Kinetic Energy Recovery System

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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. 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. Finally the complete manufacturing process of this KERS system is explained elaborately so that any researcher can follow those steps and design a KERS system for his/her bicycle.

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 callipers 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 loner 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.

1.OBJECTIVES AND IDEAS

Any project at its starting comprises of setting the objective. Then comes ideas and their comparison to get to the best method to achieve the objective. Similarly for this project a lot of brain storming resulted in a good and efficient model of KERS system for a bicycle. Form the literature survey we found that a clutch based flywheel is very much efficient and cheaper as compared to CVT type. But there are always limitations and advantages for every mechanical system. In advantage. Let us take the CVT based KERS system can give us a smoother starting after braking it has the limitation that it keeps the KERS system always engaged even the rider doesn't want to use KERS in some circumstances. In the other hand for the clutch based KERS system we have the liberty to engage and disengage the KERS system any time we want but this system also has its limitations. In a clutch based KERS system the initial jerk when the KERS system is actuated is very high. So in this this project it has been tried to develop a hybrid between a clutch type and a CVT type KERS system.

Criteria to find out different gear ratios for Charging and discharging of the flywheel:

Charging criteria:

1. High energy consumption in less time
2. To reach very high RPM (flywheel)
3. Only on pressing the right brake charging will start
4. The rear sprocket is one directional and the front sprocket is fixed.

Discharging criteria:

1. System always tries to discharge energy back to the bicycle.
2. Discharge gear ratio should be less than the charging gear ratio.
3. The rear sprocket is one directional and the front sprocket is fixed.
4. If the cycle is moving faster than the flywheel and we don't want to charge the flywheel, the system should not charge it in any means.

IDEA 1:

First when the project was undertaken the idea was to develop a completely clutch based KERS system and to reduce the initial jerk to make it more handy. The thought behind this was when the brakes are to be applied the rider first actuates the KERS and the flywheel charges. After some time the speed of the cycle will reduced and then the rider will disengage the KERS system and will apply the brakes. For this function the brake wires are connected the right brake handle; both the front an rear brakes. And the KERS system is connected to the left brake handle.

This system has its limitations. They are

- This KERS system is not user friendly.
- Braking is a very important thing when it comes to mobile vehicles. Here the rider has to plan many thing before braking. Like when to apply the Kers when to disengage it and then to apply the brakes. During all this work he may lose concentration and there is a chance of accident.
- Both front and rear brakes are connected to only one rider handle. So the mild braking is not possible. Every time the rider applies the brakes it is a hard brake.
- Again to get acquainted to this new type of braking system is tedious task.
- Customers will not prefer this product.

Due to all these disadvantages is idea is ruled out.

IDEA 2:

The second idea was to go for a completely CVT based KERS system for the bicycle. The plan here was that there will be no clutch instead the rear wheel will be connected to the flywheel directly through a chain drive. This means the flywheel is always connected to the system. During starting the rider has to keep a high gear ration to charge the flywheel fast and during discharging he has to keep a low gear ratio to increase the time of discharge and to get the maximum benefit. In this case the brake system is free and the chance of accident is completely avoid. So the safety part is done. Now coming to the actuation part of the KES system, for that the driver has been provided a controller (mechanical controller) to change the gear ratio as per his requirement.

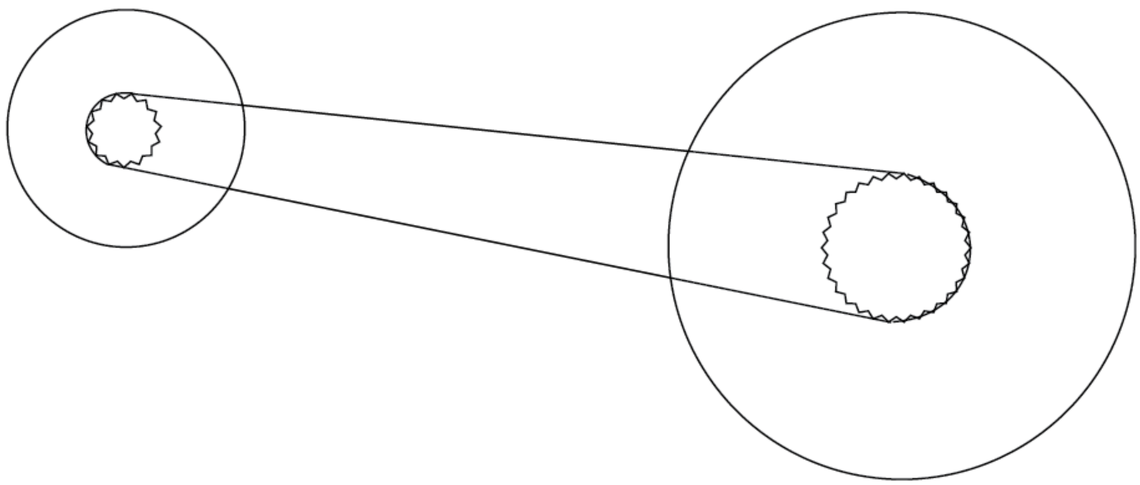

FIG-1a schematic diagram of a CVT based KERS system.

The main limitations of this system are:

- The starting effort required is very high.
- As the road is always unpredicted, sometimes this may happen that the rider has completely discharged his KERS system and he comes across an upward slant. The effort required will increase many fold.
- Due to all time engagement the system may undergo sever wear and tear.
- Also this high engagement time causes losses due to friction at the flywheel.
- The cost of the CVT is very high for a bicycle. Hens the product will not find popularity.

IDEA 3:

The next idea is a hybrid of the above two Ideas. In this case the clutch system is optimised and variable transmission (instead of CVT) system is used to get the optimum output of the KERS mechanism. This system has advantages over the above two methods and eliminated their respective limitations. In this paper the working principle, design and manufacturing process if this model is elaborately discussed.

The advantages of this system are

- This is user-friendly.
- The braking system is completely independent avoiding any chance of misshape.
- This is less costly.
- Avoids completely the initial jerk.
- Avoids the application jerk upto a large extent.
- Easy to fit.
- Marketable.
- Easy to manufacture.

2. COMPONENT OF KERBS

The components required for the making of the KERS for a bicycle are mentioned below

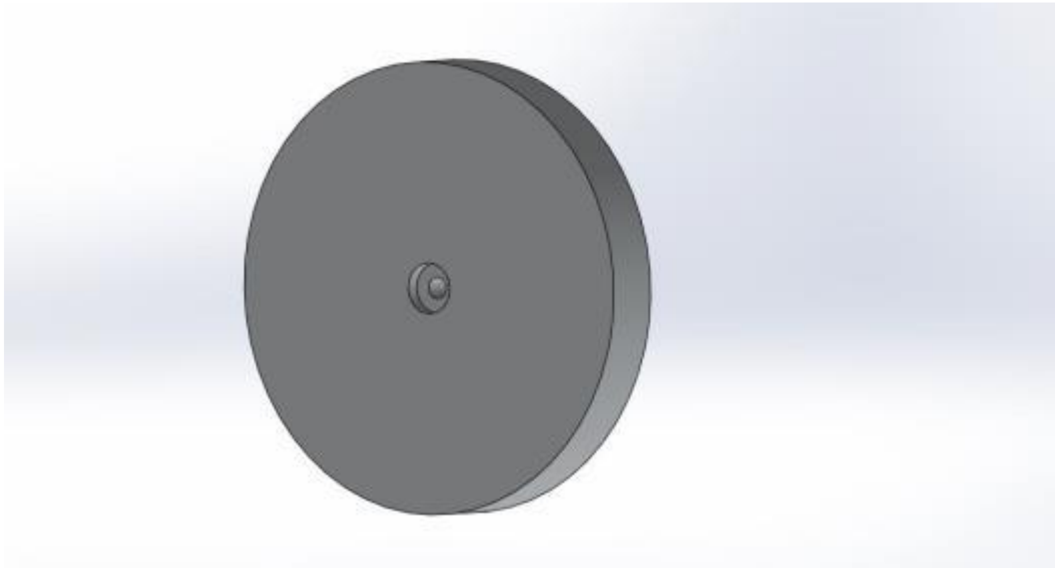

Fig 2- FLYWHEEL

FIG-3CLUTCH

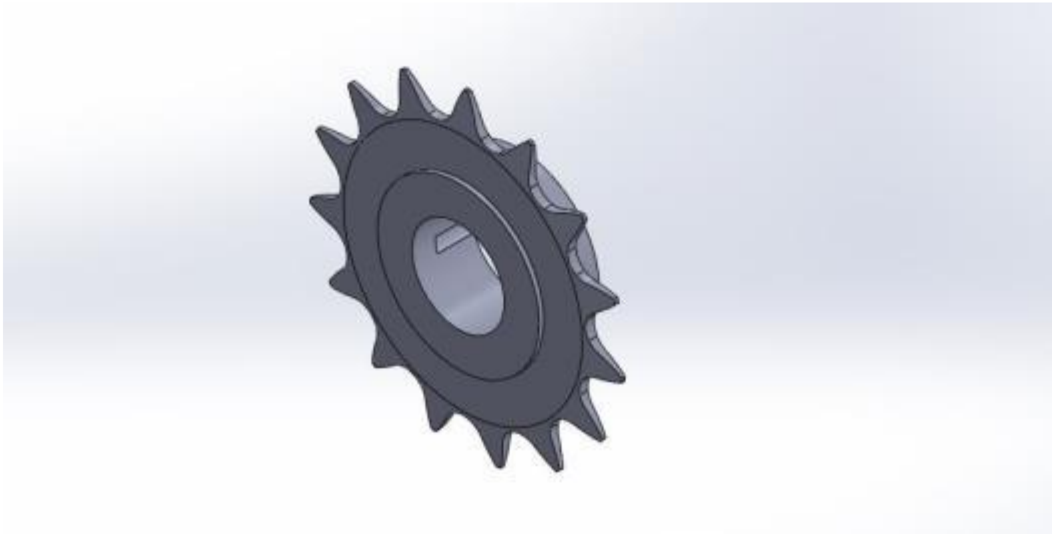

FIG-4 FRONT SPROCKET

FIG-5CLUTCH DRIVE

FIG-6 REAR SPROCKET

FIG-7BALL BEARING

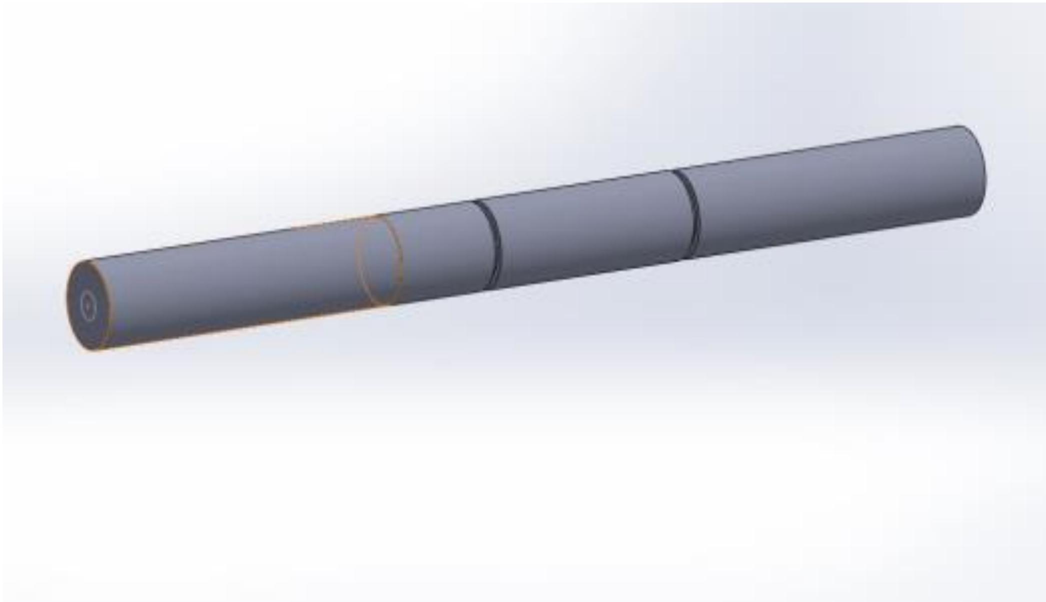

FIG-8 CENTRAL SHAFT

FIG-9 CHAIN

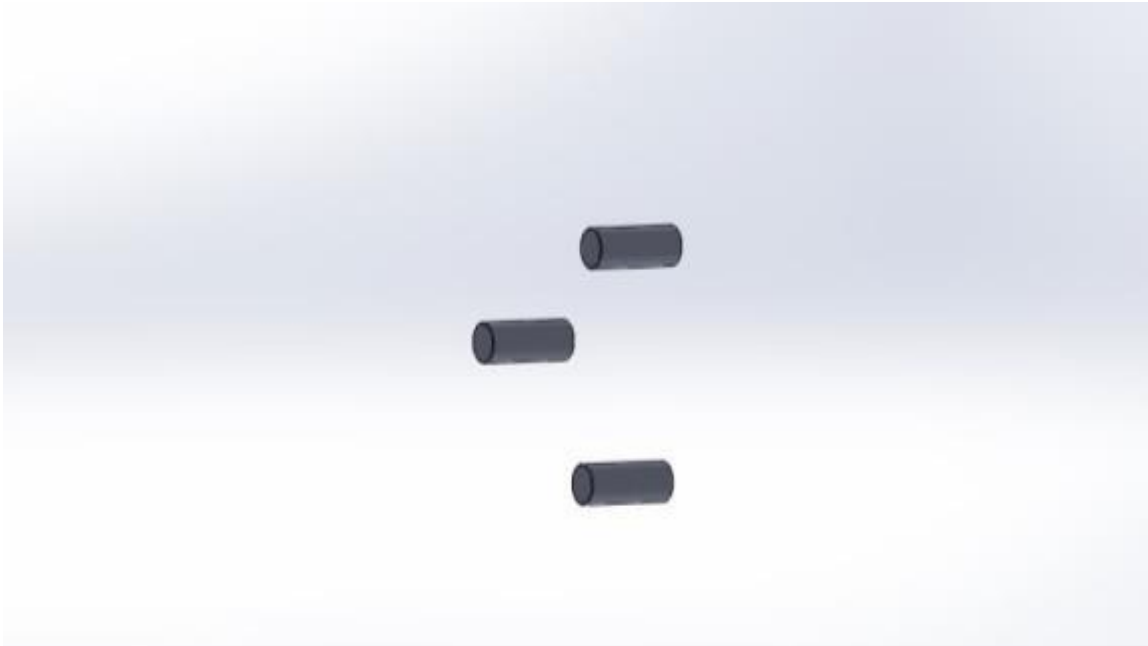

FIG-10 KEY

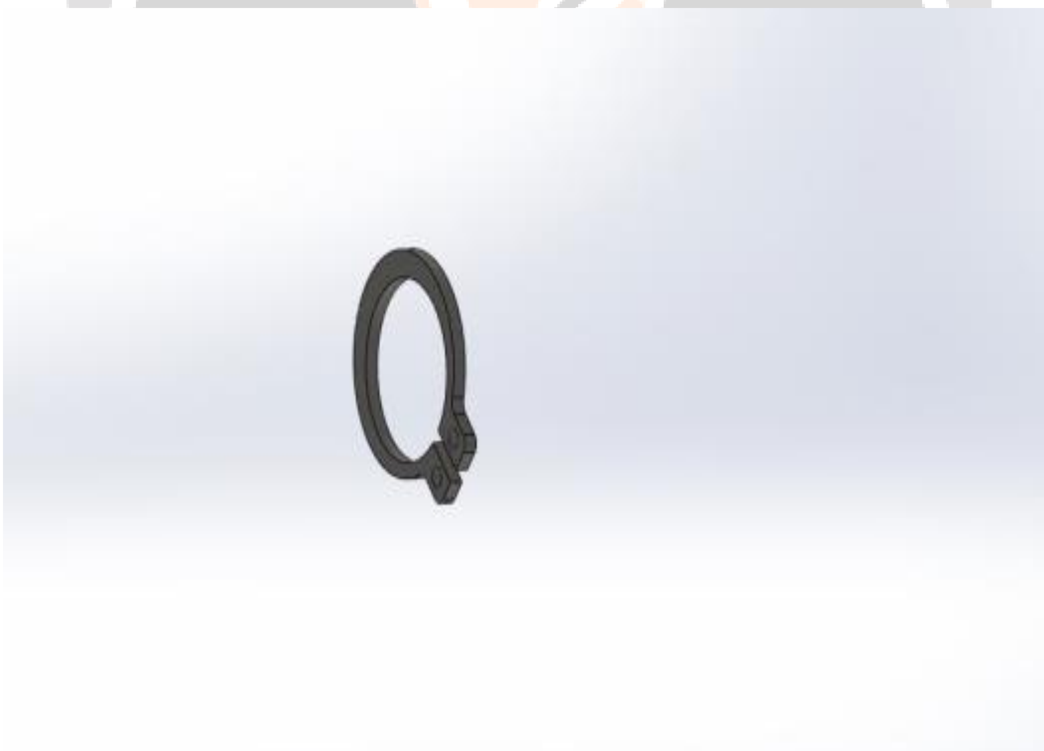

FIG-11 C CLAMP

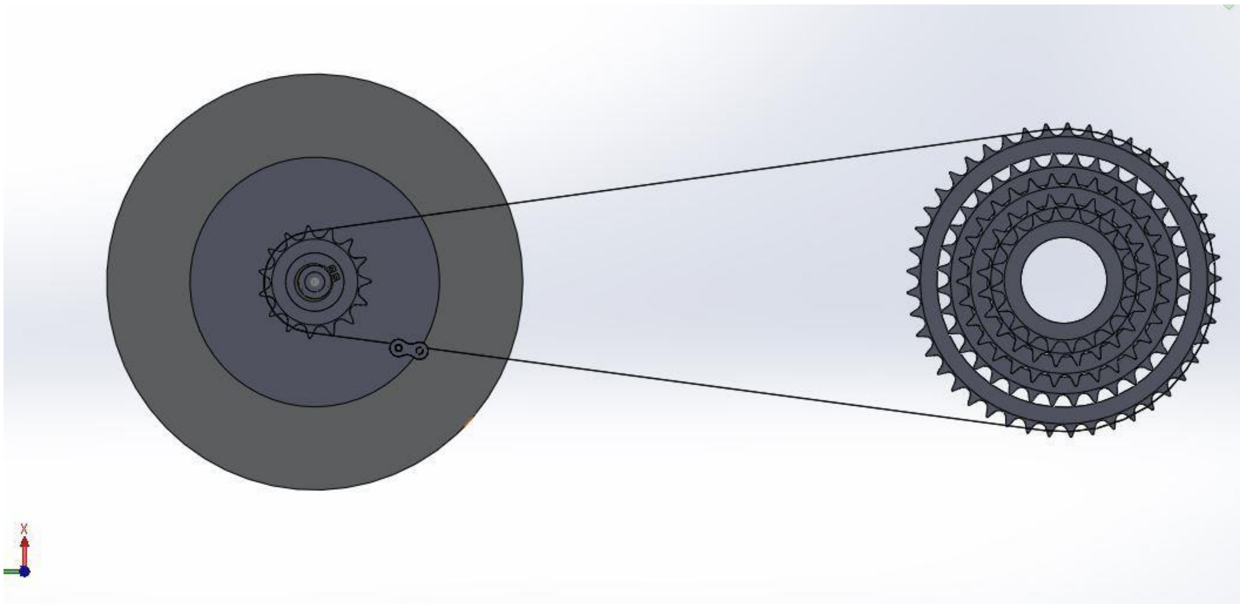

FIG-12 FRONT VIEW OF THE KERB

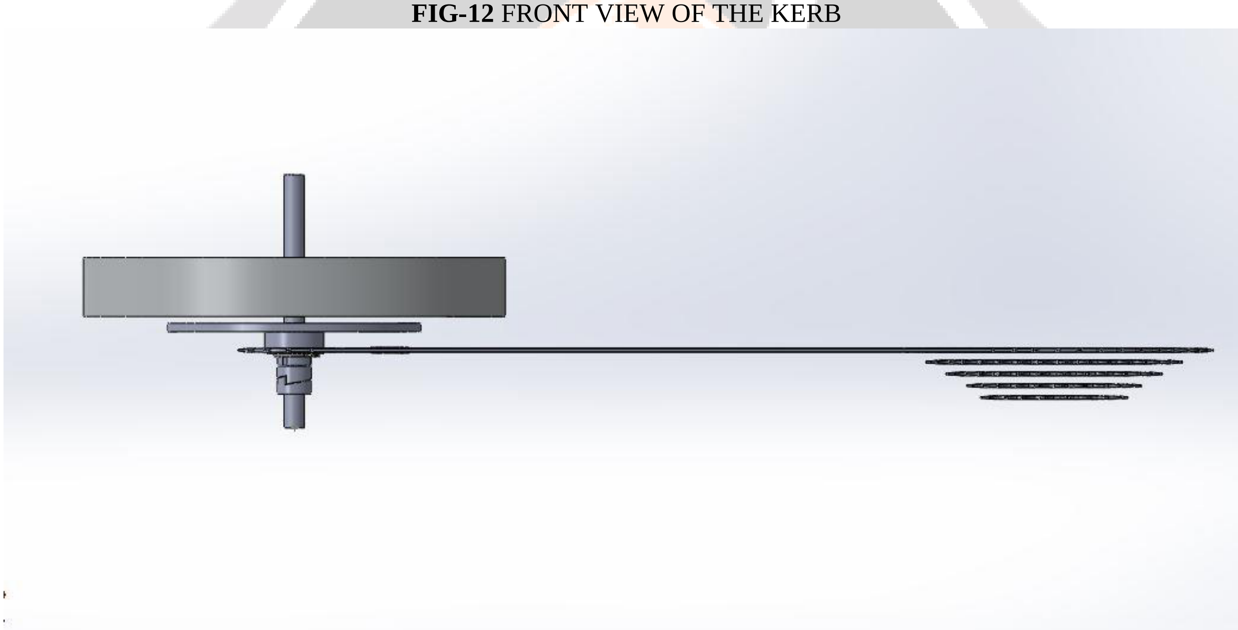

FIG-13 TOP VIEW OF KERB

3. WORKING PRINCIPAL

The working principle of the KERS system is described below in details.

1. To actuate the KERS the lever near the left brake is to be actuated. This pulls the wire connected to the clutch drive and rotates it by some angle less than 180°.
2. Due to the rotational motion of the clutch drive it undergoes translational motion, because its counterpart is fixed.
3. The translational motion of the clutch drive pushes the clutch plate to bring it in contact with the flywheel.
4. In this design we have connected the KERS actuator on the opposite side of the left brake lever so when clutch is actuate brake is not actuated (which is the default position) and when the brake will be actuated the clutch will automatically disengage.

5. The clutch drive is always in the actuated state with the help of a sprig that always keeps it rotated by nearly 150°.The rest 30° is for wear and tear compensation.
6. The clutch plate is a continuously moving part as it is connected with the front sprocket using three keys.
7. The front sprocket is driven by the rear sprockets through a chain drive.
8. The rear sprockets are a set of sprockets on which the chain can change position to get different gear ratios. These are interconnected and rotate at same RPM as the rear wheel.
9. During charging of the flywheel, power flows as follows Rear Wheel → Rear Sprocket → Chain Drive → Front Sprocket → Clutch → Flywheel
10. During the discharging cycle, power flows exactly in the reverse direction. Flywheel →Clutch →Front Sprocket →Chain Drive →Rear Sprocket →Rear Wheel.
11. As there are 5 sprockets on the rear sprocket system we can have 5 different gear ratios and can manipulate them to get the required charging and discharging conditions.
12. During charging it is preferred to use a higher gear ratio (Rear: Front) so that the flywheel can get charged within less time. But this will cause higher initial jerk while engaging.
13. So it is preferred to engage the clutch at the lowest gear ratio and then increase the gear ratio to the maximum.
14. This has an additional advantage. With every increasing gear ratio the relative velocity of the flywheel as compared to the rear wheel decreases. Thus additional torque acts on theroduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work.
flywheel and accelerates it to even higher speed. This way the flywheel can attain its maximum desired RPM smoothly.
15. Now the flywheel has its maximum potential energy. So if the driver wants to brake, he simply applies the brake and the flywheel automatically disengages as the string that actuate the flywheel is connected to the opposite end of the left handle brake as mentioned earlier.
16. Now coming to the discharging of the flywheel. Discharging can be done for a long time if we keep the sprocket ratio (rear: front) low. But if the gear ratio is more the torque will be more.
17. We need higher torque when discharging starts and low but continuous discharge when the cycle attains some speed.
18. From the previous discussion we can see that at the end of the charging cycle the gear ratio is at maximum. So when the discharging starts we simply need to reduce the gear ratio in successive intervals.
19. This has another advantage. When the gear ratio is lowered the relative velocity of the flywheel becomes more as compared to the rear wheel. So the power flows from the flywheel to the rear wheel and the cycle accelerates.
20. The gear changer for the KERS system will also be on the left hand side. So the driver has to concentrate only on hand to operate this system. And when he needs to brake (sudden brake) he simply can apply brakes. The cycle will stop.
21. The starting effort will be a little more but not that more because while starting the gear ratio is at minimum. Or if the driver is a bit smart he can apply the brake lever slightly and accelerate the bicycle easily. At that condition the KERS will be disengaged and the brakes are not also applied.
22. In normal riding the sprocket ration stays at minimum. When the rider wants to slow down (mild braking) he can simply increase the sprocket ratio with the help of gear shifter available at his left hand. And when he wants to boost his speed he can simply gear down or reduce the sprocket ratio to accelerate the bicycle.
23. The most important thing the amount of power released from the KERS system is completely controllable. The rider can release the exact amount of power he needs to release and get the required acceleration.

4. CONCLUSIONS

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.

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