spiral Spring that will store energy by compression and torsion.

III. Identified gaps in literature

In most of the recent journals and papers published, there is a concept related with the KERS, in which Flat Spiral Spring are used that will store energy by compression and torsion and advance braking system are designed. In the present proposed work, we intend to develop the efficient, economically and better method of energy recovery. In recent paper very limited work is done in KERS technique. So, the involvement of this mechanical rotating fly wheel eliminates will be very helpful for improving the paddling efficiency of the proposed work.

IV. Problem Formulation

There are two basic types of KERS systems i.e. Electrical and Mechanical. The main difference between them is in the way they convert the energy and how that energy is stored within the vehicle. Battery-based electric KERS systems require a number of energy conversions each with corresponding efficiency losses. On reapplication of the energy to the driveline, the global energy conversion efficiency is 31–34%. The mechanical KERS system storing energy mechanically in a rotating flywheel eliminates the various energy conversions and provides a global energy conversion efficiency exceeding 70%, more than twice the efficiency of an electric system. This design of KERS bicycle was motivated by a desire to build a flywheel energy storage unit as a proof of concept.

V. OBJECTIVE

1) To modify the main frame of bicycle in order to hold the flywheel, clutch and clutch actuating mechanism.
2) To reduce overall pedaling power.

VI. RESEARCH METHODOLOGY

The proposed flywheel and supporting system is to be designed and analyzed using CAD & FEA software for its strength. The frame has to take the load of the flywheel and the rider. So, to do so we have to reduce the mass of bicycle to counter the weight of the flywheel.
Now , initial mass of bicycle is = 17 kg

flywheel mass = 7.71 kg

After removing all the accessories like (mud guard , carrier & second handle bar).we can reduce weight of 4 kg. So, finally bicycle become mass of 13 kg only.
Therefore , additional weight in bicycle is only

(7.71 – 4) = 3.71 kg

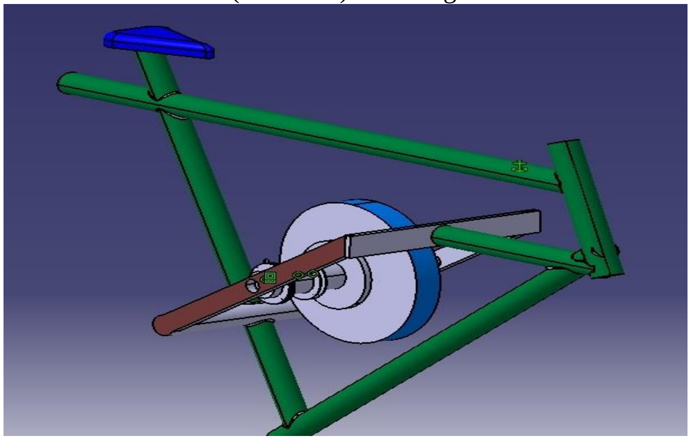

Fig. 1: Modify main frame of bicycle

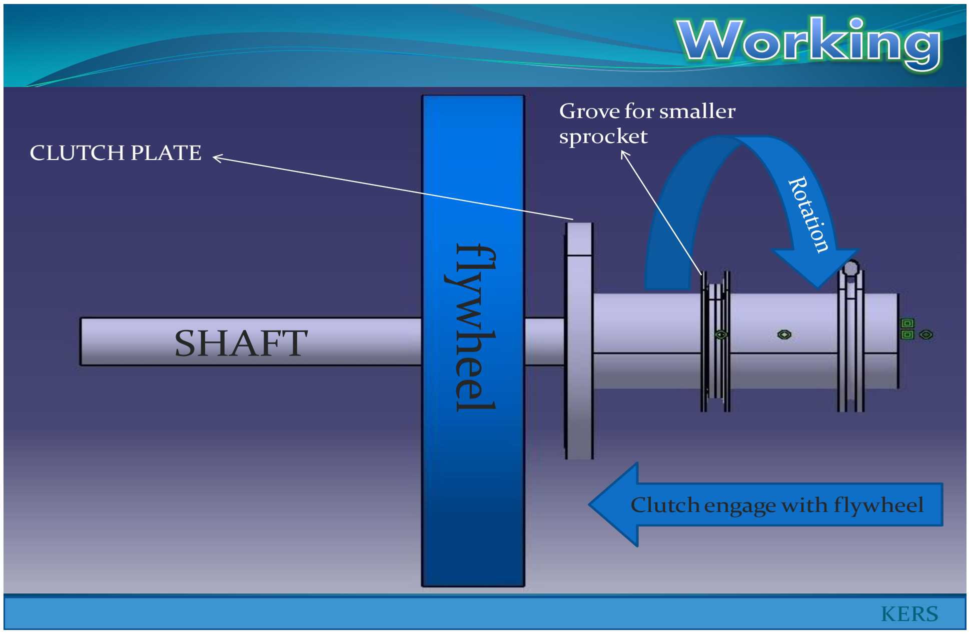

Fig. 2: Main assembly and working.

VII. CALCULATION

A. Fly wheel design consideration

- Flywheel can store maximum amount of energy. (i.e. 241.78 J, according to our speed changing consideration).
- Material of the flywheel is plane carbon steel (Mn < 1%, Si <0.1% at 27 °C)
- Density ρ =7854 kg/m³.
- Dimension of flywheel w.r.to space available in frame.
- Diameter (D) = 250 mm.
- Thickness (t) =20 mm.
- Air drag is assumed to be zero.

1) Flywheel Design

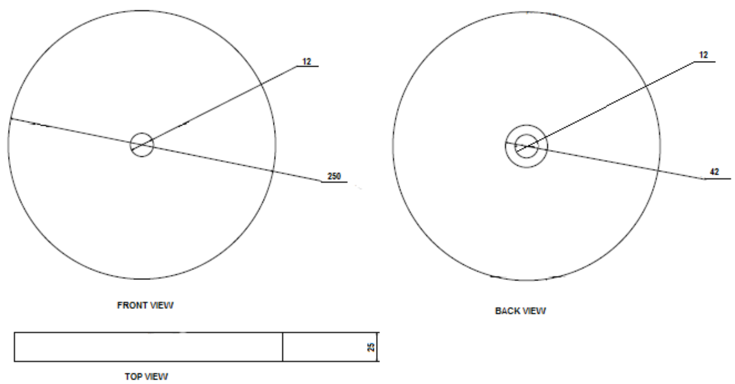

Fig. 3: 2D view dimension

Diameter of flywheel = 250mm;
Internal Diameter of flywheel = 42mm;
Width of flywheel rim = 25mm;
Selecting the Material of Flywheel as Mild Steel having density approximately equal to 7860 kg/m^3 .

∴ Mass of fly wheel = density × volume of disc

= 7860 × (Area × width of disc)

$$= 7860 \times \left(\frac{\pi}{4} \times (0.25^2 - .042^2)\right) \times 0.024$$

$$\therefore m_f = 8.998 \text{ kg} \cong 9 \text{ kg (approximately)}$$

Work required for charging flywheel,

$$W = \int_0^{\pi} T_{max} \sin\theta \; d\theta$$

$$= \int_0^{\pi} 120 \sin\theta \; d\theta$$

W = 240 J/s

Mean Torque,

$$T_{mean} = \frac{240}{2\pi} = 38.17 \text{ N-m}$$

2) Design of Frame

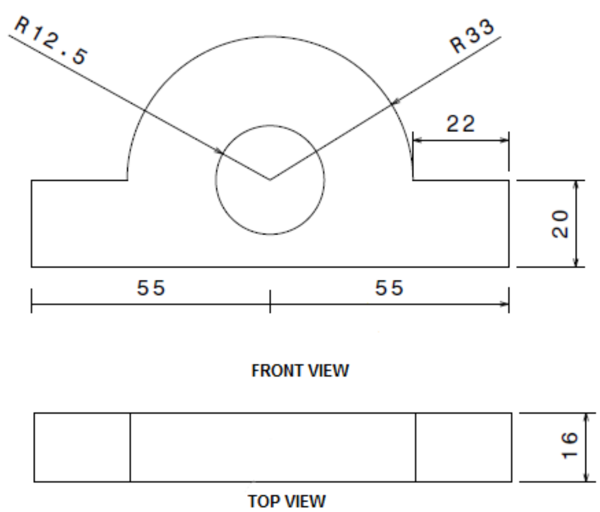

Fig. 4: Dimensions of Frame

A flange having considerable thickness handle is welded of both the rods in line. The flange is bored centrally in order to carry an axle on which whole assembly is mounted.

- Thickness of bracket = 16mm;
- Length of bracket = 55+55 =110mm;
- Diameter of the bore = 12.5 mm;
- Diameter of circular arc = 33 mm.

3) Design of Smaller Sprocket

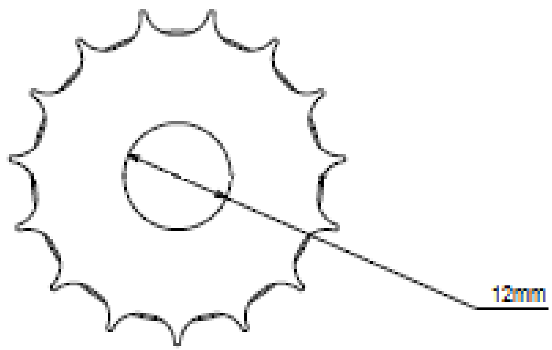

Fig. 5: Smaller Sprocket Dimensions

The smaller sprocket has to be designed as an integral part of the clutch plate.
No. of teeth on smaller sprocket = 15

$$\text{Pitch diameter of smaller sprocket} = \frac{\text{Pitch}}{\sin\left(\frac{180}{\text{no.of teeth}}\right)}$$

$$= \frac{9.525}{\sin\left(\frac{180}{15}\right)}$$

$$= 45.81 \text{ mm}$$

Internal Diameter of smaller sprocket = 13 mm

The thickness of sprocket can be adjusted by machining to suit chain specifications.

4) Design of larger sprocket

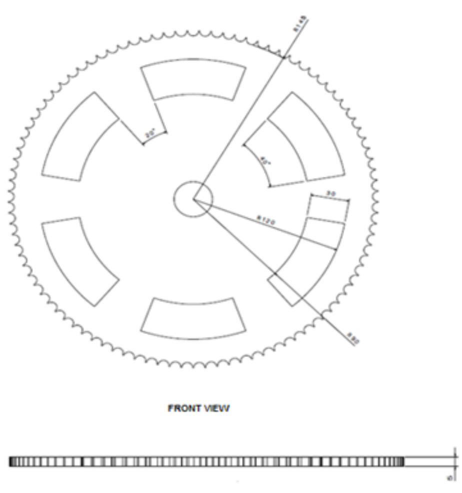

Fig. 6: Dimensions of Larger Sprocket

The larger sprocket is to be mounted on the rear wheel of bicycle.
No. of teeth on smaller sprocket = 15

$$\text{Pitch diameter of larger sprocket} = \frac{\text{Pitch}}{\sin\left(\frac{180}{\text{no.of teeth}}\right)}$$

$$= \frac{9.525}{\sin\left(\frac{180}{95}\right)}$$

$$= 288.083 \text{ mm}$$

The thickness of sprocket can be adjusted by machining to suit chain specifications.

5) Dimensions of interlocking unit

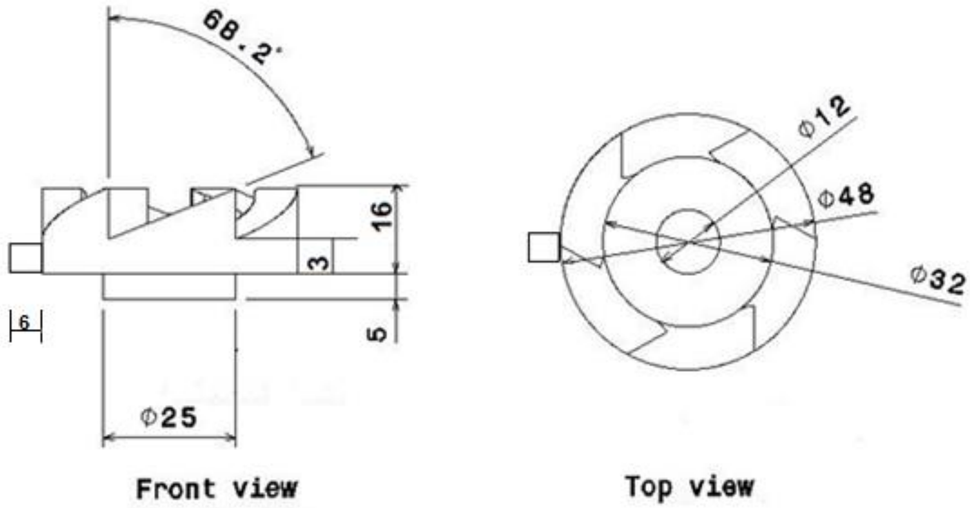

Fig. 7: Dimensions of Movable Jaw

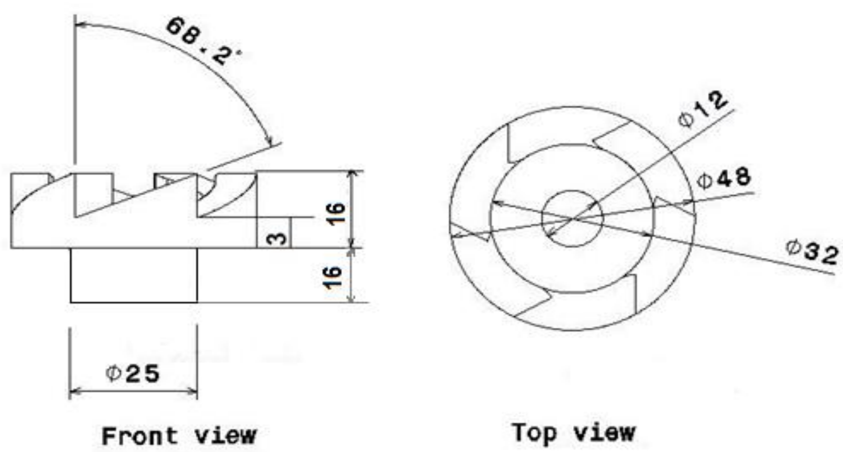

Fig. 8: Dimensions of Fixed Jaw

Dimensions:
Core Diameter = 12mm;
Outer Diameter = 48mm;
No. of divisions = 6
Tooth length = 10mm;
Tooth thickness = 8mm

6) Axial Force Calculation

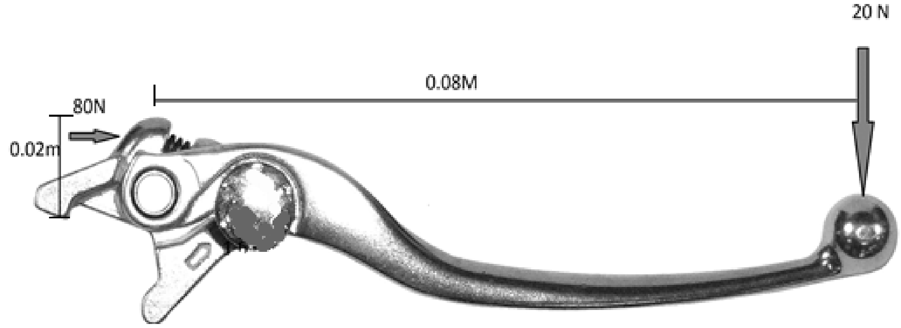

Fig. 9: Force on a Typical Brake

Average Force applied by hand on clutch actuating lever (F) =20 N
∴ Torque at hinge point = 20 X 0.08 = 1.6 N-m
And pull force to brake wire (F_p) = 1.6/0.02= 80 N
This force (F_p) is carried over tangentially (by brake wire) to the movable jaw of clutch

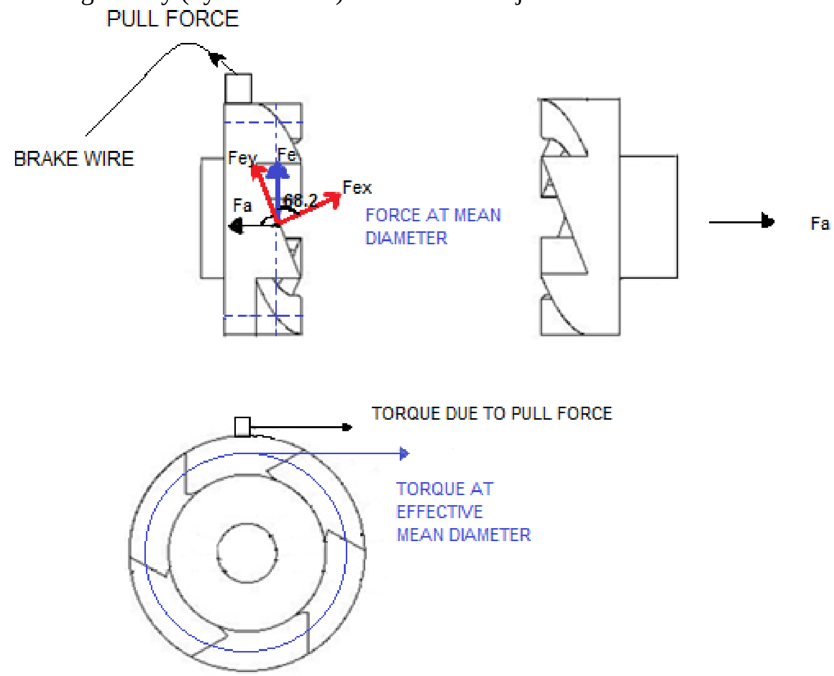

Fig. 10: Axial Force Calculation

Torque at wire and jaw connection = 80× (0.024+0.006)= 2.4 N-m
Effective Mean Diameter = $\frac{48+32}{2}$ = 40mm = 0.04 m
Torque at Effective Mean Diameter = 2.4 N-m
Force at Effective Mean Diameter, $F_e = \frac{2.4}{\frac{0.040}{2}}$ = 120 N
Vertical component of this force i.e. $F_{e_y} = F_e \sin 68.2$= 120×0.93
∴ F_{e_y} = 111.42 N
Now, Horizontal component of F_{e_y} = Axial Force (F_a) = $F_{e_y} \cos 68.2$
= 111.42 ×0.37
∴ F_a= 41.38 N

7) Clutch Design

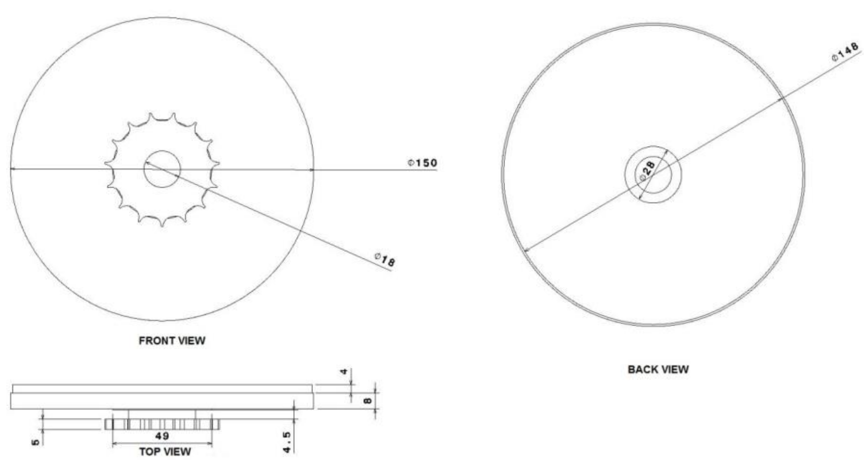

Fig. 11: Clutch Dimensions

Clutch dimensions are assumed as follows:
Diameter of disc = 150

Thickness of disc = 8mm;
Thickness of friction plate = 4mm;
Internal clutch plate Diameter = 33mm;
Outer Diameter of Bearing = 33mm;
Internal Diameter of Bearing = 12mm.

8) Torque Carrying Capacity

Torque carrying capacity of clutch plate is given by,

$$T = \frac{\mu F_a Dm N_f}{2}$$

Where,

μ = relative coefficient of friction
= 0.32 (for asbestos and steel material)
F_a= clutch actuating force = 41.38 N
D_m= mean diameter of clutch plate = $\frac{Di+Do}{2}$ (by uniform wear theory)

$$= \frac{\mathbf{28+150}}{\mathbf{2}} = 89 \text{ mm} = 0.089 \text{ m}$$

N_f = number of friction surfaces = 2
Now, torque carrying capacity

$$T = \frac{0.32 \times 41.38 \times 0.089 \times 2}{2}$$

T =1.178 N-m

9) Bearing Design

a) Specifications of Flywheel Bearing:
The type of bearing no. = 04 01;
Outer diameter = 42 mm;
Inner diameter = 12 mm;
Width = 12 mm
b) Specifications of Clutch Bearing:
The type of bearing used no. = 19 01;
Outer diameter = 42 mm

VIII. CONCLUSION

With the help of this Hybrid Torque Bicycle, we will be able to produce more pedaling power & additional modifications can be made to the design above to make it hypothetically more efficient.

IX. SCOPE FOR FUTURE

1) The use of light weighing material (like carbon material) can reduce the weight of bicycle.
2) The use of higher gear ratio at chain sprocket can increase the bicycle efficiency to a greater extent.

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