AN INTRODUCTION TO FREEVALVE TECHNOLOGY

The Freevalve concept, also known as fully variable valve actuation, offers the unique ability to have independent control of the intake and exhaust valves in an ICE. For any engine load criteria, the timing of intake and exhaust can be independently programmed. The system can then "decide" based on driving conditions which one to use to maximize performance or minimize fuel consumption and emissions. This allows more precise control over the engine which in turn provides significant performance benefits.

Freevalve uses electro-hydraulicpneumatic actuators combined with patented advanced sensor techniques. As a result, Freevalve has overcome all the typical challenges faced by other cam-less technologies.

As an example of the impact of the Freevalve technology, the Qoros "Qamfree" engine was fitted to a Qoros 3 hatchback shown at the Guangzhou Motor Show in November 2016. The engine shown at Guangzhou was a 1.6 litre turbocharged Qoros engine modified using Freevalve technology to produce 230 horsepower and 320Nm of torque. This represents a 47% increase in power, a 45% increase in torque and a 15% reduction in fuel consumption when compared to a traditional camshaft engine with similar specifications.

IMPROVED PERFORMANCE

Freevalve's technology allows full control of the combustion cycle. No other variable valve actuation system offers this level of control and reliability. Both intake and exhaust valves can be opened and closed at any desired crankshaft angle. This flexibility enables an engine to deliver lower fuel consumption and emission numbers, while still delivering increased torque and horsepower.

Freevalve allows for optimal valve times for volumetric efficiency at all RPMs, plus

- Use of intake runner inertia at all RPMs
- With Divided Exhaust Ports - 100 % scavenging of residuals is possible at all speeds and loads
- Increasing volumetric efficiency
- Reducing, or eliminating, knock even with high compression ratios
- At low RPMs, dual intake valve openings provide maximum intake runner inertia with low temperature increase effectively increasing volumetric efficiency up to 30 %
- Allows for cold start down to minus 30-degree C on pure alcohol fuels like Methanol and Ethanol, without the need for petrol support or other add on solutions
- Allows for heavy duty diesel engines in trucks and buses to run without exhaust brake as the valve timing can be tuned to do this task as well
- Allow for Turbo application without wastegate as turbo control can be done with separate exhaust valve ports
- Allow for 2-stroke operation at lower rpms in boosted applications
- Allow for multi flex fuel operation to a degree not seen before

FUEL CONSUMPTION REDUCTION

Freevalve has developed technology to reduce fuel consumption in several ways:

1. Improve engine efficiency at part load, using the Free Valve Technology system to eliminate the throttle and introduce cylinder deactivation with a method called Frequency Modulated Torque. With the DEP or HEGR engine concepts engine compression can be increased without knock problems. Increased EGR rates in both concepts will reduce heat losses while improving the combustion process.

2. The Pneumatic Hybrid provides an inexpensive and reliable solution to eliminate Standby/Idle losses (17.2%) and regenerate braking energy (almost half of the energy used in city driving) with good efficiency. This solution basically provides the same benefits as an electric hybrid, such as the Toyota Prius and Honda Insight, but without the extra cost, weight, and complexity of battery packs and electric motors.

3. The Steam Hybrid provides a means to eliminate the normal cooling system, recycle exhaust waste heat, and introduce a work-generating internal cooling cycle, further reducing engine losses. This can be realized using existing engine hardware for compact and cost-effective implementation.

COMPACTNESS

Implementation of the Freevalve system leads to a much more compact total engine package because many of the parts used in a traditional camshaft-based engine are no longer necessary. With Freevalve, OEM´s can do away with expensive parts such as the throttle body, camshaft, cam drive, timing gear and cover, wastegate, pre-catalytic converter systems and direct injection systems.

On a typical vertically positioned engine, Freevalve will reduce build height and improve pedestrian impact safety. On boxer engines, the width of the engine will be reduced dramatically. Our work with Qoros on their 1.6 litre turbocharged engine resulted in a reduction of 50mm in height and 70mm in depth.

Reduced weight and less valvetrain losses are also important benefits of the Freevalve system. Our Qoros engine is 20kg lighter after the change to Freevalve technology.

Q&A

How does Freevalve's System compare to camshafts concerning valvetrain energy consumption?

A camshaft generally consumes less energy to run/drive than a cam-less system, but a cam-less system has many ways of offsetting this on a system level. The Freevalve technology does this particularly at part load with improved combustion and pumping efficiency. In tests and simulations this have resulted in fuel consumption savings from around 5 % up to 15 %. At the same time a cam-less system allows fever valves in operation in part load per cylinder and cylinder deactivation with even fewer valves moving. This in turn also means that the total valve train energy consumption - during average operation, in a passenger car, will be less than a camshaft equivalent solution.

How does the Freevalve system's cost compare to a variable valve system?

Initially, the Freevalve system will be more expensive, but with increased manufacturing volumes, there will be the potential to match the cost of conventional valvetrain systems.

For Gasoline engines, the cost increase will be less than the cost difference to a Diesel engine, while providing Diesel-like fuel consumption.

A spark ignited Freevalve will have lower cost for catalysts than normal spark-ignited engines since a pre-cat can be eliminated.

The cost of aftertreatment system compared to a Diesel engine more than compensates for the increased cost of the Freevalve system.

How does the Freevalve system's cost compare to technology offering similar fuel consumption and CO_2 reductions?

A spark-ignited engine with the Freevalve System will cost less than a diesel engine while having equal performance, similar fuel consumption, as well as CO_2 emissions.

The Freevalve equipped engine will have substantially lower cost than electric hybrid offerings.

What level of control of the valves does the Freevalve system offer?

The Freevalve System offers full control of both valve timing and lift.

How does the system know the position of the valves?

The Freevalve System utilizes proprietary valve position sensors, which allow the controller to know the valve position to within 1/10 of a millimeter in real time.

What happens if one or more actuators fail?

If one or more actuators fail, the engine will continue to run as normal, but with slightly reduced high rpm power.

The engine will be able to provide limp-home capability even if 75% of the actuators were to fail.

To exchange an actuator at service can be compared to the work of exchanging a spark plug in complexity and amount of work. So, vastly simpler that traditional valve train work or camshaft replacement.

What happens if there is a catastrophic failure on a Freevalve equipped engine compared to a camshaft equipped engine?

If the complete system fails, the engine will simply stop running with no damage to the engine, as compared to a camshaft equipped engine which will be badly damaged or destroyed if a belt or chain breaks.

How durable are the actuators?

Freevalve actuators will have a lifetime durability in line with that of a modern engine, which means nearly a billion cycles for the most demanding commercial applications. Current endurance testing shows no measurable wear after many million cycles.