Kers energy recovery

ABSTRACT

In the past decade of the modern car era attempts at inducing Alternative Technology in cars had been made with some amount of success. This gave birth to cars that ran on Electric, Hybrid and Fuel cell technology. Though these cars are present in the market they have failed to make a significant difference as people still prefer gasoline fuelled cars. In 2009 FIA had introduced a row of technical changes to the sport also permitting the teams to run regenerative technology called KERS in an attempt to win back the fans interest and to prove that F1 does care about the environment. The technology already existed in hybrid cars but the primary purpose behind its introduction was to develop an efficient technology that could be transferred to road cars. All the major factory teams came equipped with KERS system but all of them struggled through the first half of the season many even avoiding it after three races due to reliability issues. The ban on testing made developments harder and time consuming. The KERS equipped cars won only three races in the entire season with the first win coming late after mid season. Even after investing huge amount of resources and money on KERS the teams failed to get the best out of the system. In this report the various KERS technologies developed by the F1 teams like electric, flywheel and electromechanical based KERS units and similar systems present in road cars along with their pros and cons are discussed in brief. Apart from the above, which system has more potential to be inducted in road cars is also discussed.

INTRODUCTION

I do agree that KERS in F1 would benefit the mainstream motor industry given the fact that one of the primary reasons behind its introduction was to facilitate a smooth transfer of the technology to road cars though substantial amount of work needs to be done. The 2009 F1 season introduced the widest range of technical rule changes the sport had witnessed for more than a decade. The one specific topic that got significant attention both from the F1 teams and the media was KERS a device which stores the waste energy produced during braking and releases it during acceleration. The rules limited the amount of energy recovery of KERS to 400kJ per lap, giving an extra 80hp for about 6. 5 seconds. The teams were allowed to apply any means with the condition that they pass the F1 safety standards. After months of research and development the teams came out with innovative ideas but it was evident that the field was divided into two types. Williams was the only team which developed a mechanical flywheel based KERS unit, though they never used it in a race while the rest of the field went for electric KERS unit. In contrast to what most people believe KERS is not a new technology in fact it has been used in a variety of applications including hybrid buses and cars. We shall now study both the systems and the improvements they can bring to the automobile industry.

KERS in F1 cars

As in any hybrid vehicle the primary factor that limits the efficiency gains over its lifetime is the recoverable energy storage system (RESS). The two most important characteristics of any RESS are specific energy and specific power. The former refers to the amount of energy per kilogram that the system can store and the latter to the rate at which energy can be put into or taken out of the system per kilogram. In the wake of preparations for the 2009 season teams had tested a range of different systems including electric, mechanical, hydraulic and even pneumatic based KERS units. After careful analysation majority of the teams concluded that the electric system would be the best option that would deliver the required amount of energy from the brakes. The norm in F1 to make things as compact and light as possible led the teams to this decision. With the rules allowing the teams only 60Kw of energy for 6. 5 seconds per lap, drivers had to be very wise with regard to using this extra power. The KERS system was primarily intended to aid the overtaking of cars but as seen throughout the season most of the KERS equipped cars lacked overall pace at the start of the season and used the KERS for better acceleration out of the corners and to defend their positions. The basic working of the kers unit in F1 cars is very similar to the ones in hybrid road cars.

ELECTRIC KERS

This system consists of three components, the mototr/generator; KERS control unit and the battery pack. The motor/generator is directly connected to the drive train. It produces electrical energy during braking and releases it back through the transmission when required. The energy captured is stored in the battery which in turn is connected to the Kers control unit that governs the release and storage of energy to and from the batteries. The motor/generators were provided by motorsport company's specialising in this field eg. Magnetti Marelli (supplied for Ferrari, Renault, Toyota, RedBull), Zytek (Mclaren) who worked closely with the teams to manufacture motor/generators tailor made to suit their design requirements. The heat generated during the charging and discharging process hampers the performance of the motors, hence the motor has an integrated liquid cooling system which weighs just 4kgs in total. The RESS unit (battery) has been developed by the teams themselves and Lithium-ion was the preferred choice. The entire system including the motor/generator, Kers control unit and the batteries weighs around 25-35 kgs with 25. 3 kgs being the lightest developed by Zytek for the Mclaren Mercedes team.

ADVANTAGES OF ELECTRIC KERS

- The electric systems allow the teams to be more flexible in terms of placing the various components around the car which helps for better weight distribution which is of vital importance in F1.
- The specific energy of Lithium-ion batteries in comparison is unrivalled as they can store considerably more energy per kg which helps reduce the size of RESS.

DISADVANTAGES OF ELECTRIC KERS

- Lithium-ion batteries take 1-2 hours to charge completely due to low specific power (i. e rate to charge or discharge) hence in high performance F1 cars more batteries are required which increases the overall weight of the batteries.
- Chemical batteries heat up during charging process and this takes place a number of times in KERS units which if not kept under control could cause the batteries to lose energy over the cycle or worse even explode.

- The specific power is low as the energy needs to be converted at least two times both while charging or discharging causing energy losses in the process.

MECHANICAL KERS

This system developed by the Williams F1 team is quite similar to the electric kers system consisting of a motor/generator that is matted to the transmission, an electric control unit to govern the power released to and from the motor but instead of storing the energy in a battery a flywheel is used as RESS medium acting as an electromechanical battery. They opted for the unique solution of incorporating the motor/generator into the flywheel. The figure below designed by Williams Hybrid Power shows the internal structure of the flywheel consisting of a stator mounted in the outer walls of the casing. The permanent magnets of the motor are incorporated into the composite structure of the flywheel itself thus making the flywheel magnetically loaded. This reduces the overall size and weight of the system leading to a compact structure.

The motor/generator is wound with fibre to keep the arrangement intact at high speeds. The fibre is embedded with metal particles which allow it to be magnetised as a permanent magnet. This substantially reduces the eddy current losses of the machine as there are no additional metals in the arrangement. When it spins, it can induce a current in the stator or be spun like a motor by a current through the stator. In order to achieve high specific power the flywheel is spun at speeds in excess of 50000 rpm which is possible in a vaccum.

The challenge here was to allow the transfer of energy without letting any external air from entering the vaccum. This resulted in a highly efficient system whose temperatures could be kept under control in an easy manner without affecting the performance and operational life span. The result is a compact and efficient mechanism that can be packaged easily in the car.

There was another similar system developed by Flybrid Systems LLP which had also designed a flywheel based KERS system but with a different design theory. As mentioned by J. Hilton the flywheel was made out of carbon filament wrapped around a steel hub and weighed around 5kgs. The flywheel was matted to the transmission of the car via a several fixed ratios, a clutch and CVT that was patented by Torotrak. The CVT consisted of input and output discs which were formed so that the toroidal surfaces on each disc formed the toroidal cavity. Inside each cavity there were two or three rollers in contact with the torroidal surfaces of both the input and the output shaft. When the roller is at a small radius (near the centre) on the input disc and at a large radius (near the edge) on the output disc the CVT produces a " low" ratio. Similarly a " high" ratio is produced when the rollers are moved in the opposite manner across the discs described in detail in. As highlighted in and CVT plays a vital role in the overall performance of the system without which the flywheels full potential is hard to extract. The transfer of power through the discs and rollers takes place via specially developed traction fluid. This fluid separates the rolling surfaces of the discs and rollers at their contact points. The input and output discs are clamped which results in an efficient mechanism for transferring power between the rotating discs and rollers. In order to maintain high efficiency the flywheel rotates at 60000 rpm in vaccum. The system was well capable of storing the required 60Kw of power as demanded by the teams. The total weight of the system was 25kgs consisting of both the CVT and flywheel which is the same weight as the lightest electric system.

ADVANTAGES OF MEACHANICAL KERS

- The specific power of flywheels in comparison is much greater than that of batteries.
- The energy lost during transfers amongst the system components is relatively less due to high efficiency.
- The flywheel system can deliver almost the entire amount of energy stored in it, repeatedly without any decline in efficiency.
- The mechanical system does not need to be replaced as its life cycle is as good as that of the car.

DISADVANTAGES OF MECHANICAL KERS

- The specific energy capacity of flywheels is lower than some of the advanced battery models.
- Friction produced in the bearings and seals cause the flywheel to slow down and loose energy.

KERS TECHNOLOGY USED IN ROAD CARS

Both the Electric and Mechanical KERS developed in F1 are not new to the automobile industry. Electric hybrid cars such as Toyota Prius(1997 Japenese market), Honda Civic Hybrid(2002), Ford Escape Hybrid(2005) did quite well since their introduction in the market especially the Prius. Flywheels on the other hand were introduced in transport buses in Sverdon, Switzerland

(1950) and also in small electric locomotives for shunting purposes. The reason why flywheels have not been used in road cars is because they were heavy and produced high gyroscopic forces which upset the handling characteristics of the car hence they were installed in heavy buses and trams as discussed in. The kers system in commercial and transport vehicles was used to accelerate the vehicle from low speeds or standstill situations were an engine utilises most amount of fuel thus giving better fuel average figures. The electric hybrid vehicles mentioned above had good emissions and fuel average though the actual figures were lower than those mentioned on paper. This was because manufacturers conducted tests in a secure environment were the battery system was tested in its ideal temperature range which in reality was not the case. They were then run on drive cycles whose figures wary from the real world numbers, thus resulting in efficiency figures that are inaccurate. The batteries used in hybrid cars are still quite heavy and due to constant charging and discharging wear out faster. Hence they have to be replaced from time to time. Due to the commerce involved in any new technology designers found it hard to gather money and resources to build such hybrid technology and thus the pace of development was slow. As car manufacturers face tougher emission norms hybrid technologies are getting more importance by the day.

CONCLUSIONS

Apart from increasing overtaking the main purpose of introducing KERS was to challenge the best engineers in the business to develop innovative ideas that would directly benefit the mainstream motor industry. Given the resources and pace of developments in F1, the Kers systems produced by the teams would have taken the car manufacturers much longer to develop. Both the types of KERS can be retrofitted in cars albeit with minor modifications. Given the current trend of engine downsizing they can add substantial amount of performance to the car without affecting the engine and average. The mechanical system is more efficient than the electrical systems that use inefficient batteries which makes them more likely to be induced in cars in the near future. The flywheels used in F1 cars were pretty powerful though they will be modified to suit real world situations which will be capable of storing 75kW and weigh about 35-40kg which compared to current battery systems is half the weight as seen in.

The carbon fibre used in F1 flywheels can be reduced in quantity for road cars where as the rest of the materials like aluminium and steel are readily available and would be cheaper to produce in volume than electric systems. Flywheels are easy to recycle where as the use of rare earth materials make batteries more expensive to recycle. The flywheels could be charged directly by the engines thus charging faster which would help cope with the road conditions better. The electric systems developed by F1 have proved there is room for improvement in this field but comparatively flywheels seem to be the better option in terms of overall performance gains and sustainability though further work needs to be done to make it road ready. Flybrid systems is currently testing with Jaguar, the Technology Strategy Board established by the British government is funding a project involving Prodrive and Flybrid to help develop the technology for road cars as mentioned in. Initially manufacturers plan to introduce it with high end models and latter on to city a car which supports the statement that F1 KERS will benefit the motor industry.

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