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Flywheel Based Kinetic Energy Recovery System in Bicycle

Mangalvedhe Kartik Joshi Anand Jamdar Aditya
Pathak Saurabh Kashid Sahil Kalkhaire Mayur
P.E.S. Modern College of Engineering
Savitribai Phule University of Pune
Pune 411005, India

Abstract— *Flywheel is widely used for energy storage by using its moment of inertia. It can be thought of a "mechanical" battery used for storing energy. Kinetic Energy Recovery System (KERS) is a system used for recovering the moving vehicle's kinetic energy while under braking which usually gets lost as heat into useful rotational energy (of Flywheel) which is later used to propel the vehicle. Braking wastes quite a lot energy and thus driver effort. KERS basically is intended to reuse this waste energy to reduce driver effort. The rider can use this system in traffic where constant braking action takes place. Also while slowing on a hill, he can propel himself later while accelerating up a hill without any pedal effort.*
Keywords—*Flywheel, KERS, pedal effort, brake.*

I. INTRODUCTION

Cycle is the most efficient mode of transportation with zero pollution and extremely small investment compared to others. But it involves physical efforts on rider part which makes it less soothing to use. This is where KERS can help reduce this effort. KERS is system comprising of components that can store energy while decelerating and utilize this again for boosting purpose. During braking, kinetic energy of bicycle is converted in heat energy. This compels the rider to put extra effort again while moving forward. Bicycle with KERS can harness this waste energy along with braking. There are two types of KERS system- Electrical and Flywheel based. But efficiency of electric KERS is reduced to conversion from mechanical to electric and again vice-versa. The global efficiency of these conversion is generally is around 30%. Using Flywheel based KERS, these unnecessary conversions can be avoided and efficiencies upto 70% can be achieved.

II. BACKGROUND AND MOTIVATION

One of our member participated in an event called SAE Supra. It is basically a competition where one builds a F1 type car. And F1 car uses KERS. So we thought of implementing this system on a bicycle. We studied about this so that we could build it. We read the concept or principle regarding this from [Ref. 2]. To get good ideas, we did a brainstorming among us. We were further motivated to prepare this research paper by reading [Ref. 1]. It also creates a good platform for us to do something creative in the field of engineering.

III. KERS IN BICYCLE

When we pedal, the rear tyre rotates by means of chain drive connected between pedal and rear sprocket mounted on rear axle. Here, in this system, we make use of such a hub which consists of fine threading on both sides. The basic intention behind this is to mount another sprocket apart from the existing one. Also, an arrangement is made in between the cycle frame i.e. the truss member so that a axle can be mounted. Frame modification is done for this purpose. A clutch, sprocket and flywheel is mounted on this axle. And the previous sprocket on rear axle is connected to this one by means of chain drive. Proper speed reduction is specified for smooth working. This is the general assembly required for this system.

Now, at the time when speed reduction is required, a lever is operated that will connect clutch to the flywheel. Initially flywheel is at rest. Since the rotational speed of rear tyre is more than that of flywheel, the energy will be transmitted to flywheel. This will automatically decrease bicycle speed without wastage in heat energy. Then the clutch is disengaged. But again to increase to speed instead of pedal effort, one must only engage clutch to flywheel. Flywheel by virtue of its inertia is rotating continuously by previously gained energy. Since, this time rotational speed of flywheel is greater than that of rear wheel, the flywheel will propel the bicycle ahead. This way energy recovery takes place. The the overall pedal effort for same travel is hence reduced. In situations such as traffic jams or decelerating while downhill travel where our aim is not to completely stop the bicycle but is just to slow it, this system is more effective. If complete braking is done and after sometime regeneration is required, it will be very small since flywheel speed would have decreased due to friction losses. But in other cases such as sudden braking and instant recharging our energy would not be wasted. Bicycle would move with less velocity than previous instance but no pedal effort would be required which is what the aim is.

IV. DESIGN CONSIDERATION

A number of parameters were needed to be considered while designing this system for feasible and better results. These can be specified below as:

1. Assumed speed before recovery
2. Speed Requirement after Recovery
3. Energy storing capacity
4. Clutch engaging mechanism
5. Weight of entire system
6. Should be inexpensive
7. Maintenance free
8. Ease of manufacturing
9. Comfortable to use
10. Safe
11. Reliable
12. Standardization of parts

These were few basic requirements which were analyzed in designing stage.

V. FABRICATION OF SYSTEM

A. FRAME MODIFICATION

This is the first step while manufacturing. It is essential that this done to mount the axle as previously mentioned. It is done by using M.S tubes. One end is bent (almost 90°) and welded to a plate (which is fixed using nut and bolt on a welded plate between truss at handle end) while other end is cold forged and fixed using nut and bolt on the rear axle. These side members must accommodate flywheel and clutch and hence proper spacing should be provided. Along with that it should have enough strength to take load mounted on it. It should not hinder normal pedaling.

B. FLYWHEEL

It is designed in such a way that it is dynamically balanced to avoid wobbling. Its weight distribution should give good inertia. It is the most important component in system and hence proper selection should be done. To avoid manufacturing error, we decided to use flywheel of Jeep directly whose mass fell in our calculated range. Flywheel is mounted a bearing which is press fit in axle.

C. CLUTCH

It is used for engaging rear wheel with flywheel at the time of energy storing and recovering. It basically is disc with small thickness on which a friction lining is provided. It is directly welded on sprocket which is mounted on axle. As contrary to ordinary clutch, this is normally in disengaged state. A spring is inserted between clutch and flywheel to bring it in disengaged state. The size of clutch used is large so as to increase its torque transmitting capacity and heat dissipation rate[3].

D. AXLE

The whole assembly consisting of flywheel, clutch and engaging mechanism is mounted on axle. Hence it should have sufficient strength to sustain their weight and force transmitted by chain to the clutch. So it becomes vital to select material carefully [3][4]. While manufacturing a step is provided to fix the flywheel and prevent its moving. The dimension of axle is decided by considering factors such that there is interference fit between axle and flywheel bearing and there exists a precision running fit in between axle and sprocket. Also, both ends of axle are provided with threads so as to mount it on slots provided on the side members.

E. SPROCKET

There are in all two excess sprockets provided apart from the existing one on bicycle. One is mounted on rear axle and other on the designed axle stated above. The sprocket on rear axle has more number of teeth. It also has internal threading for mounting on hub of rear axle. It is fixed using a lock ring. Speed ratio is decided so that optimum energy recovery and transmission is possible.

F. CLUTCH ENGAGING MECHANISM

It is of cam type. It is actuated by a brake lever on handle. When operated it moves forward and pushes the clutch. For retraction of mechanism a tension spring is provided.

VI. UNIQUENESS OF OUR SYSTEM

There have been a couple of models working on KERS. Our system follows the same working principle but differs in design in many ways as specified below:

1. The system is completely removable i.e. every component of KERS can be removed (and assembled) and the bicycle can be restored to its original condition. This is significant from maintenance point of view.
2. The position of axle can be adjusted by means of slot provided on side member. This helps in adjustment of tension in chain and alignment of sprockets.
3. Standardization is one of important features in our system. We have maximized use of standard components which reduced overall cost and which helps in maintenance.
4. The clutch engaging mechanism is cam type operated which has aided in compacting the system.

VII. ROAD MAP

1. Survey
2. Problem definition
3. Listing of required components
4. Design of components and load Analysis
5. Preparation of CAD model
6. Manufacturing of components

7. Assembling
8. Testing

VIII. TESTS AND RESULTS

MODE OF TEST

a. On flat road:

We drove the bicycle with approximately 25 kmph, then engaged the clutch with flywheel until the speeds of flywheel and bicycle matched. This decreased the bicycle speed along with gain in energy in the flywheel. We disengaged clutch at this moment. We further reduced speed *almost* to 0 kmph by applying the brakes. This was followed by engaging of clutch to flywheel. We measured the distance travelled due to the stored energy in flywheel. Results showed that after engagement, the bicycle further travelled approximately 10 meters from rest without any pedal effort.

b. On slope (or downhill):

We started from rest down a hill from almost 15 meters. To avoid over speeding as normally one does, he applies brakes to slow down. We, on the other hand, applied lever that engages clutch to flywheel which gave consequence with a gain in energy. Due to this the range of travel without pedaling gets increased. Results showed that almost 50 to 60 meters more travel was achieved than that achieved on flat road.

Of course, the above results may *vary* with different test conditions. And also, result can be improved with accurate manufacturing.

IX. CONCLUSION

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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