ICE MOTOR

Innovative & Creative Engineering

CVAC©

CONTINUOUS

VARIABLE

AXIAL

CAM

Mechanical fully and continuously variable camshaft

Continuous Variable Axial Cam (CVAC) is the first fully variable mechanical camshaft technology that improves internal combustion engines performance, economy and reduces emissions.

CVAC innovative camshaft can fully and continually vary the lobe shape on intake and exhaust valves of each cylinder independently. As cams' lobe shape is variable, it can alter the valves openings in duration, phase, lift and foremost in lift shape. The lobe doesn't need to follow the traditional egg-shaped cams.

Engines Manufacturers can design their own cams to fulfill their variability needs with minimal design constrains.

- First Fully variable and Fully mechanical solution
- Compatible with any type of reciprocating internal combustion engine
- Free Cam design

CVAC has unparallel capabilities to any other mechanical VVT

CVAC Solution

The CVAC technology is composed by two camshafts, one for intake and other for exhaust valves similar to a Dual Overhead Camshaft (DOHC). The cams are designed to have the desired lobe shapes for each optimum valve opening/closing settings in a 3D surface.

Intake and exhaust cams can have its own design optimized for each function. Each camshaft can independently vary the cam configuration of each cylinder by setting each positioner independently.

CVAC has mostly the same variability capability as the state of the art Electro pneumatic Camless solution. Thus, CVAC and Camless have similar capabilities and it is expected that CVAC will reach around 15% fuel consumption reduction and more than 40% on power and torque gains, as Camless systems.

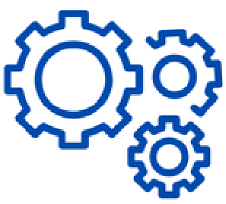
As CVAV is a mechanical solution, there no limitation on valve mass and also being being Desmodrinic there is no RPMs limitation. The cam rotation is done as a standard camshaft using a belt or chain reducing the catastrophic failure possibilities. Furthermore, it’s simpler to produce and maintain.

Each CVAC cam actuates on all valves (Intake or Exhaust) of each cylinder at the same time and can handle 1, 2 or 3 valves per cam. This reduces the complexity of a 5 valves per cylinder engines to only adding one valve to a typical two intake valves CVAC cylinder head.

CVAC has unparallel capabilities to any other mechanical VVT and will help to design Euro 7 engines, with minimal emissions but retaining performance capabilities.

- Can combine different cycles (Otto, Atkinson, Miller and others)
- Cylinder and valves independent variability
- Cylinder deactivation by compressing or blowing air
- Desmodronic
- 15% fuel consumption reduction (expected)
- 40+% on power and torque gains (expected)

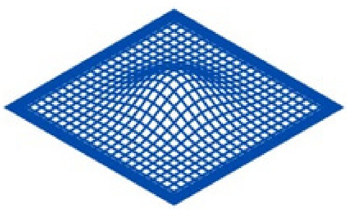
CVAC fully mechanical solution



As all mechanical camshafts, CVAC uses cams and followers. The timing variability is achieved by selecting different cam lobes using an electromagnetic positioner. The lobes shapes are limited to a continuous path on where the follower is able to mechanically follow the cam surface. Considering this limitation, the lobes can be designed with the desired slope, lift, phase and duration. The lobes do not need to follow the standard egg-shaped cams.

As the functionality of the camshaft is to open and close valves, typically the most effective way is a trapezoidal shape with rounded edges to allow the follower to be easily moved by the cam. CVAC doesn’t have this limitation and other shapes could be used. This greatly broadens the cams design possibilities and expands their options to optimize the engine output.

CVAC 3D Cam

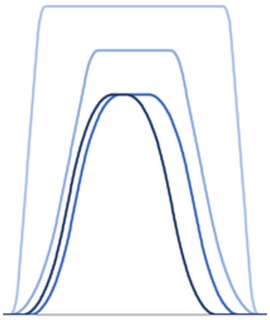


The solution uses an axial cam that is 3D shaped to have a variety of different lobes to be used at different RPMs and loads, as per engine designer needs. Each of these lobes can be selected by an electromagnetic positioner controlled by the engine’s ECU.

CVAC gives the engine manufacturer freedom to design the optimum valves timings at all engine rates. As a fully mechanical solution, the only design limitation is that the cam shape has to have smooth variations or edges to easily move the follower.

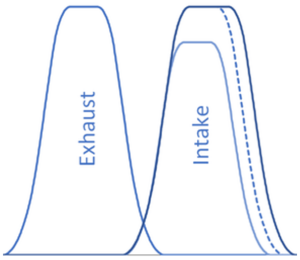
Engine manufacturers can freely design CVAC 3D Cam lobes to fulfill their needs

Lobe Flexibility



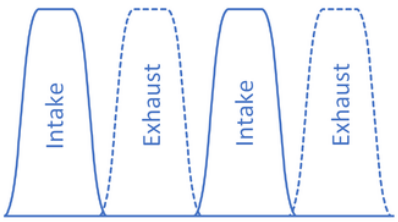
CVAC cam lobes are designed as a continuous variable 3D shape with minimum design constrains. As all mechanical cam and follower camshaft, each lobe shall be a continuous surface with rounded edges.
In the CVAC cam example it can be observed (from the darker to brighter cam diagram): (1) a standard camshaft lobe, (2) the same shape with added duration and shifted some degrees, (3) lobe with extra lift, duration and sharpened top edges and (4) a performance lobe with full lift, maximum opening velocity (lifting slope) and aggressive valve landing.
This design can apply to the intake cam and a completely different design can be used for the exhaust cam.

Lobe Flexibility



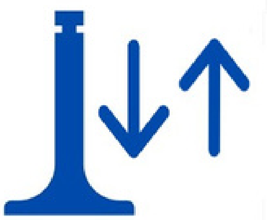
The CVAC can combine Otto cycle with other ones. The Otto cycle has similar lobe shapes for exhaust and intake valves. To achieve a consumption reduction, Atkinson or Miller cycles can be used by modifying the intake lobe (dashed line). On an Atkinson cycle (darker line) the intake valve is left open at some more degrees (a little more time), increasing the duration and center of the lobe. For Miller cycle (brighter line), the intake lobe with less duration and lift with a shifted center.

Cylinder deactivation



CVAC can deactivate cylinders to reduce the consumption at lower RPMs and loads. This can be done in the classic way, closing the intake and exhaust valves in all four strokes. But CVAC can also deactivate them by alternately opening the intake and exhaust valves. The advantage of this extra CVAC deactivation capability is that the deactivated cylinder can be used as a blower and not lose energy to compress air that will not be used to produce energy.

Cylinder deactivation



The CVAC works in a Desmodronic style (the cam pushes the valves down and pulls them up), and thus it doesn't require a return spring. This feature allows high revving cams without valves floating issue (when the closing springs cannot follow the cam). Nowadays, this issue is solved with high force or pneumatic springs, but a Desmodronic cam requires less energy as it doesn't have to compress the return springs, reducing the engine losses. Also, it allows a smooth landing of the valve on its seat even using big rates of lifts or angle, eliminating the valve seat worn or damage.

Cylinder deactivation

CVAC cam design is similar to a traditional Double Over Head Cam (DOHC). Uses traditional timing belts or chains. Aside of the CVAC camshaft, the only additional component to be added to a traditional non variable camshaft is a positioner per cylinder and cam.
The CVAC has a simple design compared with different Variable Valve Actuator available on the market. The only complex component are the 3D cams, but they can be shaped with a standard CNC machine.

Current CVAC camshaft requires a valve head with a similar shape and dimension to the standard ones. The Desmodronic solution allow shortened valves with up to 50% of standard lengths. This allows further CVAC deigns to reduce the valves head height.

CVAC Gasoline

CVAC Cam can be designed to optimize gasoline engines for any needs. As the lobe design does not need to follow the traditional egg-shape ones used in standard and variable camshafts, new valves opening and closing diagrams can be used.

Some examples of variability will be shown, mostly using the current lobe designs, but better ones will surely be designed in the future thanks to CVAC-free lobe design.

Idle & very low load needs

At idle, some cylinders will be deactivated setting the CVAC in a blower lobe. This will drastically lower the engine power losses, allowing the rest of the cylinders to make the enough power to idle the engine. These working cylinders could use an Atkinson or Miller cycle to lower the consumption.

Low load & low RPMs

At low load & low RPMs, the CVAC will be use either Atkinson or Miller lobe cycles. As a continuously variable solution, Atkinson duration or Miller duration and lift can be varied to optimize fuel consumption and emissions.

High load & low RPMs

At high load & low RPMs, the CVAC will use Otto cycle with high lift and an early intake valve closing (low duration) to optimize the volumetric efficiency.

Low load & med to high RPMs

At low load & medium or high RPMs, the CVAC will use an Otto Cycle but with medium lift to optimize the combustion.

Medium load & medium RPMs

At medium load and half revs, the CVAC will use the Otto cycle with the selection of lift, duration and optimum intake and exhaust valve overlap, to be in the optimum position for torque and consumption.

Maximum Performance

When maximum performance is needed, at high loads and RPMs, the CVAC will use Otto cycle with maximum lift and optimum intake and exhaust valves overlap to maximize the torque and power delivery.

CVAC Bi-Fuel

Bi-fuel engines are capable of running on two fuels. The most common bi-fuel engines are able to run on one fuel at a time, usually gasoline with another fuel such as natural gas (CNG), LPG or hydrogen. The CVAC solution can be used, allowing the described CVAC Gasoline or CVAC Diesel benefits depending on the ignition type and the following solutions can also be added.

Runs one fuel at a time

This Bi-fuel engine type is predominantly an Otto cycle, using one fuel at a time. To allow the engine to run optimally on each fuel, CVAC lobes can be designed having an optimum gasoline lobes section and the other part of the cam with the other fuel optimum lobes.

Runs both fuels at the same time

This Bi-fuel engine type predominantly uses diesel and natural gas fuels. Both fuels are used at the same time, since the natural gas cannot be ignited by compression (at least in a standard diesel engine) and diesel fuel is used to ignite the natural gas. The problem of these engines is that the combustion requires sophisticated control of engine parameters in order to maintain acceptable emissions levels while operating at high combustion efficiency. CVAC will allow the fine tuning of valves openings, optimizing consumption and emissions.

Mechanical variable solution that's applicable to any transportation vehicle

CVAC Diesel

Variable Valve Actuation (VVA) on Diesel engines has not a direct impact on consumption or performance as in a gasoline engine. But this doesn't mean that they are not used on diesel engines and they allow different solutions for lowering engine consumption and emissions.

CVAC free lobes design allows to different optimization capabilities in the same camshaft.

Miller Cycle

On low loads and RPMs the use of Miller cycle, instead of the classical diesel one, will allow a consumption and emissions reduction. CVAC allows late or early intake valve closings for control of effective compression ratio for Miller cycle. The valve closing point can be varied to optimize the Miller cycle on various RPMs and engine loads.

Engine Temperature Management

During low engine load operation may result in exhaust temperatures between 100°C and 250°C, where NOx aftertreatment systems are not effective. The use of CVAC to vary the air-excess ratio in the cylinder is a fuel efficient method to increase exhaust temperature under low load conditions.

Internal EGR

An exhaust gas recirculation (EGR) valve is used on most of modern engines. The EGR system is used to reduce the NOx produced by the engine while the after treatment system converts most of the engine-out emissions into safer gases before releasing them into the atmosphere, but it is required to be used at a minimum temperature before it is effective. CVAC can be used to allow negative valve overlap (NVO) as form of internal EGR, where exhaust gas is trapped inside the cylinder. NVO strategies consist of a combination of early exhaust valve closing (EVC) and late intake valve opening (IVO).

Cylinder Deactivation

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Engine braking

Engine braking is a base capability of a Truck diesel engine. It is usually done by using an exhaust valve to increase engine braking force. Using Variable Valve Actuation (VVA) solutions increase the engine braking power. Current VVA pneumatic solutions restrict exhaust valves lobes by lowering lift and duration. There are a couple of solutions that also restrict the intake lobes. CVAC solution, gets rid of egg-shaped cam lobes (of the current pneumatic solutions) and allows different lobes designs for any engine RPMs, allowing maximum braking power in any engine speed.

- Gasoline motorbikes
- Gasoline & Diesel Passenger Cars
- Gasoline & Diesel light trucks
- Diesel Trucks & heavy machinery
- Gasoline Outboard Marine
- Diesel Marine

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