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Improvement of Driving Mechanism of Rickshaw

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Abstract

In Paddle Rickshaw, it becomes tiresome to drive the Rickshaw after the braking as kinetic energy is lost during braking. But, kinetic energy can be stored as a potential energy by KERS mechanism. Kinetic Energy Recovery System, commonly abbreviated KERS, is a system to recover the kinetic energy of a moving vehicle under braking. This system stores the kinetic energy in the form of potential energy and converts it back to kinetic energy when needed. In this context, flywheel is used as KERS system to store the energy which is normally lost during braking. The driver can charge the flywheel when slowing and using proper mechanism stored potential energy can be converted back into kinetic energy to give the Rickshaw an extra acceleration.

Keywords: KERS, Flywheel energy storage, Flywheel Rickshaw, Smart braking

1. Introduction

In modern era, there is a great effort in conservation of natural resources, especially in the field of renewable energy. The total energy can be divided into two parts, which are potential energy and kinetic energy. The Potential Energy is the energy possessed by the body due to its position or state where as the Kinetic Energy is the energy the body gains due to its motion. In automobile maximum energy is lost during deceleration or braking. So when the body has come to rest, the amount of kinetic energy needs to get converted into potential energy. For this reason kinetic energy recovery system becomes interesting field in automobile sector.

In Bangladesh, Rickshaw is frequently used by passengers in every day more than any vehicle for short distance travel. There are two types of Rickshaw in Bangladesh, Electrical Rickshaw and Paddle Rickshaw. In paddle rickshaw, it is difficult to increase acceleration after braking. Electrical Rickshaw needs to charge battery everyday where electricity is one of the most vital problem in Bangladesh. Also disposal of battery has bad effects on environment. In our system, flywheel will be attached to the Rickshaw which will work to recover this kinetic energy. [1]

2. Kinetic Energy Recovery System

A kinetic energy recovery system abbreviated as KERS is an automotive system which recovers the kinetic energy of a moving vehicle under braking. The energy recovered is stored in terms of potential energy a reservoir for later use for acceleration. Examples of reservoir are high voltage batteries, flywheels, hydraulic coupling, etc. The selection of reservoir largely depends on the purpose. [2]

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. The electrical system is less efficient but it can store power for a longer duration. The mechanical system has a better efficiency than electrical system. The mechanical KERS system storing energy mechanically in a rotating flywheel eliminates the various energy conversions, more than twice the efficiency of an electric system.

3. Design Requirement

Fig. 1. Isometric View of KERS Rickshaw

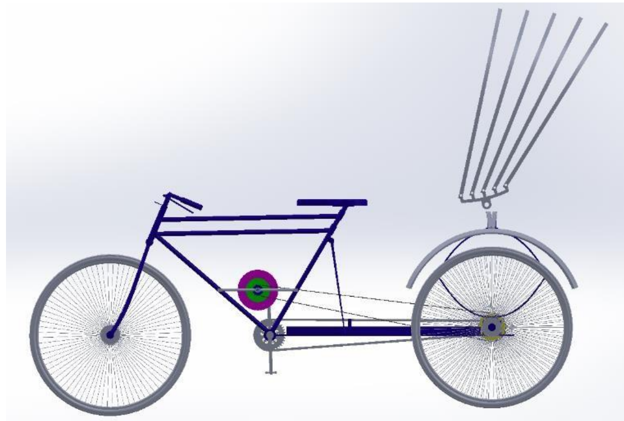

Fig. 2. Side View of KERS Rickshaw

It is the most important task in KERS system. There are many design requirements that has to be satisfied for proper functioning the KERS Rickshaw. For this reason, there are some geometrical, engineering concepts must be applied. The following list shows these requirements:

- **Flywheel design:** Flywheel has to be designed properly for gaining desired kinetic energy and therefore desired speed. It is a vital part for gaining kinetic energy by continuous rotation.
- **Clutch design:** Clutch mechanism should be designed to engage and disengage the flywheel.
- **Store energy:** Flywheel can store kinetic energy as a potential energy. This is the main requirement and the overall objective of the device and must be suitable to meet the rider's needs.
- **Light weight**: The importance of having a light weight design is driven by the rider's desire. This depends on how much energy is stored in the flywheel [4]. Moreover, the weight of the flywheel must not effect the overall weight of the Rickshaw.
- **Inexpensive and Affordable:** The product must be affordable and cheap. The main intention is to make profit easily with KERS Rickshaw.
- **Economical:** The product must be economical and the products for this design must be cheaply available. [4]
- **Environment friendly**: The designing is done in a way that the product should be safe. As there is used Flywheel for storing energy and no need to disposal such that battery, it is obviously environment friendly.
- **Reliable:** It is important to have a product that is reliable and this requirement will affect the normal bicycling process and must be easy to use. [4] **Aesthetic:** The design should always have nice look about it. The design should attract the passenger and the driver will have mental satisfaction also.
- **Comfortably :** The design should be such that the driver should feel comfortable**.**

4. Flywheel Design

Calculation for the energy stored in the flywheel:

Mass of the person riding the rickshaw	=70kg
Mass of rickshaw	= 100kg
Mass of passengers	=140kg (2persons)
Other payloads	= 20kg
Allowance for flywheel Mass	= 20kg

Total mass =350kg

Let us assume that the flywheel stores enough energy to take the whole system from rest to 10km/hr in 8sec.

v = 10km/hr = 2.78m/sec

u = 0km/hr = 0m/sec .

Time = 8sec

$$a = \frac{V-u}{t} = .348 \text{ m/s}^2 \quad (1)$$

Energy of the system when it reaches 10km/hr = E

$$E = ½mv^2 = 1352.5 \text{ joules} \quad (2)$$

So let us calculate the rpm or speed of the wheel and the flywheel

D_R= Diameter of the rickshaw wheel = 28inch ≅ 71.12 cm = .7112 m

Number of revolution made by the wheel at 10kmph per sec = v / 2πR (3)

R = 1.179 rps = 74 rpm = 1.24 rps

Force required to take the rickshaw from rest to 10kmph in 8 sec

$$Fa = ma = 121.8 \text{ N} \quad (4)$$

Now considering the rolling resistance of the rickshaw

$$F_R = Crr*N = 18.88 \text{ N} \quad (5)$$

Aerodynamic drag = F_A

$$F_A = Cd\rho Av^2 \quad (6)$$

Where Cd = coefficient of drag = 0.75(worst case)

density of air = 1.25 kg/m^3 at 25°C A =

projected area = 1m^2 (let us assume) v =

velocity of rickshaw = 2.78m/sec

F_A= 7.24 N

Other frictional resistances

F_f= 3N

Total requirement of force = F

$$F = Fa + Fr + F_A + F_f = 149.2 \text{ N} \quad (7)$$

Torque required at the center of the wheel to get this required force = T_w

$$T_w = F \times r = 53.055 \quad (8)$$

As we know that one NM is equal to one joule. So 53.055 joules of energy can be stored in the flywheel and same amount of torque can be produced from the flywheel.

Power produced by the flywheel,

$$P = \frac{2\pi NT}{3600} = \frac{2\times 3.1416\times 74\times 53.055}{3600} = 6.85 \text{ W} \quad (9)$$

When our system reaches 10kmph our flywheel should have a speed directly in proportion with the wheel speed (rpm)

Let the Sprocket ratio = s

So Flywheel rpm = 70.74s rpm = 1.23rps Energy released by the flywheel = E_{fl}

$$E_{fl} = ½ I(\omega_1^2 - \omega_2^2) \quad (10)$$

$$\omega_2 = 2\pi \times RPS = 7.73s \quad (11)$$ ω1

is constrained by the top speed of the rickshaw

$$\omega_1 = 19.52s$$

So, E_{fl} = ½ I(ω_1^2-ω_2^2) = 160.64 * I * s^2

E_{fl} will be consumed in bringing in bringing the cycle into motion 10kmph and also overcome the resistances.

$$E_{fl} = F \times \text{displacement} \quad (12)$$

$$= F \times (v^2 - u^2)/2a$$

$$\Rightarrow 160.64 * I * s^2 = 149.2 \times (2.78^2 - 0)/(2 \times 0.348)$$

$$\Rightarrow I \times s^2 = 10.31 \quad (13)$$

s is constrained by the choice of chain drive and force that can be applied comfortably by the driver. I is constrained by the availability of space and maximum mass of flywheel that is allowed. Note: We are using a circular disk flywheel

Max dia. = 25cm,

Max thickness = 3.8 cm

$$m = \rho \times \pi \times d^2 \times t = \rho \times 2.4544 \times 10^{-3} \text{ Kg} \quad (14)$$

$$I = ½ mr^2 \quad (15)$$

$$= \rho \times 1.9175 \times 10^{-5} \text{ kgm}^2$$

Putting the value of 'I' we get ρ × 1.9175 × 10−5 × s^2 = 10.31

ρ × s^2 = 537819.5

Choosing flywheel material as cast iron (ρ = 7874 Kg/m^3)

s^2= 66.80 s

= 8.17

Now putting the value of ρ we get

m = 7874 x 2.4544 x 10^{-3} = 19.32 kg

The weight of the flywheel is added 19.32 kg.

5. Components

Flywheel: Flywheel is designed properly and flywheel material is selected for proper weight. The flywheel has to be bored centrally in order to place a ball bearing so that flywheel can rotate over the axle.

Clutch: A clutch has to be provided by engaging and disengaging flywheel for power transmission. This is done by applying a clutch plate that is linearly moved to and fro. Clutch plate of 10cm radius and thickness of 6mm is used.

Axle: The axle is used to carry the flywheel and clutch units. The flywheel can be inserted after bearing is added to it and if variable diameter is provided on axle within mid-point the flywheel can be made to be inserted from one end and it automatically locks in the middle of the axle over which it rotates. [4] **Sprocket:** Two sprockets has to be used where one is attached with axle and flywheel and the other one is in the rear wheel axle. For keeping the sprocket ratio 4:1, one sprocket is with maximum teeth i.e. 52 and the other having the lesser number of teeth i.e. 13. The larger sprocket is placed at the rear wheel and the smaller sprocket at the axle end. **Flat bar:** Flat bar is used to support the flywheel weight. It can be easily bent or drawn, flattened or flared, expanded or swaged, drilled or punched. It is easily mechanically joined or welded using all the commonly used practices.

6. Frame Modification

The frame modification is the first and foremost task in the fabrication. The frame has to be modified by adding a flat bar. The flat bar has to be measured with proper dimension. Then it has to be welded and joined with the main frame. The frame should have enough strength so as to carry the flywheel and the additional forces that comes to act. It has to be taken care that the frame modification should not make any trouble for rider. The modification is done in a way that the flywheel, clutch plate can accommodate properly. The clutch mechanism is installed in a way that the rider can engage and disengage the clutch plate with comfortably during the flywheel rotation. Proper gear ratio helps to store the greater amount of kinetic energy as potential energy and recover it back when needed. [4] The chain length is 1.2 m.

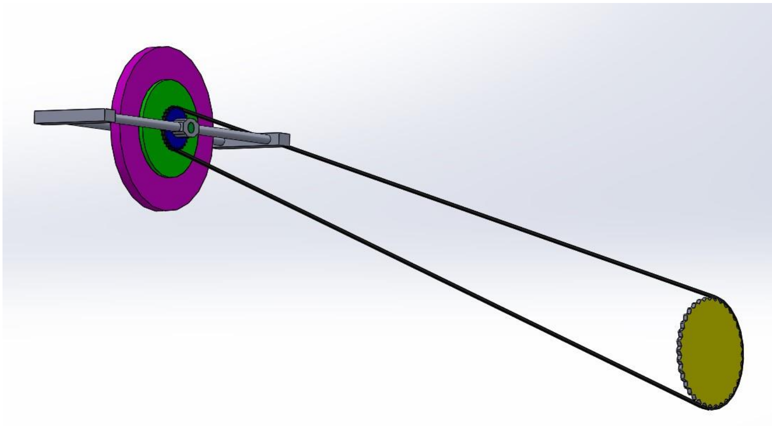

Fig. 3. KERS mechanism with modified frame

7. KERS Rickshaw Working

A clutch plate connected in the flywheel axle, always rotates with rear wheel rotation. This is being achieved by using chain transmission at a specified gear ratio, clutch sprocket helps us to increase the overall speed of flywheel. Now at a time when a speed reduction is required, clutch is applied which makes the contact between the clutch and flywheel. Then the flywheel starts rotating, also the speed of Rickshaw is decreased. Thus a regenerative braking system is achieved. Now also we can reduce the overall paddling power required in course of overrides by having clutch fully engaged. We can reduce overall pedaling power by 10 percent. [5] At the initial engage the flywheel rotation consumes energy which would result in speed reduction thus a braking effect. After some periods energy will being stored in the flywheel which can be reused by engaging clutch plate with flywheel. By this way energy transferred from flywheel to rear wheel by chain transmission. During normal ride we may need to reduce the speed because of traffic jam, speed breaker etc. we can store the kinetic energy as a potential energy that would be wasted due to speed reduction by the application of clutch. In this case we can disengage the flywheel so that stored energy in the flywheel would not be wasted. The main advantage area of the KERS Rickshaw is that the rider need not to ride Rickshaw for full time because of 10% reduction in paddling.

8. Conclusion

KERS Rickshaw is used to save the lost energy during braking. The effort of the driver will be minimized by using the KERS mechanism. The energy is stored in the flywheel as a potential energy and it can be reused by driver. It also helps the driver when normal riding by boosting the speed. As now a day's energy conservation is very necessary thing. Here we implemented KERS system in a Rickshaw with an engaging and disengaging clutch mechanism for gaining much more efficiency. The use of more efficient systems could lead to huge savings in the economy of any country.

Flywheel technology is on the rise across many kinds of technology and rightly so. It is a pollution free method of storing energy that has many current and potential applications. In the case of road vehicles there is much to be desired in terms of energy efficiency, especially when considering pollution per unit of energy. Any system of brake regeneration can help that, but flywheels have the potential to increase the efficiency of road vehicles without direct or indirect negative effects on the environment.

There is much more scope for developing the KERS Rickshaw project. As we implemented the various mating parts there are loss of energy by friction. Because of long chain length there is also the loss of energy. The chain length can be minimized by the change of flywheel position. The flywheel position can be replaced below the passenger seat as there is also more space to accommodate the flywheel. It can be helpful for saving the much more energy by reducing less energy loss. The mass of flywheel can be reduced by keeping same moment of inertia to minimize the weight of whole structure.

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