A suspension revolution in Formula I Motorsport

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A Cambridge academic equipped with no more than a pencil and paper invented a completely new suspension component which led to a unique story featuring code names, Formula 1 victories and claims of industrial espionage.

Following global internet speculation as to the nature of the device and an eventual ruling in favour of the legality of the invention by the

Formula 1 motorsport industry's ruling body, the Inerter is now used across Formula 1, IndyCar racing and a number of other branches of motorsport with potential application far beyond the racing track.

Turning back the clock to 1991, Professor Malcolm Smith was a newly appointed lecturer at the Department of Engineering. One of his research projects involved looking at active suspensions systems and how these could be utilised to obtain increased performance in grip and handling in Formula 1 motorsport. Suspension design is a critical area in differentiating the performance of one Formula 1 team from another and the quest for competitive advantage in this high-profile sport is unrelenting.

In 1994, a decision by the sport's governing body to ban active suspension systems led Professor Smith to focus on the development of passive suspension systems based on the analogy between electrical and mechanical circuits.

Using established principles in electrical circuits, a network of resistors, inductors and capacitors is necessary to create the most general passive circuit. At the time, mechanical suspension systems comprised of springs which corresponded to inductors, and dampers which corresponded to resistors. The analogy falls down somewhat with the usual third element – mass – which is not a complete analogue of a capacitor as it has only one terminal rather than the two necessary to form an exact correspondence between electrical and mechanical circuits.

Professor Smith's solution was to introduce a further element – coined the Inerter. The Inerter looks like a conventional shock absorber, with an attachment at either end and a plunger moving relative to the main body of the device. In contrast to a damper, the plunger activates a flywheel that rotates in proportion to the relative displacement between the attachment points, storing rotational energy as it spins. Working

alongside a spring and a damper, the Inerter opens the gateway to increased stability and enhanced performance on the motor racing circuit. In particular, it can be used to reduce the effect of the oscillations and increase the mechanical grip of the car.

Professor Smith was nervous about publishing his ideas at first because "it seemed so elementary a concept," he said. "It was very difficult to believe that nobody had thought of it before and I presumed that either it had been done already, or there was some sort of snag.

"As I discussed the idea with colleagues, however, I began to realise that it hadn't been done and it was possible to achieve this trade-off to improve vehicle suspension."

Initially Professor Smith took his invention to his associates at McLaren. Working through Cambridge Enterprise, the University's commercialisation arm, a joint development agreement was negotiated which granted McLaren exclusive rights to use the device in its Formula 1 cars for a limited period of time. The McLaren team, with Professor Smith working as a consultant, was able to develop and test the device to a stage where a clear lap-time advantage was demonstrated.

The Inerter's first public outing was at the 2005 Spanish Grand Prix where Kimi Raikkonen's MP4-20 car used the device in its suspension system – and drove all the way to victory. This was followed by McLaren triumphs in 10 of the remaining 15 races of the season. McLaren continued to test and develop the Inerter over the coming seasons, carefully protecting the identity and precise nature of the component in order to maintain a competitive edge over its competitors. Only a small number of the McLaren team knew the exact composition and effect of the Inerter and the subterfuge was stepped up by ascribing the decoy name 'J-damper' to the new invention – the device of course was not a damper at all, but the intention in naming it thus was to keep

the technology secret from its competitors for as long as possible.

In spite of all attempts to conceal details of the new invention, drawings of the Inerter fell into the hands of the Renault engineering team and McLaren subsequently brought a spying case against Renault which was upheld by the sport's governing body – the Fédération Internationale de l'Automobile (FIA). It is a testament to the subtle nature of the invention that although Renault were found to be in breach of the sporting code, no penalty was issued with the reasoning that 'Renault fundamentally misunderstood the operation of the system' even after having access to the drawings.

After the 2007 trial, speculation as to the exact nature of the device gathered pace, with theories abounding on Internet sites and in motoring magazines. During the trial, neither McLaren nor the FIA divulged details of the Inerter, allowing Professor Smith to continue and publish his research and McLaren to continue its own testing and development. However, in 2008, a motor sports correspondent from Autosport magazine uncovered the Cambridge connection and the fact that the so called 'J-damper' was in fact the Inerter. The way had opened up for the wider racing community to understand and benefit from the true nature of the Inerter and its potential to motor racing across Formula 1 and beyond.

The exclusivity agreement with McLaren was allowed to lapse and, in signing a deal with the US firm Penske Racing Shocks, the future of the Inerter as a vital element in Formula 1 motor racing was assured. Penske was granted a non-exclusive license to design, develop and produce generic and team specific Inerter designs, as well as future embodiments and enhancements. Shortly after the deal with Penske was agreed, a ruling was made that the use of Inerters was also permitted in the lucrative IndyCar racing market and now the majority of IndyCar teams also use the devices.

In the words of Paddy Lowe, former Technical Director at McLaren Racing and now with Mercedes Grand Prix: "The Inerter … (is) now of equal rank to the spring and the damper in our constant search for higher levels of grip and stability." Considering that the invention of the coiled spring was patented back in 1763 and that both springs and dampers have been used for well over 100 years in the suspension of motor vehicles, it is clear that Professor Smith's invention is in very good company.

Pulling back from the mad, fast world of motor racing, Malcolm Smith, now Professor of Control Engineering in the Department of Engineering, is looking ahead to a number of diverse areas in which his Inerter might be found.

"The Inerter is being researched for application in other fields beyond motorsport," he said.

"Other areas of the automotive sector could benefit – for example, heavy goods vehicles There is also the potential for a reduction in track wear for railway vehicles with suspensions incorporating Inerters. New potential application areas are being thought of with some regularity – helicopters, motorcycles, machine tools … even tall buildings could benefit from the use of Inerters."

More information: "The Inerter Concept and Its Application." www-control.eng.cam.ac.uk/fosw … mSmith/lecture_j.pdf

Provided by University of Cambridge