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Kinetic Energy Recovery System 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. In this context the mechanical kinetic energy recovery system is used 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.

Keywords - *Kinetic energy, bicycle, flywheel, energy recovery system.*

1. 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 boost to the vehicle. Kinetic energy recovery system store energy when the vehicle is braking and return it, when accelerating. During breaking, energy is wasted because kinetic energy is mostly converted into heat energy or sometimes sound energy that is dissipated into the environment. Vehicle with KERS are able to harness some of kinetic energy and in doing so will assist in braking. By a proper mechanism, this stored energy is converted back into kinetic energy giving the vehicle extra boost of power.

2. KINETIC ENERGY RECOVERY SYSTEM

A type of Regenerative braking is called KERS. KERS is an automotive system for recovering a moving vehicle's kinetic energy under braking. The recovered energy is stored in a reservoir (for example a flywheel or a battery or super capacitor) for later use under acceleration. Electrical systems use a motor-generator incorporated in the car's transmission which converts mechanical energy into electrical energy and vice versa. Once the energy has been harnessed, it is stored in a battery and released when required.

2.1 Types Of Kinetic Energy Recovery System

There are different types of devices and forms in which the Kinetic energy lost while braking can be stored.
They are:

1) Mechanical KERS
2) Electric KERS
3) Hydraulic KERS
4) Hydro-electrical KERS

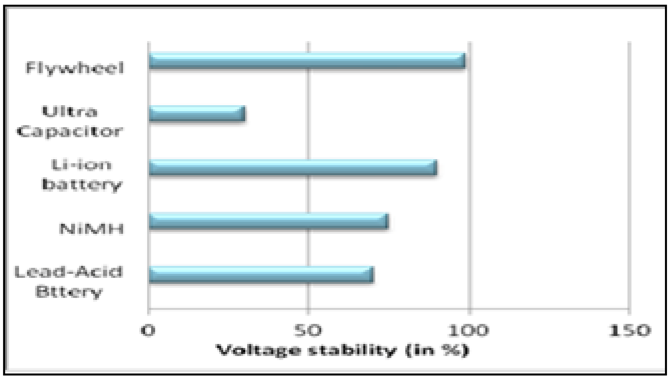

Fig 1: Voltage Stability Graph

3. DESIGN REQUIREMENTS

There are many requirements that need to be met to produce a product that is both feasible and optimal. There are also some constraints, both geometric and engineering that also need to be satisfied. The following list describes these requirements and constraints:

3.1 Store energy while braking

This is the main requirement and the overall objective of the device and must be suitable to meet the rider's needs.

3.2 Return energy to start up

Once the energy is stored in the device, it is necessary to have a simple way to release this energy back to the user in positive way. This can be accomplished with an innovative chain drive system.

3.3 Must fit on a bicycle

This is one of the most difficult constraints to achieve and most important because we are dealing with such confined spacing. The objective is to fit the flywheel and accessories in the bicycle.

3.4 Light weight

The importance of having a light weight design is driven by the rider's desire to have a bicycle that is more maneuverable and more portable. This is also a direct trade off with how much energy can be stored in the flywheel.

3.5 Inexpensive and affordable

This product must be able to make a profit and be desirable.

3.6 Safe to user and environmentally friendly

Safety is always a very important aspect whenever there is a consumer product.

3.7 Economical

The product economical and the products for this design must be cheaply available.

3.8 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.

3.9 Manufacturability

In order to make anything economical, it needs to be manufacturability, hence the important of having a product that can be made easily and cheaply.

3.10 Aesthetically pleasing

This is not a requirement that needs to be taken heavily, but the design should always have nice look about it, because looks will persuade the rider.

3.11 Modular

Having a device that can be adapted to existing bicycles is essential to be added to the existing ones so that it's easier to adopt. This also can reduce other types of manufacturing costs.

3.12 Should not hinder normal riding

To have a successful accessory for a bicycle, the ride should not feel a noticeable change in the riding performance or in the normal riding motion. A device that impedes the normal riding experience would be considered undesirable.

4. COMPONENT USED

4.1 Fly wheel: The flywheel has to be bored centrally in order to place a ball bearing so that flywheel can rotate over the axle. Also flywheel has to be selected so that the selected weight does not affect the bicycle physics and riding performance of the rider.

(a) Cast iron flywheel weighing 4.2kg.

(b) Radius of the flywheel is 122mm with thickness of 16mm.

(c) Maximum torque of 69NM @ 3500 rpm.

4.2 Clutch: A clutch has to be provided so as to control the power delivery and release from the flywheel. This can be achieved by providing a clutch plate that is linearly moved to and fro by applying a lever mechanism incorporated with a spring assembly for providing return mechanism. Linear clutch movements have to be made possible. For this purpose two cylindrical rods can be used. One end of the each rod was variably cut. This variable length is female part of another. One part of this is fixed near the frame side. This can be achieved by welding the part. Another part is made rotator. This part can be rotated by applying force on it from lever via cable. This moves only partially over fixed one and firstly this is hold in position by a spring arrangement.

(a) Clutch plate of 10cm radius and thickness of 6mm is used.

4.3 Axle: The axle has to be made so as 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. Also the clutch units sequentially clutch plate and the fixed and moving rods along with its mechanism can be mounted over the axle. An axel of 168mm length and 16mm diameter is used.

4.4 Sprocket: Two sprockets have to be used. The gear ratio is to be taken in to account here. One sprocket with higher number of teeth (52 teeth) is to be selected and other having lesser number of teeth (13teeth). The larger sprocket is to be placed at the rear wheel end and smaller sprocket at the axle end. This is to ensure that we can provide larger flywheel rotations so that energy storage increases. The gear ratio of 1:4 is maintained.

4.5 Bearing: The bearing will rest inside the flange and will be covered in oil. The purpose of the bearing is to take the torque load from the flange and not to transmit it to the end piece to allow for a successful clutch actuation. The bearing used for the bicycle belongs to 6200 series and they are single row, deep groove and Conrad type. Basic load rating c_r is 2150lbs and c_{or} is 1080lbs, basic load factor f_0 is 13.2, and limiting speed is 17000 rpm, bearing weight (approx.) 0.14lbs.

4.6 Steel pipe and U-clamp: It is easy Steel pipe is produced by cold forming flat rolled steel into tubular shapes and electric-resistance welded into solid wall tubing. Controls during the cold forming to square or rectangular shapes prevent irregularities in structure or loss of physical properties across the weld area. Since it begins as a flat rolled product, the finished tube has a uniform wall thickness and equal strength throughout. to machine and fabricate, using all common machining and fabricating operations. It can be bent or drawn, flattened or flared, expanded or swaged, drilled or punched easily. It is easily mechanically joined or welded using all the commonly used practices. Because of ease of fabrication, and a surface suitable for painting or plating, Structural Steel Square and Rectangular tube has almost unlimited applications.

4.7 Roller chain: All chains are classified according to pitch (the distance between centers of adjacent bearing pins), roller diameter and width between inner plates. Collectively, these dimensions are known as the gearing dimensions as they determine the form and width of the sprocket teeth.

5. FRAME MODIFICATION

The frame modification is the first part of the fabrication that has to be done. The frame has to be modified by adding steel tube of length 1m. The frame should have enough strength so as to carry the flywheel and the additional forces that comes to play. The modification should not hinder normal riding of the bicycle. Also the modified frame should have enough space in order to accommodate flywheel and clutch assemblies. The clutch lever is arranged to operate the clutch operation during the engaging and disengaging the flywheel rotation. The larger sprocket is fitted to the rear wheel to transmit the power to the flywheel and again recover it back. Chain of 1.2m length is used to transmit the power. This is shown in figure below.

(a) Frame width of 138mm.
(b) 3/4inch steel tube of 1m is used, weighing 0.7kg each.
(c) Radius of the wheel is 30cm.

6. KERS BICYCLE WORKING

A crank wheel connected to the rear wheels always rotates the 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 then after flywheel rotations clutch is disengaged and the brake is applied. Now when we again rides the bicycle during which we would apply clutches at this time as rear wheel rotation is lesser compared to fly wheel the energy gets transmitted from the flywheel to the wheels. Now also we can reduce the overall pedaling power required in course of overrides by having clutch fully engaged. 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. Thus if sudden braking is applied then we can disengage the flywheel connections so that flywheel energy is not wasted and going to take ride the speed of rear wheel is null and hence engage would help in returning the energy from the flywheel to rear wheel. While riding downhill we always use braking for allowing slowdown. This is the best case where we can store maximum amount of energy in our flywheel. The flywheel can be engaged for full downhill ride and after all for some distance we need not ride the bicycle which would be done by the flywheel. This is the main advantage area of KERS bicycle.

7. WEIGHT AND PERFORMANCE

Normally energy stored in the flywheel is directly proportional to the weight and radius. Hence increase in weight proves to improve the performance. But as we know that the maximum safe weight that can be used is limited due to frame properties and rider compatibility. And also after some extent the radius can’t be increased and the energy storage thus seems to be limited to some particular extend. This is also because of the fact that the total running speed is being reduced due to weight. Energy storage capacity increases with increase in weight but limitation seems to be the speed driving the flywheel. And performance of system is directly linked with the energy stored. Thus a graph can be plotted between performance and weight. Optimum value lies between 4 and 8 kg.

Energy stored in flywheel, $E = \frac{1}{2} I \omega^2$ **(1)**

Where, I is the moment of inertia
ω is the rotational velocity (rpm)
Moment of inertia, $I = kmr^2$
k is inertial constant
m is mass of the disc
r is the radius
Thus E is directly proportional to the mass of the disc.

(1) At N=200 rpm

$$E = \frac{1}{2} \times 4.2 \times 0.0144 \times 438.48$$

E=13.259 NM

As we know that one NM is equal to one joule. So 13.259 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, $P = \frac{2\pi NT}{3600} = \frac{2\pi \times 200 \times 13.259}{3600}$ = 4.628 W

(2) At N=250 rpm

$$E = \frac{1}{2} \times 4.2 \times 0.0144 \times 685.389$$

E=24.724 NM

As we know that one NM is equal to one joule. So 24.724 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, $P = \frac{2\pi NT}{3600} = \frac{2\pi \times 250 \times 24.724}{3600}$ = 9.04 W

The flywheel and transmission add weight to the bicycle. The increased weight will add to the energy required to accelerate the bicycle and to ride it uphill. However, once the rider has provided the energy to reach a cruising speed, the flywheel reduces the energy cost of slowing down from this speed since it aids in subsequent acceleration.

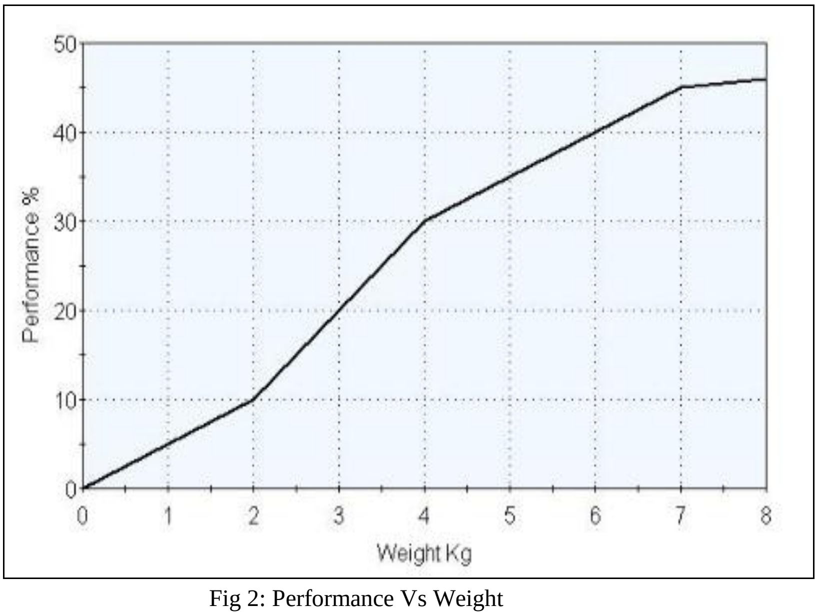

Fig 2: Performance Vs Weight

8. CONCLUSION

KERS system used in the vehicles satisfies the purpose of saving a part of the energy lost during braking. Also it can be operated at high temperature range and are efficient as compared to conventional braking system. KERS system has a wide scope for further development and the energy savings. The use of more efficient systems could lead to huge savings in the economy of any country. Here we are concluding that the topic KERS got a wide scope in engineering field to minimize the energy loss. As now a day's energy conservation is very necessary thing. Here we implemented KERS system in a bicycle with an engaging and disengaging clutch mechanism for gaining much more efficiency. As many mating parts is present large amount of friction loss is found in this system which can be improved. Boost is reduced because of friction

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