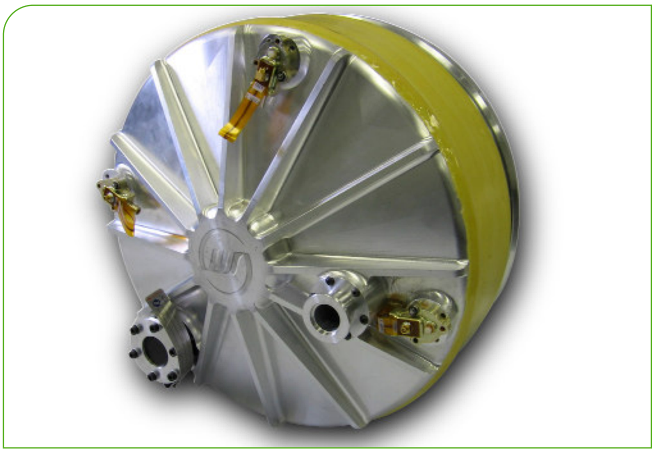
eems
energy efficient motorsport

Flywheel based kinetic energy recovery system developed for Williams F1



Company

Williams Hybrid Power

WILLIAMS HYBRIDPOWER

Key Facts

- The WHP system has a cycle life of around 10 million charge discharge cycles; far greater than the few thousand of current chemical batteries
- The WHP system allows continuous cycling with no detriment to performance or reduction in life
- The WHP system delivers specific power and power density superior to that of ultracapacitors and with significantly greater specific energy and energy density
- Specific power 3.0 kW/kg
- Specific energy 32.5 kJ/kg

Summary

Regulatory changes introduced by the governing body for international motorsport - the FIA - now permits Formula One teams to collect, retain and re-use kinetic energy that would otherwise have been wasted, as heat, under braking. The rules allow for the use of a number of technology options to store the energy, including batteries, ultracapacitors or flywheels.

Williams F1 opted for a flywheel-based Kinetic Energy Recovery System (KERS) and the flywheel energy storage element has been developed by Williams Hybrid Power (WHP). The novel, patented, electromechanical flywheel technology which WHP has successfully engineered, is now being further developed to provide a cost effective, environmentally-friendly solution for mobile or stationary energy recovery and storage applications beyond motorsport.

WHP's flywheel is electrically driven, and can be considered as an electromechanical battery. Depending on the particular application, the WHP flywheel can replace or be combined with chemical batteries and ultracapicitors.

The 2009 FIA regulations allow a KERS fitted to a Formula One car to collect and store energy during braking at a maximum rate of 60kW - the equivalent of a thousand 60W light bulbs switched on simultaneously. Up to 400kJ of this stored energy can then be re-introduced into the drivetrain each lap at a rate of up to 60kW; an increase in overall power of about 10% for 7 seconds. Drivers will have a 'boost' button allowing them to deploy this extra energy tactically during a race, for instance in order to overtake.

The Challenge

Only in the last two decades has flywheel technology been seriously considered for use in mobile applications. It was originally held back by the lack of suitably strong materials resulting in slow, heavy flywheels which exerted significant gyroscopic forces.

Test vehicles, particularly buses, were produced using mechanical flywheel systems with a continuously variable transmission (CVT) to transfer power to and from the flywheel.

Advances in carbon fibre composite technology have improved the flywheel strength and as a result the maximum rpm which can be reached. Housing the flywheel in a vacuum further increased performance but presented difficulties because the machincal linkage necessitated a high speed seal.

Electrically-driven flywheels where the rotor of the motor/generator is integrated into the flywheel itself solved the seal challenge by fully containing all moving parts within the vacuum enclosure.

The development of durable, high-performance hybrid ceramic bearings allowed the high speed carbon fibre flywheels to be adapted for use in the more demanding mobile environment.

Despite these improvements, mobile flywheels were still relatively heavy and bulky due to containment requirements and could not be continuously cycled.

> ***"The world's scarce energy resources are being depleted at an increasing rate. As a result, humankind is faced with three immense challenges: a changing climate, fragile energy security and the need for a rapid transition to the use of sustainable energy sources. Technologies exist which can mitigate these issues; however greater effort is needed to shorten development times. Williams Hybrid Power's flywheel energy storage system is one such technology and we are committed to bringing it to market as quickly as possible using the intensely focused development environment of Formula One."***
>
> Ian Foley
> Williams Hybrid Power

The Solution

WHP took these advances and the electrically powered integral motor flywheel design and radically improved its performance characteristics by incorporating Magnetically Loaded Composite (MLC) technology.

The MLC technology, which was developed in the nuclear industry by Urenco, incorporates the permanent magnets of the integral motor/generator into the composite structure of the flywheel itself by mixing magnetic powder into the resin matrix. This allows for the production of a wholly composite flywheel.

The key benefits that MLC technology brings are that the flywheel system can be made significantly smaller and lighter than conventional flywheels, very high efficiencies are possible and the flywheel can be continuously cycled with no impact on life or performance.

These characteristics make WHP’s flywheel system highly suitable for a plethora of mobile applications including one of the most technically demanding and competitive forms of motorsport - Formula One.

Lessons Learnt

WHP's development of the flywheel system for the demanding environment of a Formula One car has presented numerous challenges including the substantial weight and packaging constraints; the extreme vibration and shock loads a system must withstand; and above all the need for it to be completely safe even in the event of a high speed crash.

The permanent magnets of the WHP flywheel's integral motor are incorporated into the composite structure of the flywheel itself. In the event of a burst failure, the containment has to withstand only the crushing force of the composite material, which is less than the load of discrete metallic fragments. The reduced containment requirements minimize the overall weight of the system. The magnetic particles in the composite are magnetised after the rotor is manufactured which means that it can be magnetised as a Halbach Array; avoiding the need for backing iron to direct the magnetic flux.

As the magnets in an MLC system are comprised of tiny particles and there is no additional metal in the structure, the eddy current losses of the machine are significantly reduced. This can result in one-way efficiencies of up to 99%. The ultra-high efficiency means thermal management of the system is easier and it can be continuously cycled with no detriment to performance or reduction in life.

In addressing these challenges, WHP has accrued world-class skills in this field as well as advancing the development of electrically driven MLC flywheel systems. This puts it in an excellent position to apply the technology and its capabilities to applications beyond motorsport.

Benefits

Flywheels have the potential to become a cost-effective, environmentally friendly high-power energy storage medium that can be used to replace or complement other technologies in a variety of applications from hybrid cars to wind turbines. The development of energy storage technologies is a vital element in the transition to a more efficient and sustainable world.

WHP has benefited from choosing to initially develop the flywheel technology to improve energy efficiency in motorsport. The fast paced and competitive industry has proved to be an excellent environment in which such technologies can be rapidly advanced towards broader market readiness.

The Future

WHP believes that projects which improve the energy efficiency in motorsport have the potential to deliver much wider, positive effects to other industries and help address the global need for increased energy efficiency in all areas. WHP's flywheel technology alone is already being assessed by companies in a variety of industries for used in various applications including passenger vehicles; buses; ships; mass transit and rail systems; and renewable energy generation and distribution.

Further information

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Energy Efficient Motorsport Programme

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