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EDITION 23

Cylinder Disconnect technology

IN THIS ISSUE

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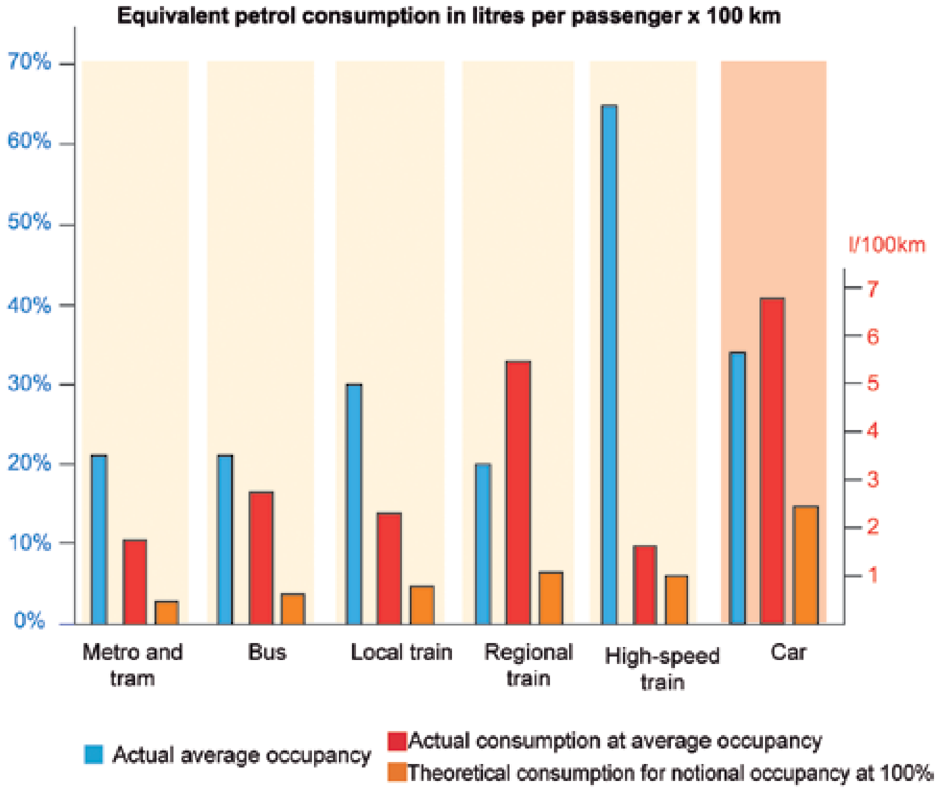
INTRODUCTION

At a moment during 2010, the number of cars on the road exceeded 1 billion units and it is calculated that, with production around 100 million units per year, this figure will be approximately 1.8 billion in 2035.

The car is the land transport means with greatest energy consumption per person and kilometre for actual and maximum occupancy rates. It is, therefore, the most inefficient and the most costly, both for the user and for society, and it also emits the highest levels of emissions to the atmosphere.



As regards the greenhouse effect and global warming, vehicles with lower capacity and driven by combustion engines produce the highest quantities of CO2 per passenger. Passenger cars are particularly to blame for this due to their high mass-performance ratio.

Emissions of polluting substances have, over recent years, become a public health problem that the authorities in different countries are attempting to solve by means of increasingly restrictive approval standards, more demanding periodic vehicle inspections and renewal policies for vehicles on the road.

The recent inclusion of limit values for CO2 emissions in the approval standards has necessitated the technical evolution of engines and the development of new technologies for the reduction of fuel consumption and, consequently, emissions. Innovations such as Start & Stop, electronically controlled hydraulic systems and smart alternators reduce the work and the subsidiary loads of the engine in order to increase its efficiency.

Thermal management of the engine and heat loss reduction is one of the most evolved features in recent times.

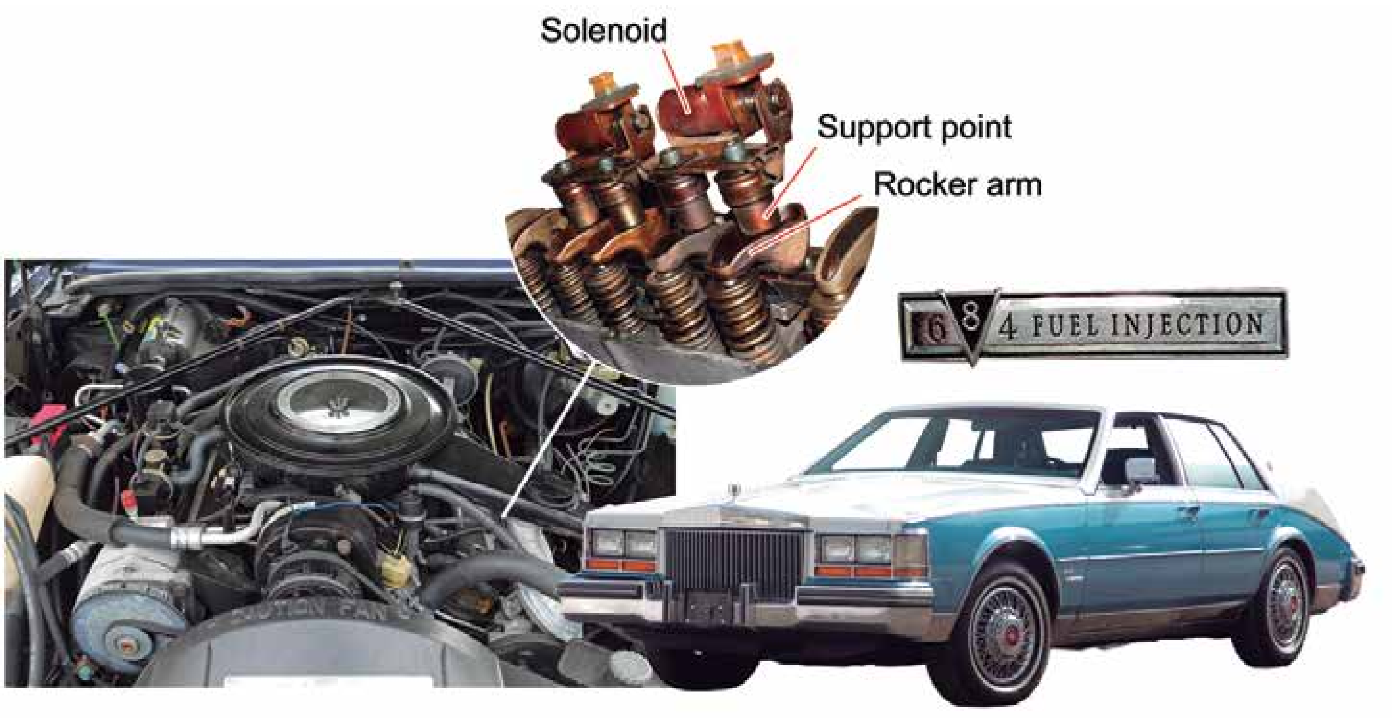
Selective cylinder deactivation is one of the measures adopted by manufacturers to further reduce emissions and consumption of their engines. It consists of disabling one or more engine cylinders in certain operating situations and increasing the work of the remaining cylinders, in order to make better use of the energy contained in the fuel. The deactivation of the cylinders reduces thermal losses at the same time as it improves the conversion of the combustion pressure into torque when the required power is low, a very common situation during urban journeys and extra-urban journeys at a moderate sustained speed.

Although the widespread implementation of this technology is relatively recent, the idea of selective cylinder deactivation has now been in development for several years and marketed by several brands under different names. For example, there is the ACT (Active Cylinder Technology) system from Volkswagen, and the ZAS (Zylinderabschaltung - cylinder active control system) from Mercedes, fitted in the V8 and V12 engines from the beginning of the century.

ORIGIN AND DEVELOPMENT OF CYLINDER DEACTIVATION

In the summer of 1967, the military expansion along the border area with Israel by neighbouring countries and the blocking of the Straits of Tiran by the Egyptian army culminated in the Israeli air strike on the Syrian and Egyptian forces which started the military conflict known as the "Six-Day War". The commercial consequences of this war led to the **1973 oil crisis**, when the Organisation of Arab Petroleum Exporting Countries decided not to export more petroleum to countries that had supported Israel during the conflict. This measure included the US and its allies in Western Europe.

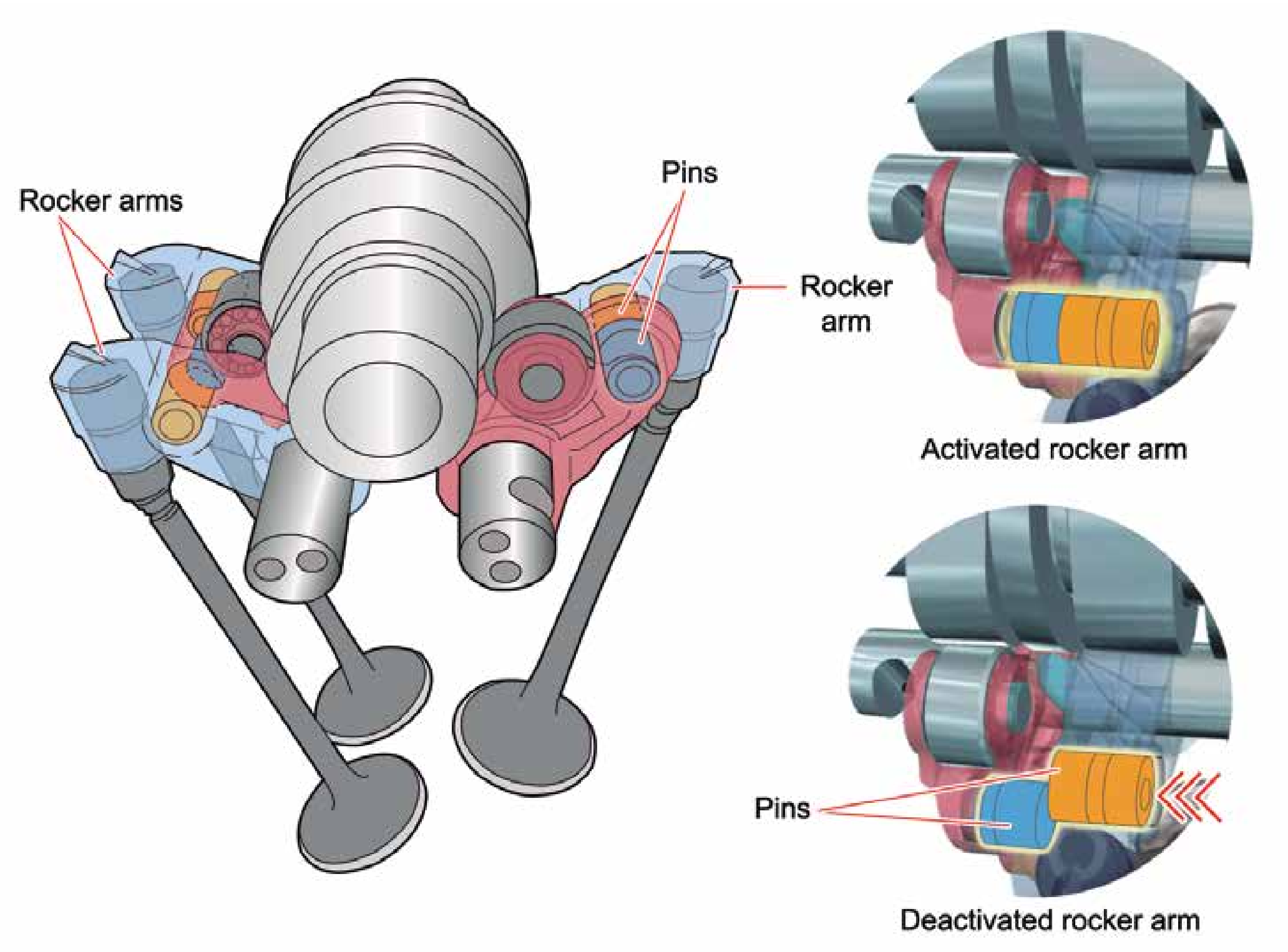
The price increase of this raw material and the high dependency of industry on it had a strong economic impact on those countries, which led to both companies and individuals having to save energy. In 1975 the United States, as an institutional response along the same line within the CAFE (Corporate Average Fuel Economy) programme, implemented new approval standards in the automotive sector that forced a reduction in car and engines size in order to achieve maximum fuel consumption of 9 litres for every 100 km travelled. Faced with this need to reduce fuel consumption, the American company **General Motors** in collaboration with the **Eaton Corporation** developed, launched and marketed the first vehicle with a cylinder deactivation system in 1981.



The vehicle in question was a **Cadillac Eldorado** equipped with an **evolved L62 engine called V8-6-4** that, according to the requested load, could work on 4, 6 or 8 cylinders, only using all of them on start-up or strong acceleration. When idling and running at low rpm, the engine works with 4 cylinders, whereas at medium speed two further cylinders come into operation. To achieve this, the control unit couples or decouples the rocker arms that transmit the moment to the valves from their respective pivot points by means of solenoids. Without a pivot point, the rocker arm does not rock and does not push the valve, and when the support point is enabled, the system returns to normal operation.

This system ceased to be used just one year after its introduction to the market (120,000 units produced) due to the poor precision of the electronics responsible for its activation and low mechanical reliability, which, together with the vibrations produced, led to many after-sales complaints and it was swiftly retired from the market. Despite the poor start, after sufficient development of the electronic systems for integrated engine management, cylinder deactivation again aroused the interest of some manufacturers nearly two decades later.

In 1999, **Daimler Chrysler** was the second manufacturer to apply this concept in mass production on its CL600, S600 and CL500 models with the 6.0 litre V12 and 5.0 litre V8 DOHC engines. The V12 had two operating modes, running on 12 or 6 cylinders, whereas the V8 could run on 8 or 4. The system used for deactivating the valves differed considerably from that used in the Cadillac. Instead of using a system that disabled the rocker arm support point or pivot, Mercedes used a split rocker arm connected by means of coupling pins hydraulically controlled by solenoids.



In addition, a sequential fuel injection system is used in this engine that cuts the fuel supply to the cylinders that are mechanically "deactivated". This solution corrects another of the defects of the system used by Cadillac, which was the condensation and accumulation of fuel in the inlet lines of the deactivated cylinders that occurred in the carburettor fed V8-6-4 engine.

Over the following years, other manufacturers developed their own cylinder deactivation systems, based in all cases on keeping all the cylinder valves closed, an essential condition to avoid harmful interference in the engine exhaust and intake flows.

Initially they were applied in large-displacement, multi-cylinder naturally aspirated engines due to the intrinsic ease of maintaining a regular ignition sequence and vibration free rotation. By using pins in the rocker arms, variable length hydraulic tappets or cams that could be moved axially on the camshaft, the deactivation of several cylinders instantly reduced the effective displacement of the engines and, therefore, their consumption.

Now we can find this technology in small displacement engines with fewer cylinders such as VW's 1.4 TSI ACT engine. Its application reduces CO2 emissions in urban and interurban approval cycles, which makes it possible to develop higher performance engines. Nevertheless, a good number of additional measures are required for its proper integration and operation, as well as specific operating strategies to reduce vibration.

OPERATING PRINCIPLE

The purpose of cylinder deactivation is to reduce engine emissions during operation at low load, a working condition that is increasingly common in the daily use of passenger vehicles.

Road speed limits and the increase in vehicle performance means that the power necessary during driving, especially in urban environments or with a high traffic density, does not exceed 30% of that available for a good part of the running time.

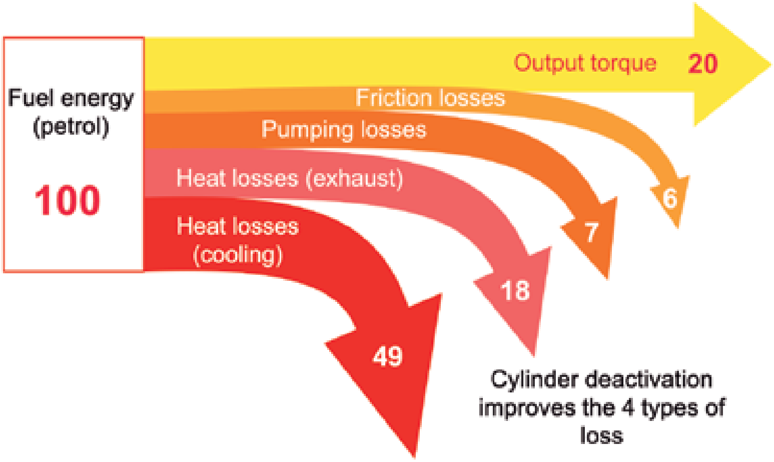
In this working context, the high engine torque available allows driving at low engine rpm, so that the throttle is nearly closed limiting the air drawn in by the cylinders.

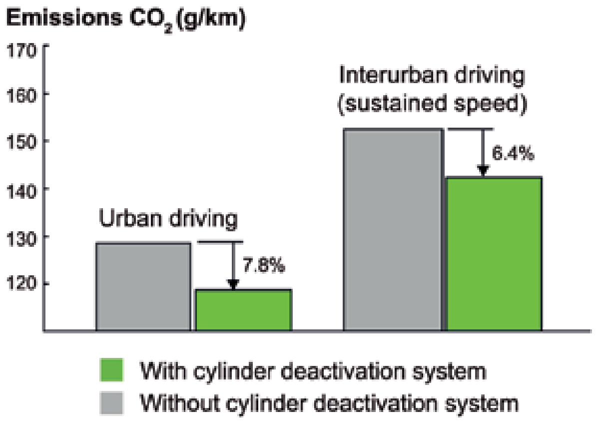
This results in an energy inefficiency known as pumping loss, a consequence of the energy necessary to move the air at high speed through a small opening.

The speed of movement of the piston is extremely variable during the intake stroke, starting at zero and accelerating to mid stroke and decelerating to zero again as it descends to reach BDC. This causes a pulsing flow of variable speed and certain resonance phenomena in the intake manifold volume that hampers the filling of the cylinders, particularly at low speed.

The partial filling of the cylinders results in a smaller final compression pressure and a quantity of reactive matter that is also smaller, which burns in a tiny fraction of time and is unlikely to convert the pressure into torque due to the reduced angle between the rod and the crankshaft crankpin.

The combustion contact surface with the combustion chamber is mainly the piston head and the cylinder head, the former is cooled by oil and the latter by the coolant. The time between successive combustions in the same cylinder is greater at low speed than at high speed, thus the cooling of both elements is at a maximum, their temperature at the start of combustion is comparatively lower and their heat absorption greater. The heat losses reduce the pressure inside the cylinders and the conversion of the fuel energy into engine torque.





Cylinder deactivation systems were designed to reduce these energy losses as much as possible by deactivating some of the cylinders and making the rest work at a higher load, this increases the opening of the throttle thus achieving the same mechanical performance. Reducing pumping losses and concentrating the combustion of the mixture in fewer cylinders reduces energy losses and increases the efficiency of the conversion of gas pressure into torque, so the same force is obtained while burning less fuel.

In combination with direct injection systems, the concentration of the fuel injected into fewer cylinders also allows higher injection pressures to be used to achieve greater homogenisation of the mixture and more complete combustion.

Deactivation of the cylinders entails keeping the intake valves and exhaust valves closed. In this situation, the sealing of the cylinder produces an air spring effect that reduces the speed loss caused by spacing of the combustions.

Without filling or additional load, the compression and decompression of the trapped gases has an equalising energy effect. The non-renewal of the gases in the deactivated cylinders and their contact with the cylinder walls and the cylinder head for a long period of time maintains a sufficient temperature to allow smooth reactivation under complete combustion conditions. Thus a change of operating mode is achieved that is almost imperceptible to the driver.

To deactivate the cylinders, several manufactures such as Mercedes, Porsche, SEAT, Audi and Volkswagen use actuators located on the camshafts that displace the cams laterally and prevent their action on the valves.

This system is explained in detail below, its main advantage lies in its electromechanical activation that avoids the drawbacks of electro-hydraulic control systems.

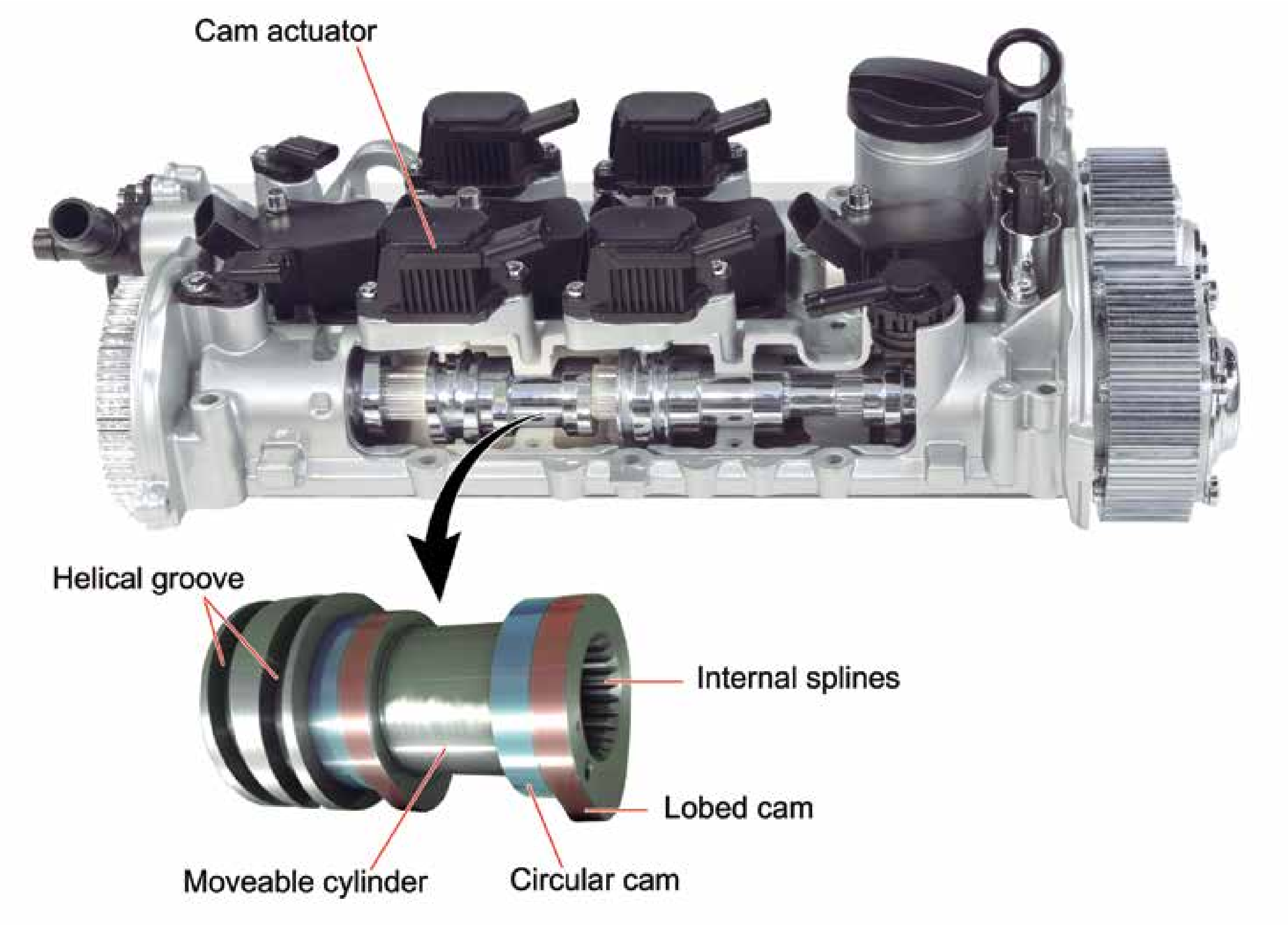
CYLINDER DEACTIVATION BY CAM DISPLACEMENT

System description

The versatility of application of this system is one of its main assets, as it can be adapted to a good number of existing engines with modifications only to the cylinder head and engine management. For this reason, it is currently one of the most used systems. It can be found on both large displacement engines (the 4.0 litre Mercedes AMG M177 V8) and smaller displacement engines (VW's 1.4 ACT engine).

The latter, a 4-cylinder engine, can operate with just 2 cylinders when under low load, specifically cylinders 1 and 4. Both the intake valves and the exhaust valves of cylinder 2 and 3 are kept closed while at the same time the engine control unit keeps the injection system and the ignition system of those cylinders inactive.

To activate and deactivate the valves and their respective cylinders, two different cams per valve are used, one lobed and the other circular, which alternate their position. Both cams are machined on a cylinder with internal splines, which can be moved axially along the complementary splines machined on the camshaft. The continuous profile of the circular cam coincides with the minimum profile of the lobed cam in order to keep the working position of the valve pushers and hydraulic tappets invariable at all times.

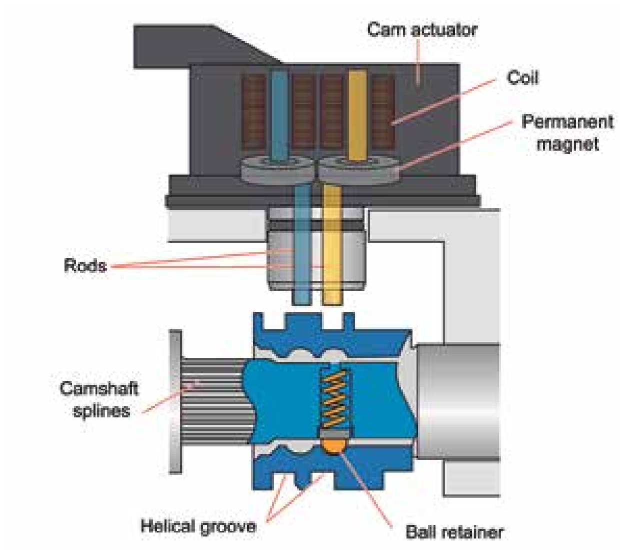


The cam cylinder is fixed in a specific position by means of a spring and ball retainer and its axial displacement is achieved by the action of one of the two deactivation actuator rods (cam actuator) on a helical groove machined into the cam cylinder itself.

In this way, the actuator only works when there is a change of position and at no time against the valve spring forces, in order to deactivate/activate the valve in just a half-turn of the camshaft in synchronisation with the compression-explosion strokes of the affected cylinder (1 crankshaft turn), providing another of the advantages of this system. The actual cylinder deactivation and activation is managed electromagnetically by means of separate components, and is carried out completely mechanically by synchronising, unequivocally and invariably, the change of state times of the valves with the piston position.

A double actuator is necessary in all cases for the intake valve and another for the exhaust valve of each cylinder, the same one can be used in 4 valve per cylinder engines, with the use of a moveable cylinder with twin cams.

In 4 cylinder engines, a total of 4 actuators and 8 solenoids are used for the deactivation of the intake and exhaust cams of cylinders 2 and 3, alternating in the engine firing order.



Two-cylinder mode

To change the position of the movable cylinder, the engine control unit energises the corresponding electromagnetic coil with the determined polarity. The repulsion between the magnetic field created by the supplied current and that of the pin's permanent magnet causes the pin to move and the insertion of its tip into the machined slot of the movable cylinder. The rotation of the camshaft together with the helical profile of the slot forces the cam cylinder to move axially, which aligns the circular cam with the valve pusher. The continuous profile and invariable diameter of the cam stops the normally reciprocating movement of the valve. After a complete turn of the crankshaft, the control unit cuts the electrical supply to the coil and the rod withdraws to its original position due to the increasing diameter of the machined channel in the following 180° of rotation of the camshaft.

The magnetic attraction between the pin's permanent magnet and the coil's metal housing keeps the magnet in its rest position without the need for additional components, while the ball retainer fixes the cam cylinder in its position until activation.

Four-cylinder mode

When the operation of the four cylinders is required, the unit energises the opposite coil of the valve actuator. The magnetic repulsion moves the activation pin which causes the movement of the cam cylinder in the opposite direction to before, just at the moment at which the circular and lobed profiles coincide. On the next half turn of the camshaft, the valve will be actuated by the variable profile cam, causing its reciprocating movement.

Activation conditions

In VW's 1.4 TSI ACT engines, the following requirements must be met to start the operation of the system:

- The engine speed must be kept constant and be between 1250 and 4000 rpm approximately.
- The current and target working torque must be less than 85 Nm.
- The engine oil temperature must be lower than 10°C.
- The lambda regulation of the mixture must be under control and active, for smooth and correct changes.

On the other hand, the system cannot operate under one of the following conditions.

- Sports driving with continuous gear changes.
- An acceleration request that requires a torque greater than 85 Nm.
- When the vehicle requires engine braking (negative engine torque requested), for example on a descending slope or deceleration.
- The heat demand from the climate control unit is high and the minimum air regulation temperature is not reached.

Advantages and disadvantages

Advantages of the system:

- Reduction of consumption depending on the engine of between 10 and 20%, which also depends on the type of driving.
- Better thermal efficiency of the engine and more complete combustion. Lower production of pollutants and CO2 emissions to the atmosphere.

Disadvantages of the system:

- Ride comfort, on deactivating and activating the system a small change in the behaviour/noise of the engine is perceptible.
- Irregular wear between the components in direct contact with combustion, such as cylinders, valves and their seats, spark plugs, etc.
- Operating actuators and selection guides. Greater number of components to diagnose in terms of electronics and mechanics.

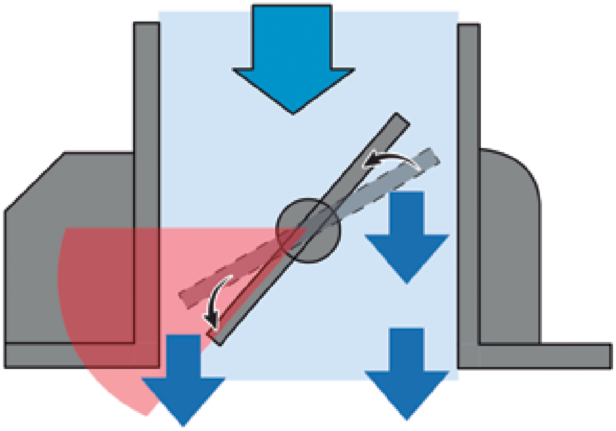
Deactivation process

The deactivation of cylinders 2 and 3 is achieved in just one complete turn of the camshaft (2 of the crankshaft), in a few milliseconds without force variations or jerking, so that the driver hardly notices the change of working mode of the engine. For this, the system follows an operating order designed to maintain the engine torque and the lambda value at 1.

The phases of the deactivation process are as follows:

- **Throttle opening regulation - 4 cylinder operation:** Prior to the deactivation of the cylinders, it must be ensured that the cylinders that will continue working will receive the air required to maintain the current engine torque.

  To achieve this, the control unit manages the opening of the throttle so that cylinders 1 and 4 receive approximately twice as much air. With the four cylinders still activated and working, a considerable increase in engine torque and acceleration would be produced. To prevent this, the electronic unit momentarily retards the ignition to reduce the pressure in the combustion chambers. This allows a stable torque to be maintained while working with a higher air intake.



- **Deactivation of the exhaust valves - 2 cylinder operation:** After the expulsion of the exhaust gases, 360° rotation of the crankshaft after ignition (retarded), the engine control unit excites the corresponding deactivation solenoids to displace their cam cylinders to the non-working position. The circular cams of each assembly are positioned over the corresponding roller rocker arms, which stops the reciprocating movement of the exhaust valves which are kept closed by the action of their springs.

- **Deactivation of injection and ignition - 2 cylinder operation:** at the same instant, the electronic management interrupts the ignition and injection of the regulated cylinders, thus preventing any possibility of combustion inside them.

- **Deactivation of the intake valves - 2 cylinder operation:** The control unit energises the intake valve deactivation actuators, 180° rotation of the crankshaft after the exhaust valves. In this way, the offset in the electrical excitation and the mechanical synchronisation between the camshaft and crankshaft guarantees the filling of the cylinder and ensures the deactivation of the intake valves during the cylinder's compression stroke. The air trapped in the cylinders produces the spring effect that partly maintains the frequency of the crankshaft's angular speed variation.

- **Ignition timing – 2 cylinder operation:** During the deactivation of cylinders 2 and 3, the engine control unit advances the ignition of cylinders 1 and 4 to achieve their maximum performance and obtain the same engine torque that existed before the deactivation.

  The complete deactivation of each cylinder occurs in just two turns of the crankshaft. Therefore, in a single working cycle of each one of the deactivated cylinders, it is guaranteed that the cylinder remains full with a more than sufficient quantity of air (last filling cycle with "double" throttle opening) for it to achieve a sufficient spring effect, especially during and just after deactivation. This reduces the frequency change intensity of the combustions and the angular speed variation of the crankshaft.

Activation process

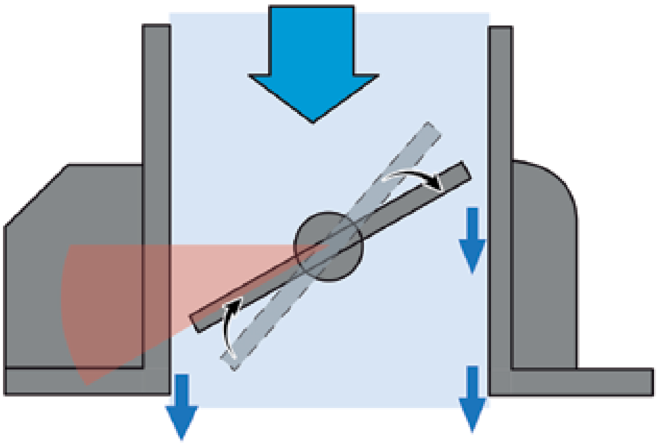
When the driving, the need for engine torque or the state of the vehicle does not allow two cylinder working mode to continue, the engine control unit starts the activation process for cylinders 2 and 3. To do this, it follows a specific sequence designed to make the change of the engine's working mode as smooth as possible.

The activation sequence consists of the following regulations:

- **Activation of the exhaust valves – 4 cylinder operation:** the control unit sends the activation signals to the solenoids of cylinders 2 and 3, 180° before TDC of the power stroke of each cylinder, to move the exhaust cam cylinders to the working position. The cams with variable profile of each assembly are positioned over their corresponding rocker arms, thus activating the reciprocating movement of the exhaust valves. One crankshaft turn after the excitation, the first effective exhaust stroke occurs in the cylinder during the activation process, which expels the air contained in the cylinder to the engine's exhaust.

- **Lambda regulation – 2 cylinder operation:** The air expelled by the cylinders during the deactivation process would momentarily change the lambda factor of the exhaust gas to a lean mixture of value $\lambda>1$. The effectiveness of the 3 way catalytic converter, particularly as regards reduction of NOx, directly depends on the stoichiometry of the exhaust gas, which is why, in order to prevent the exhaust gases becoming lean, the engine control unit increases the amount of fuel injected into the active cylinders during activation.

  The hydrocarbons and the CO resulting from combustion of a rich mixture in cylinders 1 and 4 consume the oxygen expelled by cylinders 2 and 3.



- **Intake valve control – 4 cylinder operation:** 180° of crankshaft rotation after the excitation of the exhaust actuators, the unit energises the activation coils of the intake actuators in working order. The cam cylinders are moved axially to locate the working cam over the corresponding rocker arm in order to recover the reciprocating movement of the intake valves. The opening of the valves allows the cylinders to be filled on the intake stroke, with the throttle still in the increased open position.

- **Ignition timing – 4 cylinder operation:** The unit manages the injection at a ratio of $\lambda=1$ for all the cylinders and retards the ignition point in order to prevent a sudden increase in engine torque, thus a progressive change in the working mode of the engine is achieved.

- **Throttle opening regulation - 4 cylinder operation:** The progressive closing of the throttle is managed at the same time as the ignition is advanced to achieve the prescribed engine torque. The target engine torque that results in the "reactivation" of the cylinders is usually increasing and always greater than that existing at the start of the regulation. Advancing the ignition allows the necessary performance to be obtained almost instantaneously, which facilitates the progressive closing of the throttle for a progressive change of working mode while maintaining the stoichiometric regulation of the mixture.

Main sensors and system actuators

Camshaft sensors: A Hall sensor reports on the working phase and exact position of the camshafts together with the signal from the crankshaft position sensor. This allows the cam actuators to be actuated when the valves are closed with sufficient rotation margin for the change of cam without opposing forces from the valve springs.

Intake manifold pressure and temperature sensor: The pressure in the intake manifold is very variable during the regulation of the cylinder activation and deactivation. This sensor allows the position of the throttle to be regulated and to calculate the effective filling of the cylinders.

Cam actuators: These are responsible for moving the cam cylinders axially and only work during the changes of state. The control unit recognises the effective work of the actuating pins by the return inductive signal produced by the movement of the permanent magnet to its rest position, due to the increasing profile of the return ramp machined on the cam-carrier cylinder.

The existence of the self-induced signal indicates that the return movement has occurred, and therefore the advance movement had occurred previously at the time of activation.

Crankshaft position and speed sensor: A Hall type sensor reads the speed and angular position of the engine's crankshaft in order to be able to initiate the cylinder deactivation system and manage both the ignition and injection times.

Throttle and accelerator electronic control: The position of the accelerator pedal is used to calculate the engine torque demanded by the driver, which is constantly compared with the instantaneous engine torque in order to obtain the target engine torque. If the conditions allow it and the target engine torque can be achieved by working with just two cylinders, the unit determines the deactivation of the two remaining cylinders and regulates the opening of the throttle to change the working mode in a progressive way.

Note: In the case of absence or recognised error of the signals described previously, the engine will operate in four-cylinder mode, and will indicate the fault in the system by means of a warning light on the instrument panel.

Degraded modes:

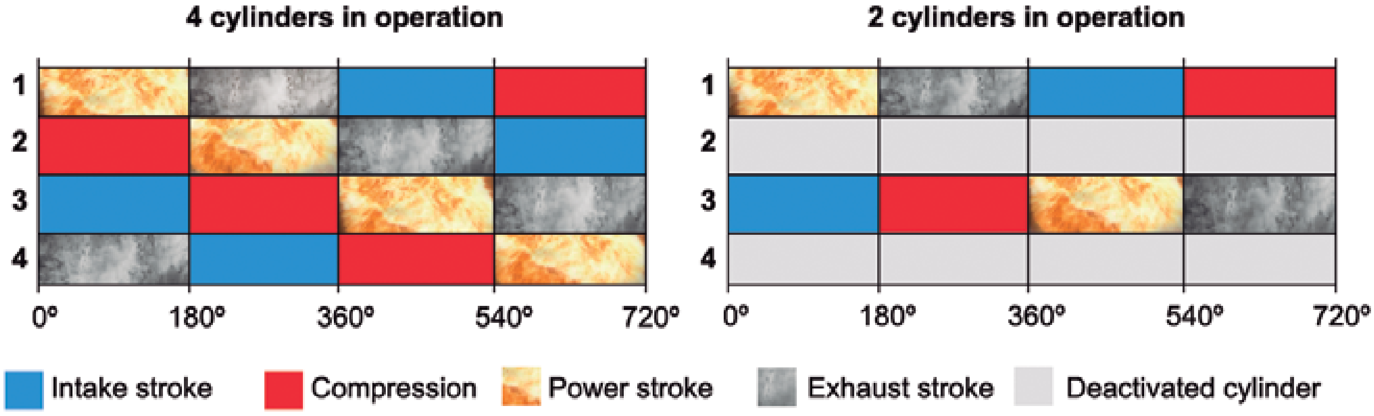
If the unit does not receive the return signal from one of the cam actuators, it interrupts the regulation cycle of the affected cylinder. When the intake actuator is affected, it also inverts the state of the exhaust valve in order to re-synchronise it with the intake valve to prevent the engine operating with a cylinder with “active” intake but with no exhaust (exhaust gases and hydrocarbons at the intake) or with an active exhaust but with no intake (fuel directly to the exhaust). Therefore, the engine will operate on 3 cylinders if the fault occurs during the deactivation regulation (one cylinder does not deactivate) and on 3 cylinders if it occurs during the activation regulation (one cylinder does not activate). The corresponding fault is recorded and the system disabled until the next operating cycle.

The engine is always started in four active cylinder mode. If the actuator fault persists, it will be on 3 cylinders and if it was the actuators of 2 cylinders, in 2 cylinder mode.

Engine construction characteristics

One of the most notable disadvantages of cylinder deactivation in in-line 4 cylinder engines are the vibrations and frequency changes that arise when the cylinders are deactivated or restarted. When the engine runs on four cylinders there are two ignitions per crankshaft turn, whereas while working during deactivation only one ignition occurs per turn and, in this case, at the ends of the crankshaft.

The acoustic resonances, both during intake and exhaust, occur at half the usual frequency and are also more intense due to the work with increased filling of the active cylinders.

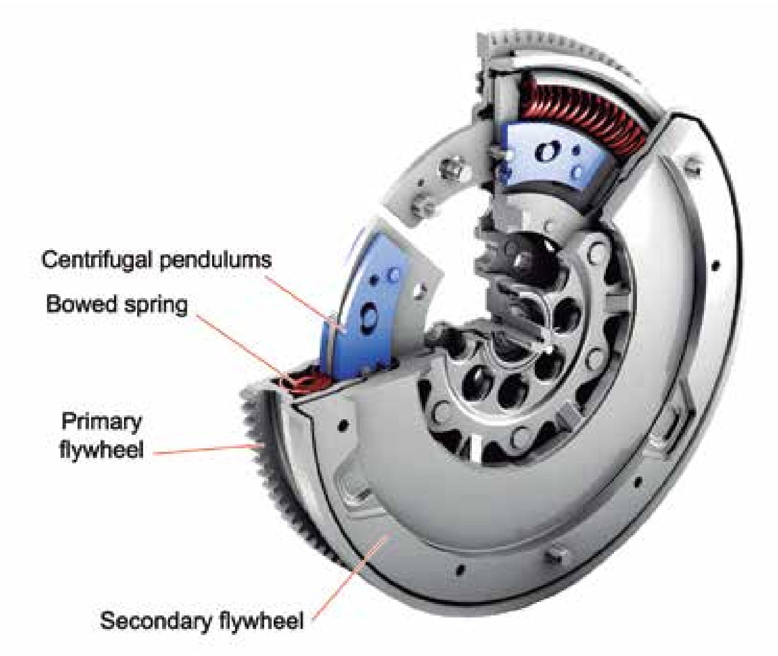


To achieve the ride comfort necessary, the engine’s reciprocating train is lightened at the same time as its structural rigidity is increased and the structure of the transverse mounting is improved in the direction of travel.

The **engine mounts** are redesigned to minimise the oscillations and to prevent resonance of the low-frequency vibrations, which are the most perceptible, by stopping their transmission to the body and the vehicle occupants.

A **dual mass flywheel** is also used to regularise transmission of the torque at low speed. A flywheel connected by means of springs which stores kinetic energy as the crankshaft rotates at times of higher engine torque and returns it when there is lower force delivery, which smooths out the rotation force received by the gearbox and the other components of the transmission system.

The alternating operation from one mode to another also means that the pulses of the burnt gases in the **exhaust line** must be reduced. For this, the cross-section and length of the exhaust pipes are modified, with the fitting of an intermediate silencer, to prevent the lowest sound frequencies.



OTHER CYLINDER DEACTIVATION SYSTEMS

Deactivation system using hydraulic tappets

This is a very common system that is used, for example, in Mazda engines, such as that used by the **194 CV CX-5 Skyactiv-G**. The operating principle is the same as that explained up until now, other than the valve override mechanism.

The actuation from the camshaft to the valves is by means of roller rocker arms and hydraulic tappets of adjustable length. The valve is located on one of the ends of the rocker arm and the hydraulic tappet on the other (which maintains a clearance of 0 mm).

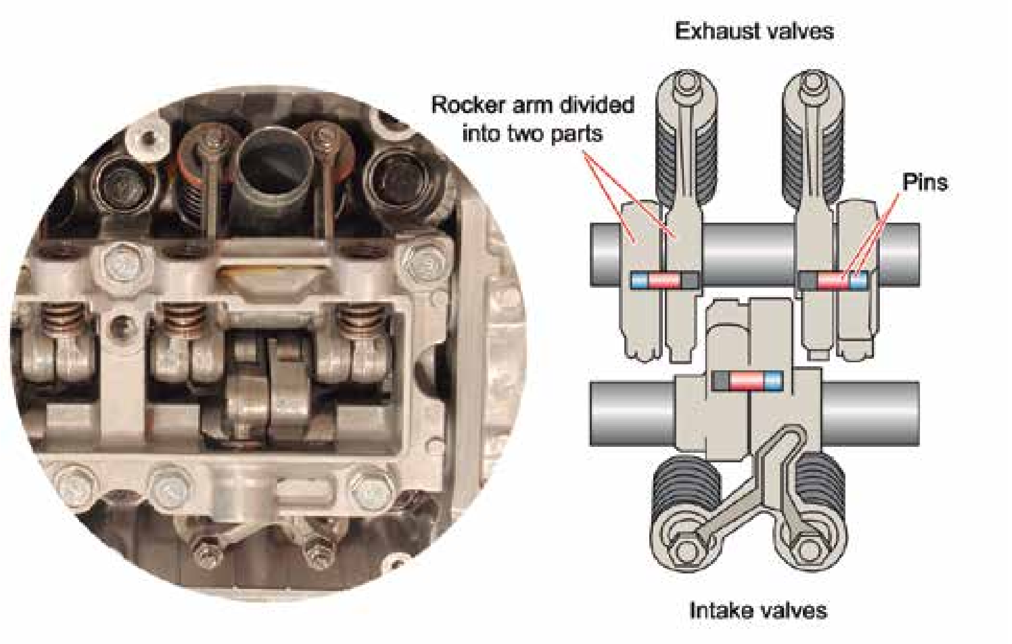
When the working conditions are met for deactivation, the control unit deactivates two of the four cylinders. For this, it sends a PWM signal to an oil control valve (OCV) so that the pressure is released from the relevant hydraulic tappets. Without the applied hydraulic pressure to keep it rigid, the tappet absorbs the cam travel and the rocker arm movement, so the reciprocating movement of the valve no longer occurs and it remains closed.

To reactivate the 4 cylinders, the engine control unit sends another PWM signal to the OCV so that the hydraulic tappets again receive their hydraulic working pressure. Once the tappets have the necessary internal pressure, they recover their support point function so that the rocker arms push the valves correctly.

In contrast to other systems, the deactivation by hydraulic tappets in the Mazda is carried out on cylinders 1 and 4, and the work is concentrated in the central cylinders of the engine block in order to reduce vibrations.

Deactivation system using the rocker arms

This is a deactivation system used by Honda with a very similar operating principle to the i-VTEC valve lift system, except that, in this case, the cylinders are deactivated selectively according to driving conditions. An example of this system can be found in the **Accord** model with the **J35A VCM** engine, which can go from 6 cylinders to 4 and even 3, when working conditions allow, in order to maximise fuel saving.



The system is based on the use of composite rocker arms (divided into two parts) which are connected or disconnected by means of hydraulically controlled pins. One part of the rocker arms works on the valves, while the other receives the camshaft movement through a roller. At rest, the pins located inside the rocker arms keep both parts connected, in such a way that the rocker arms tilt on their axes to transmit the profile variation of the cams to the valves.

When cylinder deactivation is required, the engine control unit sends an activation signal to the solenoids in order to increase the oil pressure inside the rocker arms through channels in the rocker arm shafts. The pressure inside the rocker arms causes the movement of the pins when these are not applying a force, i.e. with the valves at rest, which disconnects the two halves of the rocker arm and stops the valves rising. For cylinder activation, the hydraulic pressure is reduced, allowing the pins to return to their original position by the force of the recovery springs.

When working with a low load, the engine operates with just 3 cylinders by overriding the work of a complete bank to save fuel. For this, the engine control unit takes some of the main information into consideration, such as the position of the accelerator and engine rpm. The deactivation of a complete bank only affects one engine catalytic converter, while the rest continue to maintain the correct ratio of the exhaust gas.

For a moderate load, the system activates another cylinder to satisfy the power needs at that time. With only 1 active cylinder, the temperature of the catalytic converter of the corresponding bank is comparatively low, but its capacity is sufficient for the volume and gas that it must process.

A higher power demand means putting the 6 cylinders back into operation. To ensure that the engine starts, this is done in all cases with all the cylinders in operation, as there is no oil pressure for the deactivation regulation.

At the time of cylinder deactivation, the spark plugs receive the ignition voltage to minimise the temperature loss and to prevent the incrustations caused by incomplete combustion in the cylinder.

The rigidity of this engine's mounts is actively regulated to reduce vibrations and noise arising from the changes of cylinder mode.

COMMON FAULTS

The common faults in engines equipped with cylinder deactivation will depend on the type of system used. Generally speaking, the components that are subjected to mechanical force wear out due to fatigue and temperature change, such as tappets, rocker arms, cams, pushrods, etc. In the worst case, these can break. As regards the control elements such as solenoids, their failure is usually due to electrical reasons (power supply failure, communication problems with the engine control unit, etc.).

Fault codes and cam actuator checks

DTC of the deactivation system of cylinder number 2

INTAKE STROKE		EXHAUST STROKE	
P11A500	Adjustment of cam A of cylinder 2 (electrical interruption or fault).	**P11C100**	Adjustment of exhaust cam A of cylinder 2 (electrical interruption or fault).
P11A600	Adjustment of cam A of cylinder 2 (electrical interruption or fault).	**P11C200**	Adjustment of exhaust cam B of cylinder 2 (electrical interruption or fault).
P11A700	Adjustment of cam B of cylinder 2 (electrical interruption or fault).	**P11D500**	Adjustment of exhaust cam A of cylinder 2 (implausible signal).
P11A800	Adjustment of cam B of cylinder 2 (electrical interruption or fault).	**P11D600**	Adjustment of exhaust cam B of cylinder 2 (implausible signal).
P12A900	Adjustment of cam A of cylinder 2 (defective operation).	**P12B900**	Adjustment of exhaust cam A of cylinder 2 (defective operation).
P12B100	Adjustment of cam B of cylinder 2 (defective operation).	**P12C100**	Adjustment of exhaust cam B of cylinder 2 (defective operation).
P12CA00	Adjustment of cam B of cylinder 2.	**P12D200**	Adjustment of exhaust cam B of cylinder 2.
P12DA00	Implausible switching of cam A of cylinder 2.	**P12E200**	Adjustment of exhaust cam A of cylinder 2 (defective operation).
P31A200	Adjustment of cam B of cylinder 2 (connection to ground).	**P31AA00**	Adjustment of exhaust cam B of cylinder 2 (connection to ground).
P31B200	Adjustment of cam A of cylinder 2 (connection to ground).	**P31BA00**	Adjustment of exhaust cam A of cylinder 2 (connection to ground).

DTC of the deactivation system of cylinder number 3

INTAKE STROKE		EXHAUST STROKE	
P11A900	Adjustment of cam A of cylinder 3 (electrical interruption or fault).	**P11C400**	Adjustment of exhaust cam B of cylinder 3 (electrical interruption or fault).
P11AA00	Adjustment of cam A of cylinder 3 (electrical interruption or fault).	**P11D700**	Adjustment of exhaust cam A of cylinder 3 (implausible signal).
P11AB00	Adjustment of cam B of cylinder 3 (electrical interruption or fault).	**P11D800**	Adjustment of exhaust cam B of cylinder 3 (implausible signal).
P11AC00	Adjustment of cam B of cylinder 3 (electrical interruption or fault).	**P12BA00**	Adjustment of exhaust cam A of cylinder 3 (defective operation).
P12AA00	Adjustment of cam A of cylinder 3 (defective operation).	**P12C200**	Adjustment of exhaust cam B of cylinder 3 (defective operation).
P12B200	Adjustment of cam B of cylinder 3 (defective operation).	**P12D300**	Adjustment of exhaust cam B of cylinder 3
P12CB00	Adjustment of cam B of cylinder 3.	**P12E300**	Adjustment of exhaust cam A of cylinder 3
P12DB00	Adjustment of exhaust cam A of cylinder 3 (implausible switching).	**P31AB00**	Adjustment of exhaust cam B of cylinder 3 (connection to ground).
P31A300	Adjustment of cam B of cylinder 3 (connection to ground).	**P31BB00**	Adjustment of exhaust cam A of cylinder 3 (connection to ground).
P31B300	Adjustment of cam A of cylinder 3 (connection to ground).		

The electrical checks to carry out on the cam actuator are usually the following:

Power supply check

- Ignition on.
- Component connector unplugged.
- Terminal 2 positive with respect to ground.
- Nominal value 11 V to 13.5 V

Component side check

- Component side terminal 1 with respect to terminal 2.
- Ignition off.
- Nominal value between 7 to 13 ohms.

- Component side terminal 3 with respect to terminal 2.
- Ignition off.
- Nominal value between 0 to 5 ohms.

- Component side terminal 1 with respect to terminal 3.
- Ignition off.
- Nominal value between 15 to 21 ohms.

Other checks

- Leakage to positive, ground or interruption.
- Defective actuator element, despite the check.
- Engine control module.
- System power supply voltage after relay.

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