Kinetic Energy Recovery System

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***Abstract* - The term KERS refers to a technology that is used to recover the kinetic energy of any object that is lost while retardation or deceleration. 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. Kinetic Energy Recovery Systems (KERS) is a type of regenerative braking system which has different approaches to store and reuse the lost energy. In case of automobiles, energy conservation can be done by using regenerative braking systems (RBS). When driving an automobile, a great amount of kinetic energy is wasted when brakes are applied, which then makes the start up fairly energy consuming. In case of automobiles, energy conservation can be done by using regenerative braking systems (RBS) by kinetic energy recovery system. So the target of recovering the energy lost in braking is completed under the various types of Kinetic Energy Recovery System (KERS).The vehicle may be built using various KERS designs, based on type of KERS used. This paper shows a detailed description about KERS.**

***Key Words* - KERS, RBS, kinetic Energy**

I. INTRODUCTION

In today's busy world it has been necessary to look over the energy crises in the world. Maximum energy is lost in any type of rolling application is while retarding the motion it is either rotary or linear. In this era of energy crises this loss is not negligible especially when it can be utilized. The concept of recovering the kinetic energy of vehicle was first implemented in Formula-1 cars. In such competitions there is more importance of the energy boost then the energy at a constant supply. Which is the special quality of the KERS; it gives back the energy to the main system and provides a high pick-up at release of brakes.

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 vehicle. KERS has a very wide range of applications in today's world of advanced technologies. As it is applicable in bicycles, bikes, cars as well as any other rolling application that has a variation in speed because of deceleration, as these all are it is commercial and practical application.

KERS system used in the vehicles satisfies the purpose of saving a part of the energy lost during braking and it can be operated at high temperature range and are efficient as compared to conventional braking system. The results from some of the test that he conducted show that around 30% of the energy delivered can be recovered by the system. 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.

Sreevalsan Menon[1] implemented KERS system in a bicycle with an engaging and disengaging clutch mechanism for gaining much more efficiency.

Flywheel technology is on the rise across many kinds of technology. It is a pollution free method of storing energy that has many current and potential applications. In the case of road vehicles there is much to be desired in terms of energy efficiency, especially when considering pollution per unit of energy. Any system of brake regeneration can help that, but flywheels have the potential to increase the efficiency of road vehicles without direct or indirect negative effects on the environment. The batteries used in hybrids do not last the cars lifetime and can have costly environmental effects. [2]

The engines have few cylinders, and are turbocharged and directly injected, gasoline or Diesel depending on the target use. KERS is preferably mechanical, but electric and electro-mechanical solutions are also options. The best mobility solution in the short term is the use of simple, lightweight vehicles equipped with front small, high power density, internal combustion engines and rear kinetic energy recovery system brakes.

Alberto. Boretti also named the mechanical KERS as M-KERS and electrical KERS as E-KERS and in his research they he found that M-KERS on the rear non-motored wheels, the thermal engine powering the front wheels has to supply 0.31 MJ/km or 30.82 MJ/100 km for a 1000 kg vehicle of standard rolling and aerodynamic resistances covering a modified version of the new European driving cycle. [3]

Kevin Ludlum [4] displayed a fairly simple design with implementation of a kinetic energy recovery system with a non-negligible increase in the efficiency of a bicycle. Also reasoned to use a flywheel that, flywheel has environmental impact only at its time of production, and has the potential to heavily outweigh those costs through its use. Bikes do not have the pollution problems, cars and other modes of transportation have, but they can serve as a good analogy for how a kinetic energy recovery system can increase the efficiency of a vehicle. [4]

A comparison of other battery energy storage and regenerative braking with KERS and observed by **Cibulka, J. [5]** that in comparison with other battery storage technologies, KERS offers:

- Cycle durability- 90% efficiency of flywheel (including power electronics) in both directions during KERS reference duty cycle.

- Extensive operating temperature range.
- Steady voltage and power level, which is independent of load, temperature and state of charge.
- High efficiency at whole working speed range.
- No chemistry included thus, no environmental pollution and great recycling capability.

Using KERS with the use of more efficient systems could lead to huge savings in the economy of any country. It is 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 are present large amount of friction loss is found in this system which can be improved. Boost is reduced because of friction. [6]

U. Mugunthan, U. Nijanthan have been performed an overdrive test to observe the efficiency of bicycle. It has been found out that the flywheel supplies an energy with which the cycle could move forward by 10% of the given input. Depending upon the input given, the efficiency varies. But only 10% can be obtained by this principle. This system when installed in vehicles would save a greater amount of energy lost during the braking of the vehicle. This energy can be stored and can be reused when needed. It is more efficient when compared to the conventional braking system. We would conclude that, this recovery system has to be developed further and has a wide range of research which can be conducted in the future. [7]

The regenerative braking 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. The results from some of the test conducted show that around 30% of the energy delivered can be recovered by the system. Regenerative braking 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 [8].

II. ABOUT KERS SYSTEM

TYPES OF KINETIC ENERGY RECOVERY SYSTEM

1. Mechanical KERS

In this system the energy is stored by means of either flywheel or spring. Here the braking energy is used to turn a flywheel or spring and when extra power is needed the wheels are coupled up to the spinning flywheel to give a boost in power or springs are released to restore the energy into the main drive.

It has been put into use for Formula 1 cars since the year 2009.

(a) Flywheel storage: In this type of mechanical KERS the fly wheel is used with a higher gear ratio mechanism.

(b) Elastic Spring energy storage: The use of spring ensure the permanent storage of energy until used by the driver unlike flywheel regeneration system in which the energy stored decreases with time and is eventually lost.

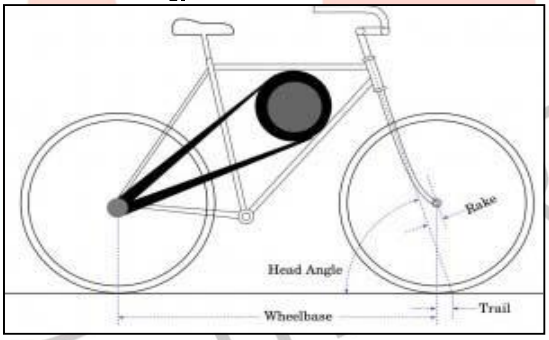

Fig.1 working model of a flywheel bicycle

Fig.2 Elastic Spring

Some advantages of using this system are as mentioned below:-

- The energy stored is permanent. Therefore the energy can be released whenever required.
- Use of planetary gear system allows energy to be transmitted in the same sense of rotation as that of the axle.
- The system is robust, compact and can be mounted easily inside wheel rim.
- Unlike flywheel based KERS, this system is inexpensive.
- Compared to Regenerative Braking System this mechanical KERS is more efficient due to fewer conversions.

Control system has been described and they concluded that the new Distributed control system, Supervisory control and data acquisition and communication systems make it possible to integrate protection, control and monitoring together to its maximum benefits. The innovative development of automatic switching will yield more benefits to distribution utilities.

Truly, distribution automation and system monitoring are the logical choice for the utilities to improve system performance, and to achieve customers and shareholders satisfactions.

2. Electric KERS

With this system when brake is applied to the vehicle a small portion of the rotational force or the kinetic energy is captured by the electric motor mounted at one end of the engine crankshaft. The key function of the electric motor is to charge the batteries under barking and releasing the same energy on acceleration. KERS components for battery storage systems are:

- Electric Propulsion Motor /Generator.
- Power Electronics – Inverter, and the Quad Flywheel Storage.
- Electric Propulsion Motor and Generator in one are also known as a MGU – Motor Generator Unit.
- Capacitors are fundamental electrical circuit elements that store electrical energy in the order of microfarads and assist in filtering

2.1 PRINCIPLE OF WORKING

If you use mechanical energy to rotate the coil at uniform angular velocity ω in the magnetic field it will produce a sinusoidal *emf* in the coil.

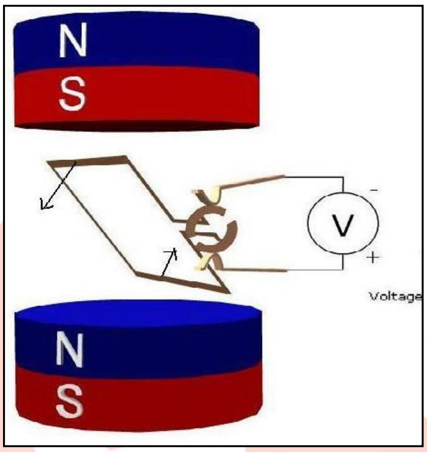

Fig.3 Principal of KERS

Electrical KERS brake consists of:-

- A driving wheel linked with a rotary shaft
- A motor
- A battery charging circuit
- A set of batteries or other storing device.

3. Hydraulic KERS

In a hydraulic accumulator the potential energy is stored in the form of a compressed gas or spring, which is used to exert a force against an incompressible fluid. Accumulators store energy when the hydraulic system pressure is greater than the accumulator pressure and releases hydraulic energy in the opposite case. Regenerative braking in vehicles using a variable displacement hydraulic pump/motor together with a hydro-pneumatic accumulator has attracted considerable interest during the last 20–25 years. Such a system is particularly suitable for application in city buses

Despite the significant gains in the efficient use of energy that can be brought about by hydro-pneumatic regenerative braking, its use has not attained great popularity. The added cost, which may represent 10–15% of the total for the vehicle, is undoubtedly a deterrent.

4. Hydro-electrical KERS

In this system the combination of electric and hydraulic system is used to store the energy.

Hydraulic accumulator has the characteristics of higher power density and is well suited for frequent acceleration and deceleration under city traffic conditions. It can provide high power for accelerations and can recover more efficiently power during regenerative braking in comparison with electric counterparts However; the relatively lower energy density brings the packaging limit for the increasing accumulator size.

The regenerative component consists of,

- A fixed displacement hydraulic pump/ motor.
- A hydro-pneumatic accumulator.

A hydraulic-accumulator/battery hybrid energy system, called hydraulic/electric synergy system (HESS), is designed to overcome the drawbacks of existing single energy storage sources used in heavy hybrid vehicles.

4.1 ADVANTAGES: -

1. High power capability.
2. High speeds attained in lesser time.
3. Overtaking and defense improved in F1.
4. Fuel Consumption to be reduced.

5. Light weight and small size.
6. Long system life.
7. A truly green solution.
8. High efficiency storage and recovery.
9. Low embedded carbon content.
10. Low cost in volume manufacture.

4.2 LIMITATIONS: -

1. Storage capability.
2. Weight increment, particularly important in F1 cars.
3. Explosion in batteries.
4. Electric shocks.
5. Incidents regarding gearbox locking.
6. Teams not ready to spend millions for developing the technology.

III. COMPARATIVE STUDY [9]

1. Voltage stability:

Instability in voltage can lead to quick wear and tear of the energy storage device.

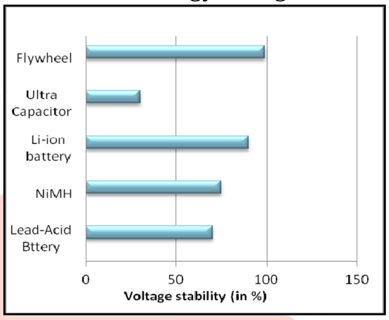

Fig. 4 Voltage stability of different KERS

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 are at the lowest position with 30% stability

2. Efficiency:

Efficiency in storage technologies can be defined as the amount of energy stored by the system to the amount of energy given out or utilized for other use.

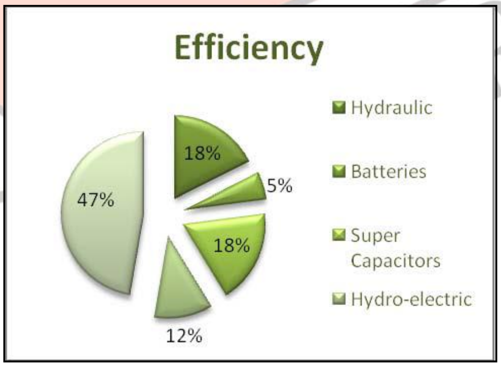

Fig 5 Efficiency of different KERS

Figure 5 shows that super-capacitors have maximum efficiency with hydraulic storage devices not being too far from it which is followed b the presently in use mechanical KERS (i.e. flywheel). Batteries have the least efficiency because their discharge rate is faster as compared to the rate at which they charge.

Even though super-capacitors have high efficiency, they cannot be used in KERS yet because at constant speed, super-capacitors cannot capture the kinetic energy lost while braking.

3. Fuel consumption & Temperature range

Fuel consumption is the main aspect targeted by hybrid cars. This is to conserve and protect the non-renewable and natural resources.

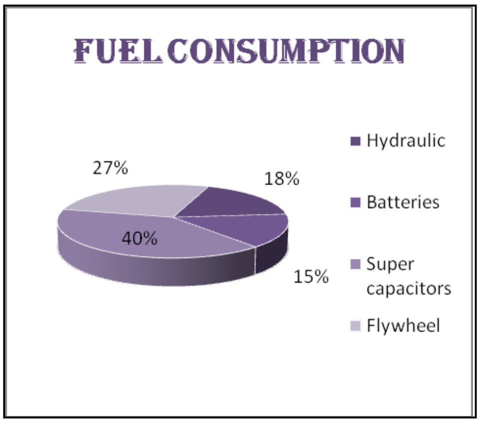

Fig. 6 Comparison of fuel consumption of different KERS

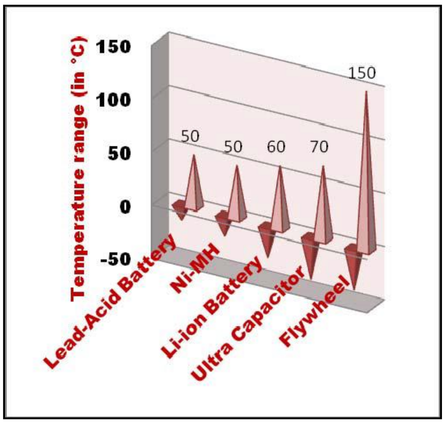

Fig. 7 Temperature range of different KERS

It is seen (from figure 6) that 40% of fuel consumption reduction takes place if super-capacitors are prioritized as storage device. Second being flywheel with27% followed by hydraulic energy system and batteries with 18% and 15% fuel consumption reduction respectively.

Batteries contribute least because they have short life and less conversion capacity as compared to other storage devices since their maximum and minimum temperature range is very small.

So they have not proven themselves as a capable KERS. The graph below shows that phenomena in detail

4. Cost

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. 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.

So the target of recovering the energy lost in braking is completed under the various types of Kinetic Energy Recovery System (KERS).The vehicle may be built using various KERS designs, based on type of KERS used. This paper showed a detailed description about KERS.

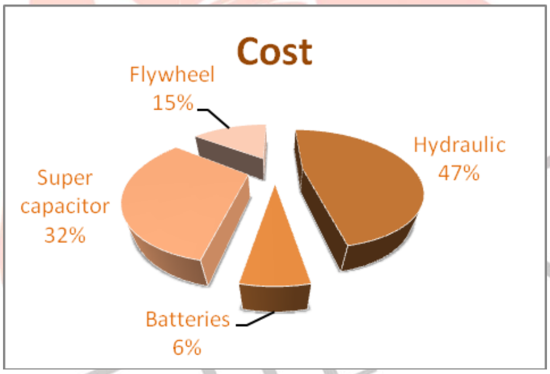

Fig. 8 Cost comparison of different KERS

IV. CONCLUSION

The formation for the KERS of any vehicle can be proven into the advancement of the modern technology. The use of the technology for enhancing the efficiency of the already existing devices can be proven into a drastic performance improvement of the machines.

REFERENCES

[1] Sreevalsan S Menon, Sooraj M S, Sanjay Mohan, Rino Disney, Suneeth Sukumaran, "Design And Analysis Of Kinetic Energy Recovery System In Bicycles", Vol. 2, Issue 8, August 2013,International Journal of Innovative Research in Science, Engineering and Technology ISSN: 2319-8753

[2] Sameer. G. Patil, Rithwik M Singh, "Regenerative braking principle by using kinetic energy recovery system-A review", VOL-2, ISSUE-2, 2015. ISSN (PRINT): 2393-8374, (ONLINE): 2394-0697

[3] Alberto. Boretti, *"A fun-to-drive, economical and environmentally friendly mobility solution",* Journal of power technologies 93 (4) -2013

[4] Kevin Ludlum, *"Optimizing Flywheel Design for use as a Kinetic Energy Recovery System for a Bicycle", 3/6/13.*

[5] Cibulka, J. *"Kinetic energy recovery system by means of flywheel energy storage",*ADVANCED ENGINEERING-3(2009)1, ISSN 1846-5900.

[6] Pavan kumar L N, Dileepraj H M, & Dikshith M E, *"Kinetic Energy Recovery System Bicycle",* International Journal of Ignited Minds (IJIMIINDS), Volume: 01 Issue: 09,Sep-2014.

[7] U. Mugunthan, U. Nijanthan, *"Design & Fabrication of Mechanism for Recovery of Kinetic Energy in Bicycle Using Flywheel",* ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Issue 5, May 2015, International Journal of Emerging Technology and Advanced Engineering.

[8] Siddharth K. Patil, *“Regenerative Braking System in Automobiles”,* ISSN: 2249-5762 (Online), IJRMET Vol. 2, Issue 2, May - Oct 2012.
[9] Radhika Kapoor, *“Comparative Study on Various KERS”,* Proceedings of the World Congress on Engineering 2013 Vol. III, WCE 2013, July 3 - 5, 2013, London, U.K.
[10] Mayuresh Thombre, Prajyot Borkar, Mangirish Bhobe, *“Kinetic Energy Recovery System Using Spring”,* World Academy of Science, Engineering and Technology, International Journal of Mechanical, Aerospace, Industrial, Mechatronics and Manufacturing Engineering Vol:8, No:4, 2014