



4.0 TFSI ENGINE WITH CYLINDER ON DEMAND

The new 4.0 TFSI, a powerful V8 with twin turbochargers, is equipped with “cylinder on demand” technology. When operating at part load, four of its cylinders are deactivated. This reduces fuel consumption by an average of five percent. To complement this system there are two further technologies: Active noise control (ANC) and active engine mounts. They ensure that the car’s occupants do not hear or sense any disturbing noise or vibration even if the engine is operating in the four-cylinder mode.

On the new 4.0 TFSI, cylinders are deactivated if the load on the engine is low. The upper limit for the deactivation to take effect, depending on engine speed, is between about 25 and 40 percent of maximum torque, in other words about 120 and 250 Nm (88.51 and 184.39 lb-ft). In this operating range the mean effective pressure rises to eight bar. Coolant temperature must be at least 30°C (86°F) and third gear or higher must have been selected. The engine must be running at more than idle speed, namely between 960 and 3,500 rpm.

If these preconditions are satisfied, the system closes the inlet and exhaust valves of two cylinders on each bank. The V8 continues to run as a V4 with a regular firing order, but with the mixture in only two cylinders instead of four being ignited on each revolution of the crankshaft. Instead of 1 - 5 - 4 - 8 - 6 - 3 - 7 - 2, the firing order is then 1 - 4 - 6 - 7; efficiency in the active cylinders is increased because the operating points are displaced toward higher loads.

Intelligent operation: the enhanced AVS system

The necessary valves are closed on the four camshafts by an enhanced version of the Audi valvelift system (AVS). Its sleeves can be slid sideways electromagnetically, and have an additional “zero-lift” cam; since this does not move the cam followers, the valve springs keep the valves closed. At the same time, the engine management system shuts down fuel injection and ignition.

In the deactivated cylinders, the pistons continue to move because they are being driven by the crankshaft; before the valves close the combustion chambers are again filled with fresh air and the fuel injection and ignition shut down. This intake of fresh air lowers pressure in the cylinders and reduces the energy needed to move the pistons – an important factor for increased efficiency.

As soon as the driver presses firmly down on the accelerator pedal, the deactivated cylinders cut in again. The return to eight-cylinder operation, like the cylinder deactivation process, takes place so smoothly and quickly that it is difficult to notice. It is completed on average in just 300 milliseconds. The actual changeover naturally involves a temporary drop in efficiency, so that the reduction in fuel consumption only sets in three seconds or more after cylinder deactivation.

Audi has therefore developed a control logic that monitors movement of the accelerator and brake pedals and the steering wheel by the driver. If an irregular pattern is detected, cylinder deactivation may be inhibited in certain situations, for instance at a roundabout or when the car is driven hard on interurban roads. Cylinder deactivation lasting only a few seconds would tend to



increase fuel consumption rather than decreasing it.

The “cylinder on demand” system is ready to operate all the time, even in the S mode of the automatic transmission or the dynamic setting of Audi drive select. It saves the most fuel when the car is driven steadily at a moderate speed, in the manner customary on many main roads.

ANC and active engine mounts

V8 engines are not only noted for their pulling power and harmonious throttle response but also for their smooth running. This is also true of the new Audi 4.0 TFSI. When the V8 engine operates as a V4, its crankshaft and reciprocating components tend to generate higher torsional vibration, depending on load and engine speed. This causes airborne noise to reach the interior of the car. The exhaust system, which is of large size, also emits drumming noise that is difficult to suppress completely despite the use of an intelligent flap-valve system. The aim is therefore to reduce all these disturbing noises to a level that the driver and passengers cannot hear.

ANC: noise and opposing noise equals no noise

Active noise control (ANC) counteracts unwanted noise by generating a similar noise. This principle is known as destructive interference: If two sound waves of the same frequency are superimposed, their amplitudes – the peaks and troughs that determine the sound pressure – can be arranged to cancel each other out. The amplitudes must be of the same strength, but the phases opposed by 180 degrees. Acoustics experts refer to this as “noise cancellation”.

The Audi models in which the new 4.0 TFSI will be available are equipped with four small microphones; these are visible in the roof lining. Each of them registers the complete noise spectrum in its immediate area. From these signals the ANC control unit computes a differentiated spatial sound image; information on actual engine speed is also obtained from the crankshaft sensor.

In all the previously calibrated zones in which the system identified disturbing noise, it emits a targeted, precisely modulated cancellation sound. A particular challenge is for the ANC to react especially quickly and accurately in the short periods during which cylinder deactivation or reactivation takes place.

Active noise control is active whenever needed – whether the sound system is switched on, deactivated, loud, soft or muted. It operates with whichever sound system is installed, even with the Bang & Olufsen Advanced Sound System.

Active engine mounts: counteracting vibration for greater refinement

Audi normally uses firm, sporty settings for its engine mounts. For many years now certain models – notably the A8 at the top end of the range – and various engines have had switchable electromagnetic mounts. These have two operating settings: at idle speed they have a “soft”



characteristic to prevent noise and vibration from reaching the interior, but when the car is being driven a firmer damping rate is selected in order to suppress engine vibration.

The active engine mounting that Audi has developed for the 4.0 TFSI takes this technology a decisive step further - it cancels out engine vibrations with out-of-phase counter-oscillations. The key component is an electromagnetic oscillating-coil actuator. This has a rapid stroke that is transmitted via a flexible diaphragm to the hydraulic fluid in the mounting, which also absorbs oscillating movements from the engine. In the fluid these are overlaid by the actuator movements and cancelled out.

The control units for the active engine mounts receive their signals from two sources. Engine speed is detected by the crankshaft sensor; these signals are used to compute the precise phase and frequency of the actuator signal. Acceleration sensors on the two engine mounts supply the data that determine the amplitude necessary to cancel out the vibration.

When the new 4.0 TFSI is running in the four-cylinder mode, it generates a certain amount of engine vibration and drumming noise of what is known as the second order. They are not typical of a V8, but the counter-vibration generated by the active mounts reduces them to an undetectable level.

At idle speed with all eight cylinders in operation, engine excitation of the fourth order occurs. This too is largely eliminated by the active engine mounts so that the engine appears to be running even more smoothly.

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