Design and Fabrication of Kinetic Energy Recovery System: Literature View

Lodade Nikhil, Daundkar Nitesh, Mahalungkar Satish, Kale Satyawan, Patil Sateesh

Abstract— **Now days increasing huge energy demand and increased alertness of people towards the healthiness in developing countries like India are some of driving forces for the development of new technology and saving of energy. The law of conservation has become requirement in today's world, mainly in all new technology. In many of rolling applications maximum energy is lost during deceleration or braking. This problem has been fixed with the introduction of kinetic energy recovery system. Kinetic Energy Recovery System (K.E.R.S) is a type of regenerative braking system which has different approaches to store and reuse the lost energy. This paper gives an idea about a flywheel based kinetic energy recovery system (K.E.R.S) concept by showing the application of the same on a bicycle to improve the performance and and/or efficiency of the bicycle. Thus this is nothing but humanly powered machine. Flywheel rotor design is the key of researching and developing flywheel energy storage system. Thus this paper represents a literature report reviewing the human power flywheel motor as well as the flywheel design**

Index Terms— **KERS, Bicycle, Regenerative Braking, Flywheel, Kinetic Energy Recovery.**

I. INTRODUCTION

The acronym KERS stands for Kinetic Energy Recovery System. The device recovers the kinetic energy that is present in the waste heat created by the car's braking process. It stores that energy and converts it into power that can be called upon to boost acceleration [5].

A Kinetic Energy Recovery is a Mechanism that reduces vehicle speed by converting some of its kinetic energy into another useful form of energy – electric current, compressed air etcetera. This captured energy is then stored for future use or fed back into a power system for use by other vehicles. For example, electrical regenerative brakes in electric railway vehicles feed the generated electricity back into the supply system [4].

KERS is a type of regenerative braking concept which is primarily used in formula-1 cars for the purpose of speed boosting. The energy which is applied for braking purpose of a vehicle is normally wasted; however this energy can be saved and effectively utilized as and when required. Generally when the brakes are applied, the braking energy gets converted into heat which is wasted; however this energy can be saved and effectively utilized as and when required. Generally when the brakes are applied, the braking energy gets converted into heat which is wasted however in this scenario when the brakes are applied the energy is passed to the motors which are mounted on the front wheels. The motors as this stage act as generator converting the mechanical energy to electrical which is then passed to motors/flywheel arrangement resulting in rotation of flywheel. This rotational energy as and when requires can be restored by the means of motors to the wheels thus providing the necessary boost in speed [6].

In order to understand the concept of KERS and its impact on vehicle energy performance, a simple example is presented: Consider a 300 kg (~ 661lbs) vehicle moving at an initial speed of 72 km/h(~ 45mph).Now, on braking the vehicle to a speed of 32 km/h(~ 20 mph) the amount of energy spent is around 47.8 kJ using the equation given below,

$$E_k = ½ * mv^2 \qquad (1)$$

Where, E_k: Kinetic Energy of the vehicle; m: Mass of the vehicle and v: Velocity of the vehicle. Ideally, this is the amount of energy available for capturing at each instance of braking. If regenerative braking was used on such a vehicle it would be able to capture this amount of energy and reuse this same energy which would otherwise have been lost in the form of heat, sound etc. Now, even if we suppose that the efficiency of the brake is 25% of this, there would still be an amount of 11.85 kJ (25% of 47.8kJ) of energy available at each braking instance, which shows the amount of energy that can be utilized for beneficial causes. This energy is roughly, neglecting all losses, enough to accelerate a car from 0 km/h to around 32 km/h). This stored energy using R.B.S. can be reutilized for different purposes, either to help improve performance or fuel efficiency, in either case assisting in 'Load Sharing' [2].

II. WORKING

The components used in the system are flywheel, clutch, chain drive, Bearing, frame. Flywheel which is mounted on the frame is driven by the rear wheel through the chain drive and clutch mechanism. When one has to apply the brakes the mechanism is such that clutch gets engaged with the flywheel and it starts rotating thus storing the braking energy. The mechanism designed is such that by manually pressing the lever (Rear brake lever of the bicycle) the clutch can engage with the flywheel this depends upon the convenience of the biker. The stored energy is utilized when the speed of bicycle decreases below the average range of speed i.e. rear wheel

Manuscript received Sep 23, 2015

Lodade Nikhil, UG Student , Department of Mechanical Engineering, Savitribai Phule Pune University, Pune, India
Daundkar Nitesh, UG Student , Department of Mechanical Engineering, Savitribai Phule Pune University, Pune, India
Mahalungkar Satish, UG Student , Department of Mechanical Engineering, Savitribai Phule Pune University, Pune, India
Kale Satyawan, UG Student, Department of Mechanical Engineering, Savitribai Phule Pune University, Pune, India
Patil Sateesh, Assistant Professor, Department of Mechanical Engineering, P K Technical campus, Chakan, Pune, Maharashtra, India

speed. The flywheel energy by the means of chain in this case can be restored back to the bicycle thus fulfilling its torque requirement. Consider for instance riding on a slope or in the case of mountain biking, when the speed of bicycle is more than average speed range the engagement of flywheel is facilitated and the flywheel keeps on rotating for a certain period of time mainly due to inertia this motion can be transferred back to the rear wheel thus assisting the forward motion of the bicycle.

The first class of flywheels uses steel as the main structural material. The second class of flywheels uses a metallic hub and composite rim made up of an advanced composite material such as carbon-fiber or graphite. The metal hub of composite flywheels had the same geometrical shape and work condition with the steel flywheels. This section mainly determines their maximum outer radius. The design method is similar in composite rim [7].

1. Flywheel as mechanical energy storage device

A flywheel such as the one illustrated in Figure is a mechanical device that is commonly used to store kinetic energy associated with its rotation at high speed. The stored energy is then released to the intended application such as described in Section II after the supplied energy is either discontinued or reduced in the magnitudes.

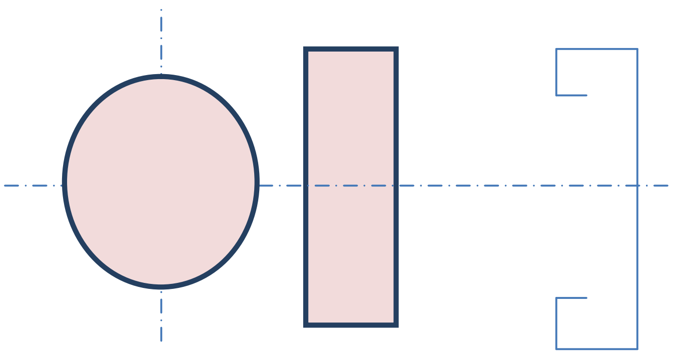

Fig. 1 Flywheel

Fig. 1 shows two popular geometry of flywheels: the uniform cross-section wheels in the middle and the thick-rim flywheels to the right. The kinetic energy that can be stored in a flywheel spinning at an angular velocity ω may be computed by the following expression:

$$KE = \frac{1}{2} I\dot{\omega}^2 \qquad (2)$$

Where, I is the mass moment of inertia of the spinning wheel. Below Equation is used to compute the mass moment of inertia for flywheel with uniform thickness:

$$I = \frac{1}{2} Mr^2 \qquad (3)$$

With M and R being the mass and the radius of the wheel respectively. The angular velocity of the spinning flywheel ω is maintained by applying torques that is equal to in which α is the angular acceleration of the spinning wheel [5]. The flywheel is where the energy is stored from the brake regeneration. A 20 inch diameter bike wheel rim will be used as the flywheel since it will be smaller than the 26 inch wheels on the bike, is an off the shelf part that is easy to get, has most of its mass on the outer edge, would be easy to add weight to if necessary, and has a hub that will be easy to attach to the axle [6]. Instability in voltage can lead to quick wear and tear of the energy storage device. Fig. 2 shows that in comparison with other storage systems, flywheels offer maximum steady voltage and power level, which is independent of load, temperature and state of charge. Second being Lithium ion (Li-ion) battery followed by Nickel metal hydride NiMH and Lead-acid batteries. Super-capacitors / ultra-capacitors being the lowest with 30% stability. Reason being that super-capacitors have self-discharge properties [4].

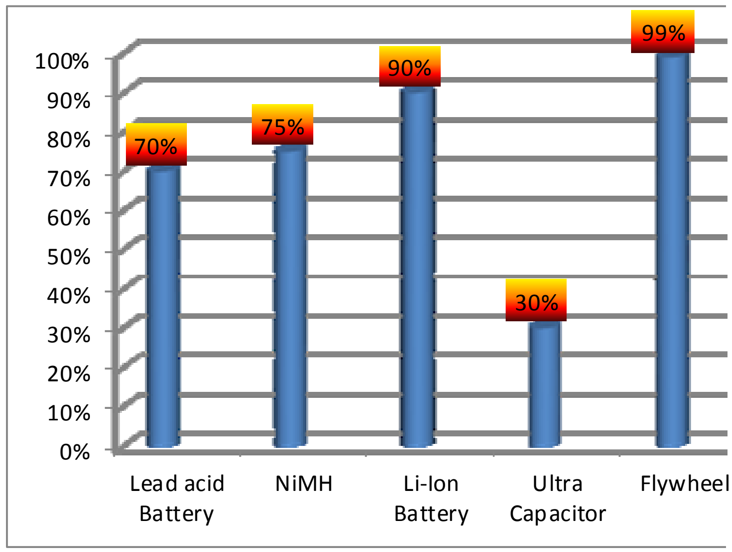

Fig.2 Energy comparison

Cost is the main drawback of every Hybrid vehicle. Causes of high cost are the materials used in making these vehicles and their storage technologies.

Fig. 3 shows that flywheel- system is the cheapest after batteries with 15% and 6%. However, flywheels are currently use because of the efficiency they give in this low cost. Batteries cannot store enough energy and hence charge and discharge quickly. Hydraulic systems are the most expensive of them all followed by super capacitors with 47% and 32% respectively [7].

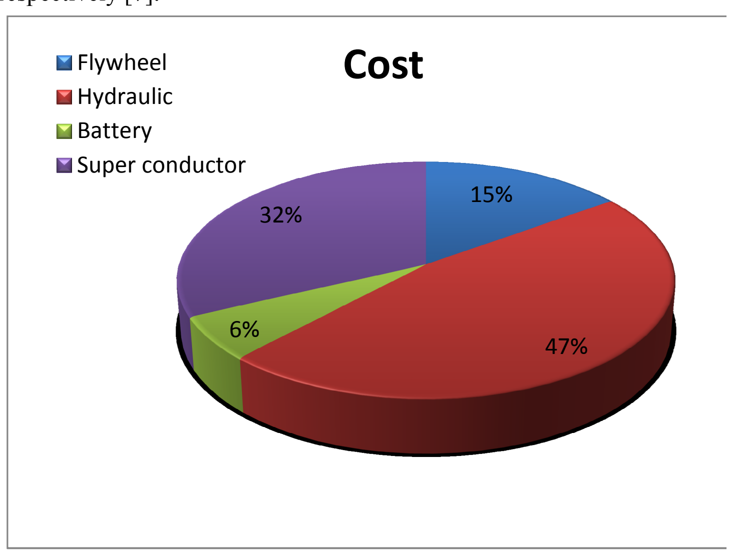

Fig.3 Cost comparison

Advantages-

1. Enhanced Performance
2. High power capability

3. Light weight and small size with Long system life
4. Completely Safe and a Truly Green Solution
5. High efficiency Storage and Recovery

CONCLUSION

KERS (Kinetic energy recovery system) is a system which is very efficiently used in as an energy recovery device or regenerative braking concept. Similar concept can be employed for a non-polluting device such as bicycle with the intention of reducing human effort to ride the bicycle. 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. The proposed design is a simple implementation of the same idea which uses flywheel as an energy bank or energy storing device. The idea was successfully implemented as well as validated by manufacturing and mounting the KERS system on a non geared bicycle and the results obtained were non negligible as well as encouraging. However there are certain areas that need to be looked upon, better results in terms of reduction in pedaling power can be obtained by better weight optimization. Continuously variable transmission can also be an option for better transmission efficiency. Ergonomics can also be taken into account, the idea of double centrifugal clutch if implemented successfully will make the entire transmission automatic leading to better comfort and hassle free driving experience.

REFERENCES

1. Sreevalsan S Menon, Sooraj M S, Sanjay Mohan, Rino Disney, Suneeth Sukumaran, “Design And Analysis Of Kinetic Energy Recovery System In Bicycles” International Journal of Innovative Research in Science, Engineering and Technology, ISSN: 2319-8753, August 2013.
2. Sameer.G. Patil, Rithwik M Singh, Suryakant Tripathi, Rajkumar Jakhar, “Regenerative Braking Principle By Using Kinetic Energy Recovery System –A Review” ISSN 2393-8374, 2015.
3. Kevin Ludlum, “Optimizing Flywheel Design for use as a Kinetic Energy Recovery System for a Bicycle” 3 June 2013.
4. Cibulka, J. “Kinetic Energy Recovery System By Means Of Flywheel Energy Storage” advanced engineering, ISSN 1846-5900.
5. Pottabattini naveen, Mamidi ranga rao, Novle Krishna, Aashish ambekar, Monica naga sai latchireddy, “Kinetic Energy Recovery System” International Journal of Scientific & Engineering Research, ISSN 2229-5518, January-2014.
6. Nishad Kumbhojkar, Kunal Mohite, Anand Kulkarni, Sanket Patil, “Design And Implementation Of Kinetic Energy Recovery System (Kers) In Bicycle” International Journal of Mechanical Engineering and Technology (IJMET), ISSN 0976 – 6340, April 2015.
7. Sheng Xu , “Design and Prototyping of a Low-Speed Flywheel System for Automotive Brake Energy Recovery” The Ohio State University, 2012.
8. V. Praveen, M. Arun , “Kinetic Energy Recovery System In Bicycle” International Journal Of Pure And Applied Research In Engineering And Technology, ISSN: 2319-507X, IJPRET, 2014