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KINETIC ENERGY RECOVERY SYSTEM IN BICYCLE

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Abstract: Kinetic Energy Recovery System (KERS) is a system for recovering the moving vehicle's kinetic energy under braking and also to convert the usual loss in kinetic energy into gain in kinetic energy. When riding a bicycle, a great amount of kinetic energy is lost while braking, making start up fairly strenuous. Here we used mechanical kinetic energy recovery system by means of a flywheel to store the energy which is normally lost during braking, and reuse it to help propel the rider when starting. The rider can charge the flywheel when slowing or descending a hill and boost the bike when accelerating or climbing a hill. The flywheel increases maximum acceleration and nets 10% pedal energy savings during a ride where speeds are between 12.5 and 15 mph.

Keywords: Kinetic Energy, Flywheel, Efficiency

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INTRODUCTION

KERS 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. Kinetic energy recovery systems (KERS) store energy when the vehicle is braking and return it when accelerating. During braking, energy is wasted because kinetic energy is mostly converted into heat energy or sometimes sound energy that is dissipated into the environment.

- LITERATURE REVIEW

The energy stored in a flywheel is its rotational kinetic energy

$E = \frac{1}{2} I\omega^2$ E= 1/2 Iω^2 (1)

Where is the rotational velocity and *I* is the moment of inertia, which is defined as

$I = \int r^2\, dm = cmr^2$ (2)

Where c is a constant determined by the mass distribution. Substituting equation 2 into equation 1 we get

$E = \frac{1}{2} cmr^2\omega^2$ (3)

Therefore we have four variables to consider for energy storage in the flywheel. The same amount of energy will be transferred to the flywheel no matter what the design is, so our choice of design will simply place the energy more in some variable than others. There is no downside to maximizing c, so a flywheel with a majority of its mass at maximum r is a must in the design.

The radius will be limited by our placement of the flywheel and the size of the bike. The rotational velocity will be limited by our transmission design. The cost of additional mass will be discussed in the next section.

3.2 EFFICIENCY

The gain you get from a flywheel must be measured against the extra power required to move the bicycle from the extra weight of the flywheel. Extra work is needed to accelerate the bike because of the flywheel. Therefore the efficiency gained from the flywheel can be shown as

$$\varepsilon_{total} = \varepsilon_{gained} - \varepsilon_{lost} \qquad (4)$$

The efficiency gained can be expressed as the energy stored in the flywheel (from the above section) over the total energy in the bike. The efficiency lost can be expressed as the energy required to push the extra weight of the bike over the total energy in the bike.

$$\varepsilon_{total} = \frac{E_{flywheel}}{E_{total}} - \frac{E_{flyaccel}}{E_{total}} \qquad (5)$$

After plugging in equation 3, we get

$$\varepsilon_{total} = \frac{\frac{1}{2}\eta c m_f \omega^2 r^2}{\frac{1}{2}m_{total}v^2} - \frac{\frac{1}{2}m_f v^2}{\frac{1}{2}m_{total}v^2} \qquad (6)$$

Where is the efficiency, is the efficiency of the transmission, is the mass of the flywheel, and is the velocity of the bike. Canceling like terms we get

$$\varepsilon_{total} = \frac{\eta c m_f \omega^2 r^2}{m_{total}v^2} = \frac{m_f}{m_{total}} \qquad (7)$$

With this in mind the flywheel design should minimize the mass of the flywheel in favor of a larger radius or faster speed, since the total efficiency will be much higher.

3.3 TRANSMISSION

It will be necessary to design a transmission to transfer energy from the bike to the flywheel and vice versa. The gear ratios will determine the properties of the transmission, and is measured in many different ways. The relative size of the gears will determine the maximum speed the flywheel will spin at relative to the bike. The gear ratio, R, is defined as

$$R = \frac{\omega_A}{\omega_B} = \frac{N_B}{N_A} = \frac{T_B}{T_A} = \frac{r_B}{r_A}$$

Where is the rotational speed, N is the number of teeth in the gear, T is the torque, and r is the radius, and A and B refer to the two different gears. A high gear ratio means that B will have high torque and A will have high speed. Therefore, a flywheel designed to operate at a high speed will need a high gear ratio transmission, considering the flywheel as A. For a flywheel that operates at low speeds but has a large radius, the gear ratio would need to be low since it will require more torque to spin a flywheel with a large radius.

Also, the target speed for maximal efficiency must be taken into consideration. A flywheel that will be used to add a boost after a complete stop should have a high gear ratio because gear B should have high torque to get the bike wheels spinning again. However, a flywheel that will be used for an extra boost after slowing down, but still remaining at high speeds, the transmission should have a low gear ratio so that gear B can spin fast. If the flywheel were to have a large radius and be used for stop and go, or if the flywheel were to spin quickly and be used for a boost at high speeds, the gear ratio could be even to maximize torque in gears A and B, or to maximize speed in gears A and B.

- REQUIREMENTS AND CONSTRAINTS

1. Store Energy While Braking

2. Return Energy to Start Up

3. Must Fit On a Bicycle

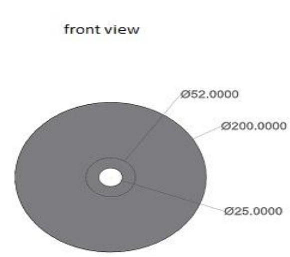
4. Light Weight

5. Good Stopping Range

6. Good Stopping Force

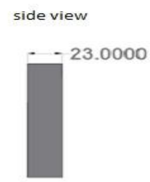
7. Inexpensive and Affordable

- REQUIREMENTS AND CONSTRAINTS



To insert the flywheel in the ordinary bicycle frame modification has to be done to it. Hence too long hollow cylindrical shaft are to be welded to the original frame.

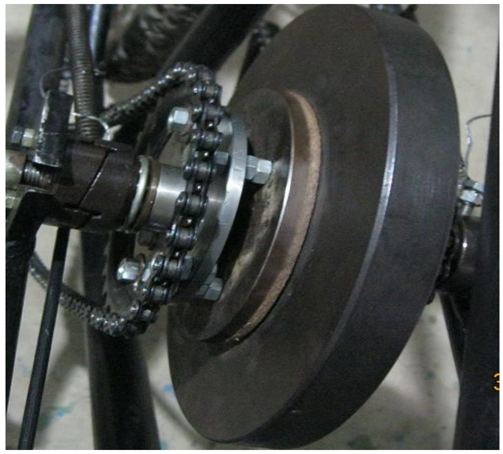
The frame is modified in such a way that we can adjust the axle of the flywheel and rear wheel axle. This is used to fit the chain without slip. Frame is modified by using welding process.

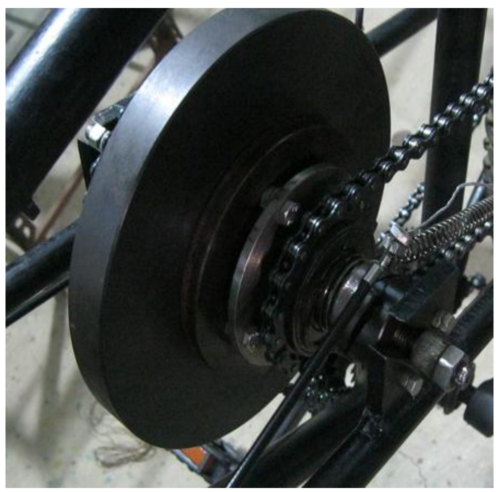


- **POWER TRANSMISSION SYSTEM**

There are three chains used for transmission.1st chain transmits power from pedal crank to rear wheel to run the cycle.2nd chain transmits power from rear wheel to clutch to activate the breaking action and to store the kinetic energy in flywheel.3rd wheel transmits power from flywheel to crank to initialize acceleration when slowing down.

Two clutches are used during the process.1st one is used to slow down the rear wheel by engaging it with the flywheel and stores the kinetic energy in that flywheel.2nd is used to regain the acceleration by engaging it to retrieve the energy from the flywheel.





Kinetic (or dynamic) friction occurs when two objects are moving relative to each other and rub together (like a sled on the ground). The coefficient of kinetic friction is typically denoted as μ_k, and is usually less than the coefficient of static friction for the same materials. However, Richard Feynman comments that "with dry metals it is very hard to show any difference.

New models are beginning to show how kinetic friction can be greater than static friction. Kinetic friction is now understood, in many cases, to be primarily caused by chemical bonding between the surfaces, rather than interlocking asperities; however, in many other cases roughness effects are dominant, for example in rubber to road friction. Surface roughness and contact area, however, do affect kinetic friction for micro- and nano-scale objects where surface area forces dominate inertial forces.

- **Working principle**

A crank wheel connected to the rear wheels always rotates the left side clutch plate, connected in the flywheel axle. This is being achieved by using chain transmission at a specified gear ratio, crank to 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 bicycle is decreased. Thus a regenerative braking system is achieved.

On course energy is stored in flywheel. In case the brake has to be applied fully it should not affect the flywheel rotation for that purpose the crank is driven by freewheel so that if wheel stop it rotation, the flywheel still rotate. Now when we again rides the bicycle during which we would apply the right side clutch then energy gets transmitted from the flywheel to the pedal Now also we can reduce the overall pedaling power required in course of overrides by having clutch fully engaged.

We can reduce overall pedaling power by 10 per cent. Also situation arises such as traffic jam, down climbing a hill where we do not intend to apply brake fully. For such cases we can apply our smart braking system which would allow us to decelerate and allow us to boost acceleration after this during normal riding and distance that can be covered by pedaling can also improve. During normal rides situations may arise we need to reduce the speed without braking fully such as traffic jams taking turns etc.

We can store the energy that would normally be wasted due to speed reduction by the application of clutch. When the clutch is engaged that time due to initial engage the flywheel rotation consumes energy which would result in speed reduction thus a braking effect. After some instances the energy is being stored in the flywheel this can be reused by the engage of clutch plate and energy transfer from the flywheel occurs whenever the rotation is high enough to rotate rear wheel.

- **CONCLUSION**

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.

The batteries used in hybrids do not last the cars lifetime and can have costly environmental effects. A flywheel has environmental impact only at its time of production, and has the potential to heavily outweigh those costs through its use. Bikes do not have the pollution problems cars and other modes of transportation have, but they can serve as a good analogy for how a kinetic energy recovery system can increase the efficiency of a vehicle.

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