KERS Bicycle

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Abstract- **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. When riding a bicycle it becomes too tiresome to start the bicycle again after braking. If the bicycle is provided with a kinetic energy recovery system then the rider will have two power sources that he can use at his will. When brakes are applied kinetic energy is wasted because the kinetic energy converts into heat energy due to friction at the contact surface and the heat energy dissipates into the atmosphere due to thermal radiation. Vehicles equipped with KERS devices are able to take some of its kinetic energy out slowing down the vehicle. This is a form of braking in which energy is not wasted, instead gets stored in some device.**

Keywords- KERS., literature review, Regenerative braking, Flywheel energy storage.

I. INTRODUCTION

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.

In recent days recovering Kinetic energy has become an interesting area of research for many. Let us first find out why? The total energy in this universe can be broadly divided into two parts 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. As we know notion is a relative concept so as the Kinetic energy. For example a car possess some Kinetic energy with respect to road but with respect another car moving at same speed it has no Kinetic energy. So when we need to impart motion into a body we have to convert some amount potential energy into Kinetic energy. When that body has to come to rest, that amount of kinetic energy needs to get converted into Potential energy. But in nature the form of potential energy to which the Kinetic energy gets converted is of a lower grade, in most of the cases, and is very difficult to reuse. Taking the example of a car, when we run a car we burn petrol and convert the potential energy of the petrol into the Kinetic energy of the car and when we apply the brakes the kinetic energy converts into heat energy in the brake calipers and eventually gets diffused into the atmosphere. If this energy would have been saved it could have been used.

There are two type of Kinetic Energy Recovery Systems which have gained popularity in recent days. One is Electrical KERS and another is Mechanical KERS. Both have their respective pros and cons. The electrical system is less efficient but it can store power for a longer duration and gives us the agility to manipulate the torque and rpm output as per our requirement. In the other hand the mechanical system has a better efficiency (nearly twice as that of the prior one) but it is prone to decay due to its inherent property of friction, though it is very small in value, hence cannot be stored for longer period and need to be used within a short period of time. In the real world we can find many situations where we need to use the recovered Kinetic energy with in very short span of time of its recovery and we don't even need a wide range of torque and rpm output as a particular range of torque & rpm combinations satisfy our requirements completely. A bicycle is a perfect example of this kind.

This is why KERS for bicycle has been chosen as the final year project. There has been a lot of work related to this topic but this topic still needs more research. During the project the goal will be to design an optimized mechanical KERS which will improve the storing time of the kinetic energy as well as improve the compatibility and manufacturability of the system.

II. LITERATURE REVIEW

The first of these systems to be revealed was the Flybrid. This system weighs 24 kg (53 lbs) and has an energy capacity of 400 kJ after allowing for internal losses. A maximum power boost of 60 kW (81.6 PS, 80.4 HP) for 6.67 seconds is available. The 240 mm (9.4") diameter flywheel weighs 5.0 kg (11 lbs) and revolves at up to 64,500 rpm. The maximum torque generated at the flywheel is 18 Nm (13.3 ft-lbs), and the torque at the gearbox connection is correspondingly higher for the change in speed. The system occupies 13 liters of volume. Two small accidents were reported during testing of various KERS systems in the year 2008. The first incident happened with Red Bull Racing when the team tested their KERS battery for the first time in July, the battery malfunctioned and accidentally caused a fire, to avoid any causality evacuated the building. The second incident happened within a week. A BMW Sauber mechanic got an electric shock when he touched Christian Klien's KERS-equipped car during a test at the Jerez circuit.

Formula one has stated that they support environment friendly technology and they have allowed use of KERS in 2009 F1 championship. Ferrari, BMW, Renault and McLaren were the fore teams using the KERS in their cars.

Vodafone McLaren Mercedes was the first team to win a F1 GP using a KERS equipped car on July 26, 2009 at the Hungarian Grand Prix. Lewis Hamilton was driving that car to become the first driver to win. Kimi Räikkönen won Belgian Grand Prix with KERS equipped Ferrari on 30th August 2009. This time the KERS contributed directly to race victory. Giancarlo Fisichella who came out second in that race claimed that he was faster than Kimi Räikkönen and Kimi only beat him because of KERS equipped car. KERS helped Kimi win the race substantially and get the lead.

In 2011, though KERS was legal no team used it on a united assertion. In 2011 F1 changed the rules and increased the minimum driver and car weight limit by 20Kg and the total weight to 640kg. This time the FOTA teams agreed to use the KERS devices and KERS is back in race. This time also the KERS system was options but all the teams except three used KERS devices on their cars.

Fig.no.1 Ferrari F1

WilliamsF1 was the first to develop their own flywheel-based KERS system. Unfortunately they could not use it in their F1 cars because of packaging issues. Thus they developed an electrical KERS system of their own. They even set up Williams Hybrid Power to sell their developments in the field of KERS. In the year 2012 Audi announced to use Williams Hybrid Power in its Le Mans R18 hybrid car. By the year 2014, the power accumulation capacity of KERS systems has increased from 80bhp to 160bhp. F1 started using 1.6 litre V6 engines with an integration with KERS devices instead of 2.4 litre V8 engines.

KERS system can also be used on a bicycle. Students of the University of Michigan working with EPA has developed a system called RBLA (hydraulic Regenerative Brake Launch Assist). Recovery of Kinetic energy has also been done by mounting a flywheel on a bike frame and connecting it with a CVT to the back wheel. By shifting the gear, 20% of the kinetic energy can be stored in the flywheel, ready to give an acceleration boost by re-shifting the gear.

III. METHODOLOGY

This project will progress as per by providing firstly an in-depth review of Regenerative Braking System (RBS), and explaining its types. Then deal is with the design and selection of various components. The gears and shafts needs to be selected based on the calculations, after which the bearing will be chosen. With the progress of the design of various components, assembly is to be done. After the manufacturing of the complete rig, it will be run for a specific period, which will notify its success.

IV. MOTION OF INERTIA

The moment of inertia, otherwise known as the angular mass or rotational inertia, of a rigid body determines the torque needed for a desired angular acceleration about a rotational axis. It depends on the body's mass distribution and the axis chosen, with larger moments requiring more torque to change the body's rotation. It is an extensive (additive) property: the moment of inertia of a composite system is the sum of the moments of inertia of its component subsystems (all taken about the same axis).

V. FABRICATION

a. FLYWHEEL

A flywheel is a rotating mechanical device that is used to store rotational energy. Flywheels have an inertia called the moment of inertia and thus resist changes in rotational speed. The amount of energy stored in a flywheel is proportional to the square of its rotational speed. Energy is transferred to a flywheel by the application of a torque to it, thereby increasing its rotational speed, and hence its stored energy. Conversely, a flywheel releases stored energy by applying torque to a mechanical load, thereby decreasing the flywheel's rotational speed.

Fig.no.2 Flywheel

b. SPROCKET

A sprocket or sprocket-wheel is a profiled wheel with teeth, or cogs, that mesh with a chain, track or other perforated or indented material. The name 'sprocket' applies generally to any wheel upon which radial projections engage a chain passing over it. It is distinguished from a gear in that sprockets are never meshed together directly, and differs from a pulley in that sprockets have teeth and pulleys are smooth except for timing pulleys used with toothed belts.

Sprockets are used in bicycles, motorcycles, cars, tracked vehicles, and other machinery either to transmit rotary motion

between two shafts where gears are unsuitable or to impart linear motion to a track, tape etc.

Fig.no.3 Sprocket

c.   REAR SPROCKET

Your gearing ratio is, simply put, the ratio of teeth between the front and rear sprockets. This ratio determines how engine RPM is translated into wheel speed by the bike. Changing sprocket sizes, front or rear, will change this ratio, and therefore change the way your bike puts power to the ground.

Fig.no.4 Rear Sprocket

d.   BALL BEARING

A ball bearing is a type of rolling-element bearing that uses balls to maintain the separation between the bearing races. The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads. It achieves this by using at least two races to contain the balls and transmit the loads through the balls. In most applications, one race is stationary and the other is attached to the rotating assembly (e.g., a hub or shaft). As one of the bearing races rotates it causes the balls to rotate as well. Because the balls are rolling they have a much lower coefficient of friction than if two flat surfaces were sliding against each other.

Ball bearings tend to have lower load capacity for their size than other kinds of rolling-element bearings due to the smaller contact area between the balls and races. However, they can tolerate some misalignment of the inner and outer races.
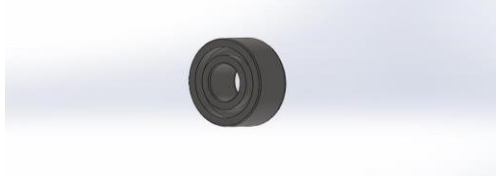

Fig.no.5 Ball Bearing

VI.KERS BICYCLE

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. By a proper mechanism, this stored energy is converted back into kinetic energy giving the vehicle extra boost of power.

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 fly wheel 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.

Fig.no.6 KERS Bicycle

VII.   WORKING

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. When riding a bicycle it becomes too tiresome to start the bicycle again after braking. If the bicycle is provided with a kinetic energy recovery system then the rider will have two power sources that he can use at his will. When brakes are applied kinetic energy is wasted because the kinetic energy converts into heat energy due to friction at the contact surface and the heat energy dissipates into the atmosphere due to thermal radiation. Vehicles equipped with KERS devices are able to take some of its kinetic energy out slowing down the vehicle. This is a form of braking in which energy is not wasted, instead gets stored in some device. Using a proper mechanism, this energy that is stored in terms of potential energy can be converted back into kinetic energy to give the vehicle an extra boost of power. In the literature review, different types of available KERS systems are compared and a mechanical based KERS system is found to be the best suitable for a bicycle. Mechanical KERS system there are of two types, one is a clutch based and another is a CVT based K.E. recovery system. In this project, a hybrid of the above two type of KERS systems is designed. Instead of CVT

a variable sprocket ratio is used to make the power transmission smoother.

Fig.no.7 Working

VIII.   CALCULATION

Calculation for the energy stored in the flywheel:

Weight of the person riding the bicycle   = 70kg

Weight of bicycle	=	10kg
Other payloads	=	10kg
Allowance for flywheel weight	=	0.5kg
Total weight	=	100kg

Let us assume that the flywheel stores enough energy to take the whole system from rest to 10km/hr in 5sec.

$$v = 10km/hr = \frac{50}{18} = 2.78m/sec$$

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

$$Time = 5sec$$

$$a = (V - U)/Time$$

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

E = 1/2mv²
E = 1/2*90.5*2.78²
E = 349.71 joules

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

D_R =Diameter of the bicycle wheel
= 10 inches = 250 mm

Number of revolution made by the wheel ar 10 Kmph per sec
= v/2πR
= 2.78*1000/2*π*125

= 3.539 rps
= 212.3 rpm

Force required to take the bicyle from rest to 10 Kmph in 5 sec

$$F_a = ma = 55.56N$$

Considering the rolling resistance of the bicycle
F_R = 20 watt at 10kmph = 7.2N
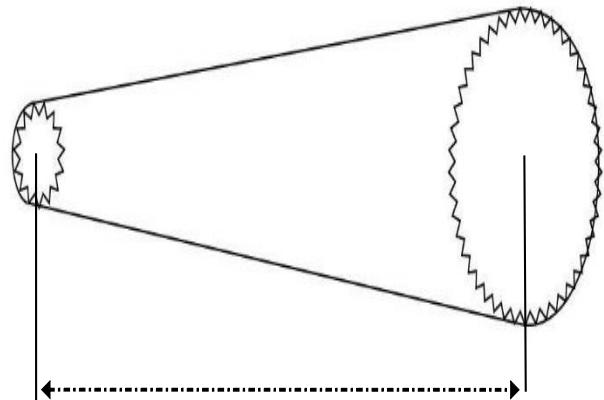
Calculation of the length of chain

Fig.no.8 Calculation of the length of chain

T_1= number of teeth on the smaller sprocket
P = pitch of the chain
T_2 = number of teeth on the larger sprocket.
X = center distance
K = number of units of the chain links used
L = length of the chain
p = pitch of the chain

The length of the chain can be found out by multiplying the number of units with the pitch of the chain.

$$L = K \times p$$

Number of chain links can be found from the following formula as mentioned in the book of "Machine Design" by Khurmi & Gupta

$$= \frac{T_1+T_2}{2} + \frac{2X}{p} + \left(\frac{T_2-T_1}{2\pi}\right)^2 \times \frac{p}{X}$$

The value of K obtained from the above equation can be approximated to the next/ nearest even number.
The looseness can be compensated by using an idling gear.

First let us consider the following set of data
T_1 =18
T_2 = 30
X = Distance between center = 0.52 m
(Approximately, because this distance varies from cycle to cycle.)
p = 12.7mm
K = (18+30/2)+(2*520/12.7)+(30-18/2*π)² * 12.7/520

= 105.96

≅ 106

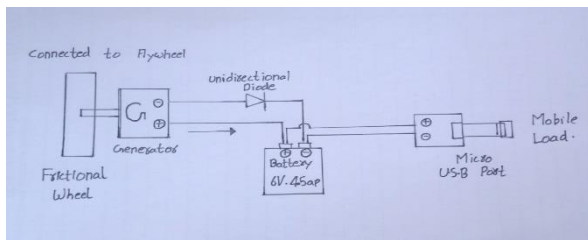L = 196 × 12.7

= 1346.2 mm

Fig.no.9 Block Diagram

Calculating the power generated by productive bicycling:

Specifications:

Battery = 6v, 4.5 amp

Generator produce = 1v - 18v

Here V_{min} = 1V.   & V_{max} = 18V

         I = 0.5amp

Then, P_{min} = V_{min} * I

         = 1 * 0.5 = 0.5w

& P_{max} = V_{max} * I

         = 18 * 0.5 = 9 w

So, if we ride bicycle for 6hr (Considering it as ideally)

Then power produce by generator would be

         = 6 * 4.5

         = 27 w

But actually we ride the bicycle for 4 hr

Then power produce by generator would be

         = 4 * 4.5

         = 18 w

So the efficiency we get

         η = 18/27 * 100

         = 66.66 %

So the efficiency we get by riding bicycle is 66.66%

IX.SCOPE AHEAD

This project has a huge future scope. The design in this project can be fabricated. The KERS system can be automated using PID controllers. Instead of using lever arm servo motors can be used. The flywheel weight can be optimised. Multilayer flywheel can be designed using lighter material at the centre and heavier material at the periphery. The design of the flywheel can be optimised. Instead of chain drive efficient belt drive CVT can be used to improve the power transmission. Design of a KERS with multi sprocket front sprocket system can be done. This allow the use of even broader range of sprocket ratios and will increase the efficiency. Research work can be done to shift the flywheel to the rear wheel centre that will save lot of space and reduce the amount of complexity. Design of the left handle with required mechanical advantage and aesthetics can be done. Design of the KERS housing can be done. As all the manufacturing procedures for the KERS components are described elaborately in this project can be used to develop a production line for large scale production this product can be brought to the market.

X.RESULT

The flywheel bicycle increases efficiency on rides where the rider slows often. The additional weight is outweighed by the ability to recover energy normally lost during braking. Thus the addition of extra weight does not make it difficult for the rider. Also clutch provided helps in deciding the time period of activity. The overall result is that KERS system is efficient in storing the energy normally lost in braking and returns it for boosting.

XI.   CONCLUSION

In this project a flywheel based KERS system was designed. The product designed in this project is a hybrid of clutch and CVT based KERS systems. This system is expected to be cheaper than CVT based KERS system. Effective and efficient manufacturing procedures for the components of the KERS were also found out.   Using FEA analysis the components are tested and modified to avoid failure. This project can guide anyone to fabricate his own KERS system for his bicycle very easily. It was found that all the components were safe under the extreme operating condition. Different types of KERS systems and their uses were also studied. It was found that flywheel can be used instead of battery to store and deliver energy efficiently. As use of flywheel in bicycle is a new concept, this field has a huge scope and wide range of implementation ahead.

KERS shows a significant improvement in cycling performance. This can be said on the basis of test results. It is a system which enables the rider to conserve his energy. Since energy conservation is of vital essence in today's world, KERS fulfils this aim. It has wide scope of improvement in future.

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