

FREEVALVE

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 a greater degree of control over the engine which in turn provides significant performance benefits.

While the fully variable valve actuation concept has been widely tested, no manufacturer has been able to implement it in large scale production due to various technical problems along with packaging disadvantages and higher cost.

Previous fully variable valve actuation engines use either electro-magnetic or electro-hydraulic to open the poppet valves. Instead of using these actuator types, FreeValve uses electro-hydraulic-pneumatic actuators combined with advanced sensor techniques. As a result, FreeValve has overcome all of the typical challenges faced by other Free Valve techniques.

In 2016, FreeValve technology was shown in production form via a partnership with Qoros Automotive, from China. The Qoros “Qamfree” engine was fitted to a Qoros 3 hatchback shown at the Ghuanzhou 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 provides maximum intake runner inertia with low temperature increase effectively increasing volumetric efficiency up to 30 %

FUEL CONSUMPTION REDUCTION

The Internal Combustion Engine has been around for more than one hundred years. No other technology has received so much attention. It has been thoroughly questioned and subjected to

massive research and invention. Could such a mature technology really have significant potential for further improvement?

We believe that internal combustion engine efficiency will improve more in the next ten years than the previous one hundred. The main contributing factor will be the development of advanced electronic control systems and actuators.

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, manufacturers are able to 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?

During normal driving, the Freevalve System typically consumes 10% less energy than a conventional valvetrain arrangement.

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 Co2 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 Co2 consumption. 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.

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 have a lifetime equal to that of a modern engine. Freevalve actuators have been tested in extreme conditions for hundreds of millions of cycles with no measurable wear.