The AJD-V6 Diesel Engine - Celebrating 20 years

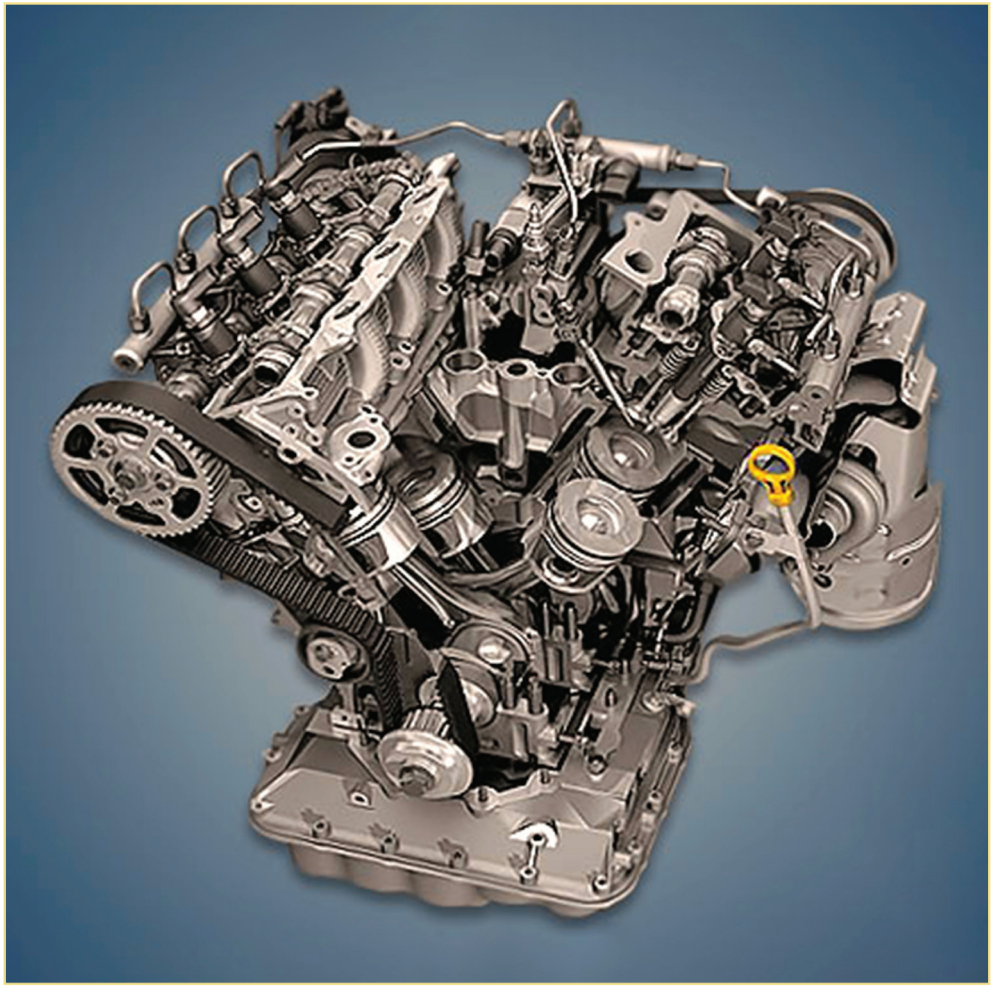
Back in the 1980s a diesel-engined Jaguar was unthinkable, but from about 2004, the best-selling XJ and XF derivatives were diesel powered.

Although unjustified today, a diesel-powered saloon car is very much a dirty word. It is ironic that Jaguar was criticised for being so late to the party when it came to oil burners.

A cautious toe was dipped with the introduction of the X-Type diesel in 2003, its Mondeo-derived platform providing a useful development short cut, but the first all-Jaguar diesel model was the S-Type 2.7D introduced in 2004.

Auto Express tested the S-Type diesel and noted that the mid-range pull was incredible and that high-speed refinement was up there with class leaders such as the BMW 530d. They added that if you spend much time on the motorway, the new diesel's relaxed cruising ability and incredible torque is preferable to a petrol model – with returns of 40 mpg (7.0 L/100km).

Quite clearly that kind of economy added a whole new dimension to Jaguar ownership and when the unit was installed in the aluminium-bodied X350 XJ in 2005, the smooth and torquey diesel suited the car's long-legged feel beautifully.



This cutaway shows several of the V6 engines important features; the belt driven camshafts, inlet tracks cast into the cylinder heads, and the extremely rigid bottom end with no less than six bolts securing each main bearing.

The engine in its 'dressed' state with covers

The Diesel Engine- Basic Explanation

Also known as compression ignition, the basic diesel principle was first patented by Rudolph Diesel back in 1893. While retaining the four-stroke cycle, a diesel engine uses the heat of compression to ignite the fuel, unlike the 'Otto' cycle in which petrol is ignited by a spark.

Diesel engines generally require a much stronger cylinder block than petrol engines to cope with the much higher compression ratio, plus a means to provide an initial heat source when starting and a precise method for timing the injection of fuel at high pressure, as that is what determines the point of ignition rather than a distributor, coil and spark plugs

Until recently, most diesel engines consisted of a rigid cast iron block and cylinder head, together with a crankshaft-driven mechanical injection unit to meter the fuel at high pressure to each individual cylinder. Glow plugs protrude into the cylinder and are heated electrically prior to and during the

initial start from cold, but from then on the combustion cycle in a basic diesel engine is self-perpetuating — it will run without any electrical assistance whatsoever. In fact, it must be physically stopped by cutting off the fuel supply and closing the throttle butterfly.

With higher levels of compression than in a petrol engine (typically 17-22:1 as against 8-12:1), a diesel engine is even more ideally suited to turbo charging, and it has been the development of the turbo diesel that has helped the compression ignition engine cross over from mainly commercial applications into the passenger car market.

However, with the combination of increased power and ever tightening emissions regulations, it has become necessary to include progressively more mechanical and electronic aids. By the mid to late 1990s, the average TDi engine bay had become a complex mass of pipes, levers and cables, in a similar way to how the last carburetted petrol engines appeared before fuel injection came along.

The solution, as with a petrol engine, has been to use electronically switched injectors feeding high pressure fuel (according to a fuel map stored in the car's computer).

It is this method of fuelling, in fact, that gives the common rail turbo diesel its name in reference to the single high pressure fuel rail that replaced the individual pipes running from the metering unit to each cylinder.

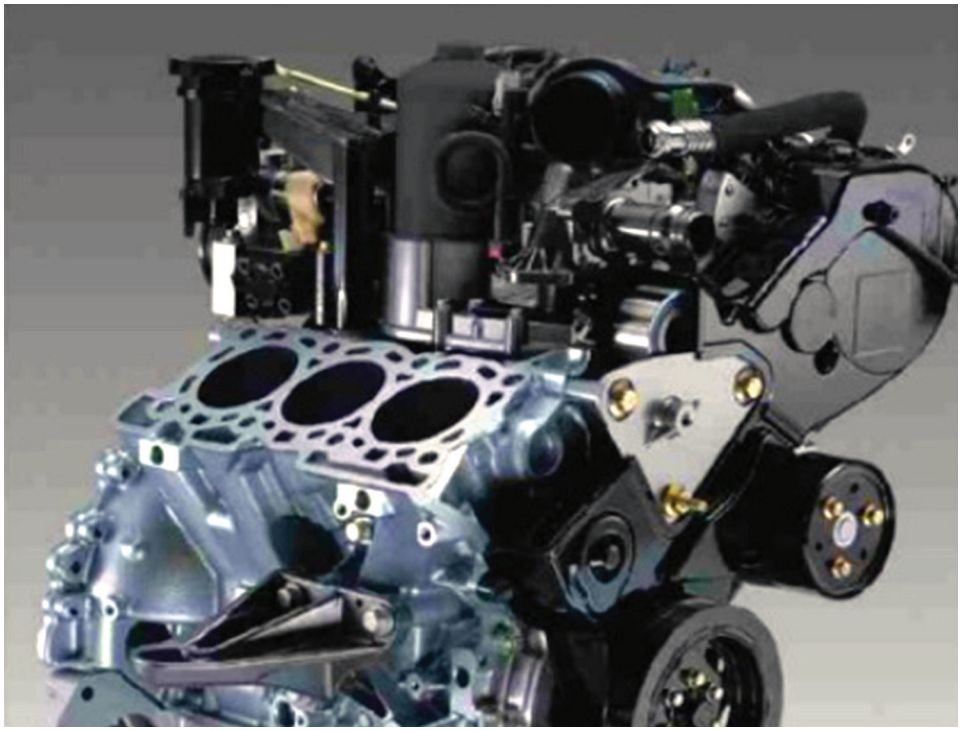
The AJD-V6 Structure

The compressed graphite iron (CGI) used for the cylinder block has been around for a long time, but until recently the technology to machine it was expensive. CGI is not only significantly stronger than conventional cast iron, but also more durable.

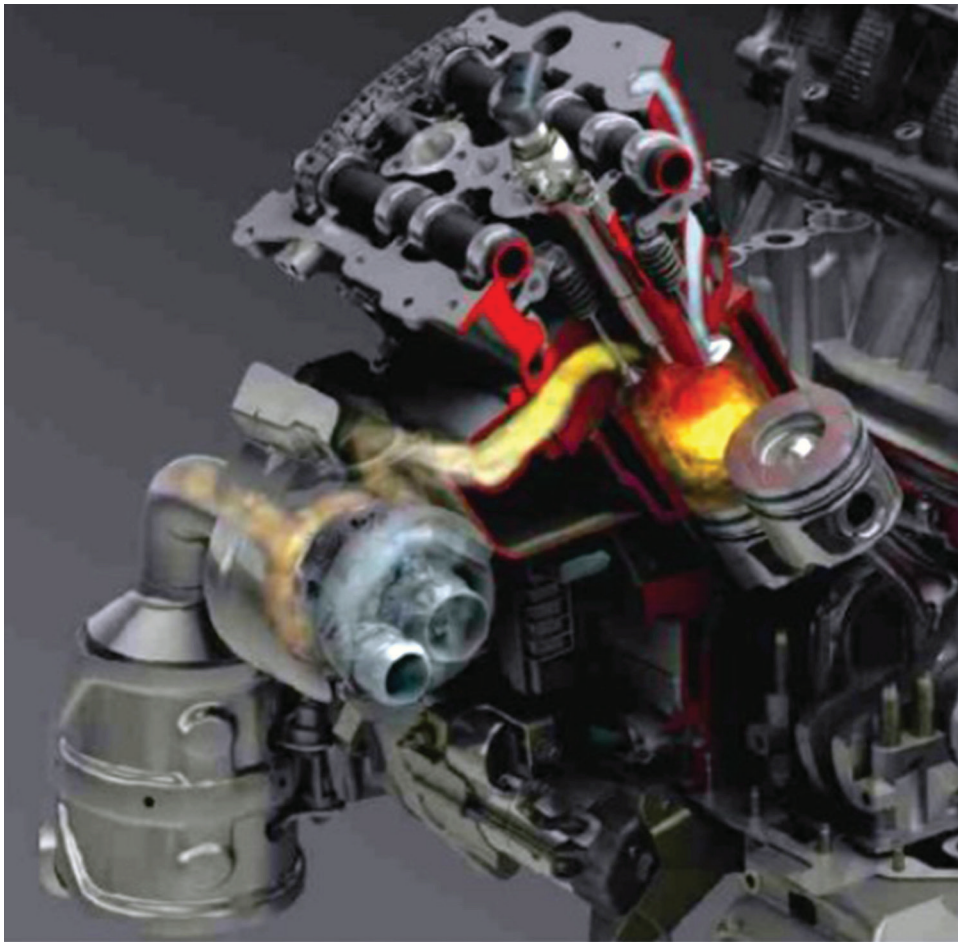
The greater strength of the CGI compared to conventional cast iron enabled the designers to use less material and consequently get the weight down to just 202kg - just 3kg more than the petrol V6. However, it was claimed that it took the factory eight years to develop suitable machining equipment to handle the harder metal.

Anchored firmly to the crankcase with cross-bolted main bearings is a forged steel crankshaft - the connecting rods are also made from forged steel and are fitted with

Inside Jaguars V6 Diesel



(Front to rear). With one cylinder head removed, within the "V" is the plastic thermostat housing, cartridge oil filter and the high pressure fuel pump (belt driven from a pulley on the left exhaust cam).



This view illustrates the gas flow, from the long inlet tract, through the cylinder and short exhaust tract to the turbocharger and close-coupled catalyst, where any unburned fuel is turned into CO_2 and water.

cast aluminium pistons which are cooled by oil sprayed from ports in the cylinder walls.

Topping off this advanced metallurgy is a pair of aluminium cylinder heads, more reminiscent of a high-performance petrol engine, each with camshafts and four valves per cylinder. The cam covers are moulded integrally with the inlet manifold and incorporate a port deactivation system which uses flaps to alter the swirl pattern of the incoming compressed air, according to engine load and engine speed.

Finally, to ensure minimum noise transmission, not only is extensive insulation fitted around the engine, but the sump is double-skinned, the cam covers are insulated from the head and dual insulated engine mounts are used, together with a special differential to cushion the increased torque and prevent harshness on acceleration.

Fuel Injection

While a standard petrol engine runs fuel injection pressures somewhere between 30-50psi, the AJD-V6 lifts its fuel pressure to over 23,000 psi. This cannot be done with a conventional electric pump, so a mechanical pump is mounted at the rear of the V, fed by an electric lift pump in the tank.

There is also a third pump, incorporated into the mechanical pump casing to feed it with only as much fuel as is necessary to avoid wasting precious energy pressurising fuel that is not yet needed.

The injectors are also well worth a mention, as they utilise Piezo ceramic shims which distort when electricity is applied; the shims are only wafer thin, so a stack 45mm high is needed to open the nozzle to the required 0.8mm. With a super-fast reaction time, these injectors are able to open and close several times within each combustion cycle to deliver the precise amount of fuel required to control the burn, and produce maximum power with low emissions and minimal noise.

Turbo Charging

The turbocharger is certainly an effective way to increase power, but it does have two big disadvantages. Turbos take time to spin up, causing the dreaded lag, and as they are rigidly coupled to the speed of the exhaust

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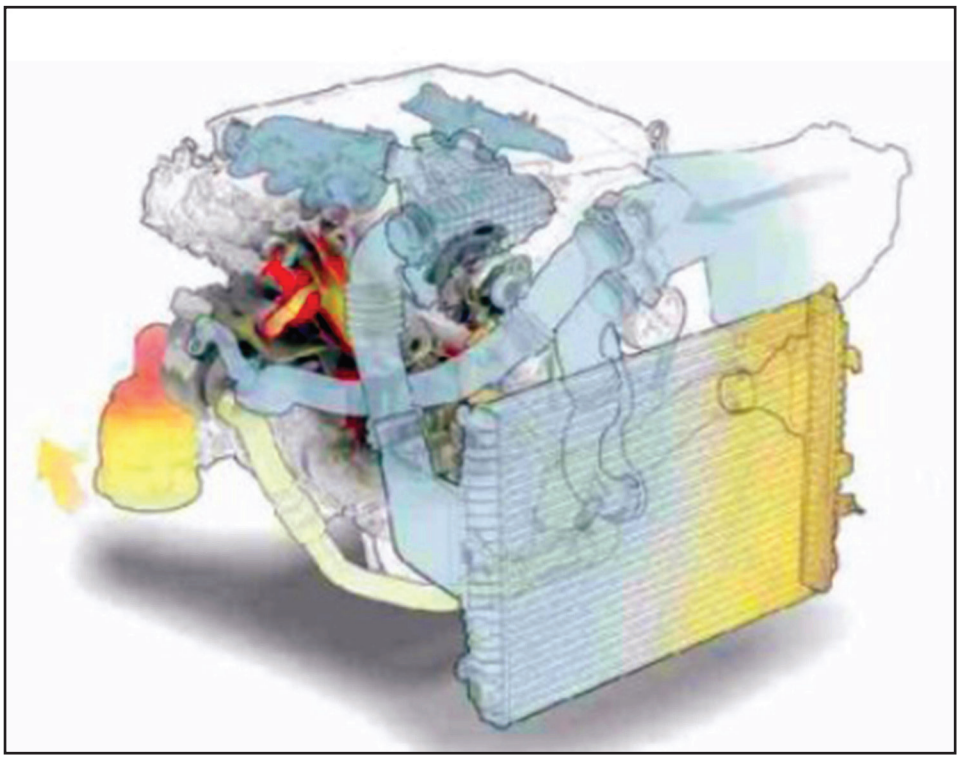
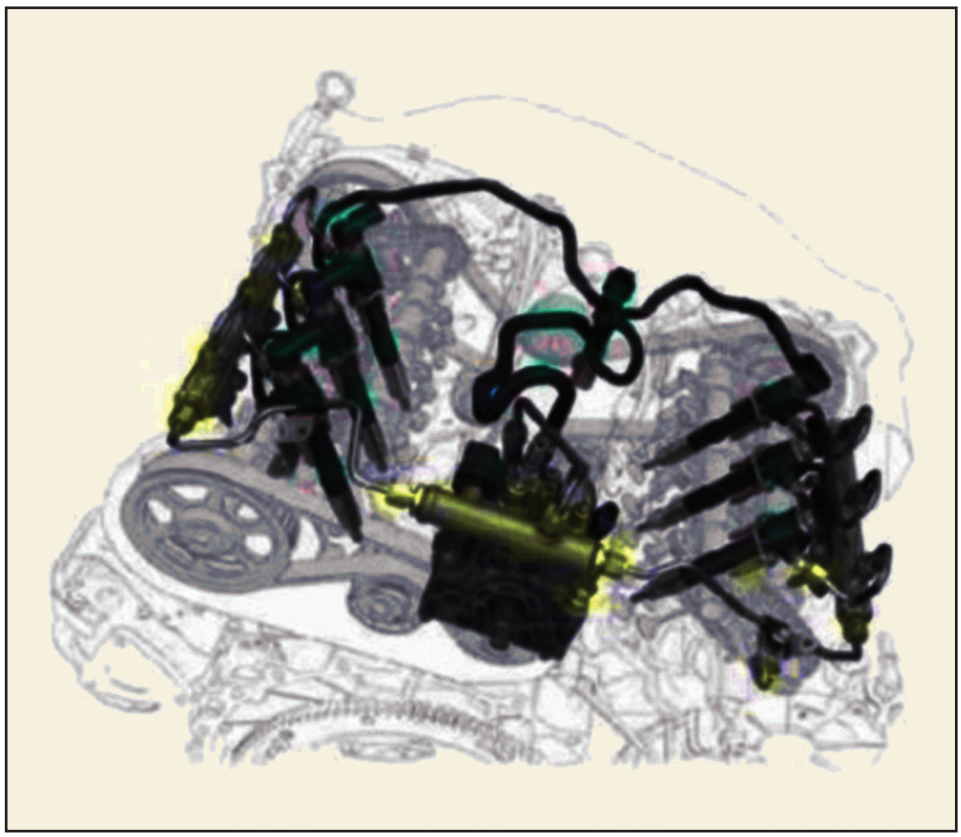
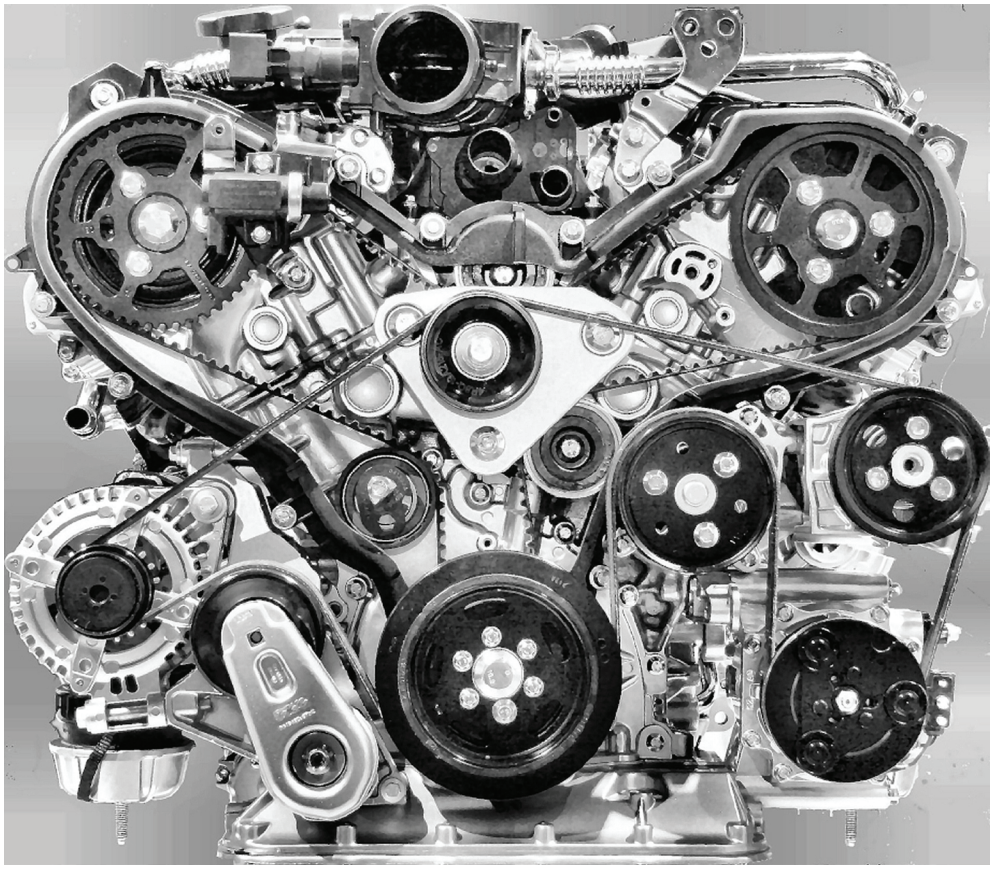


Filtered air is drawn in via twin hot wire airflow meters to each turbo, and from those via a T-Junction to the left hand side of an air-to-air intercooler mounted in front of the main radiator. From the intercooler outlet the cooled, compressed air passes through a single throttle body and divides again at the inlet manifolds that are moulded integrally with the cam covers.



The fuel delivery system consists of a high-pressure pump, which raises the diesel to over 23,000 psi. Twin fuel rails and electronically controlled injectors which use Piezo ceramic 'stacks', can open in as little as 0.2 milliseconds and cycle as many as five times during each combustion cycle.



gas, they aren't flexible with regard to when the boost is produced (other than a waste gate to limit maximum boost).

This usually causes a sudden surge of power that isn't really suited to a luxury car.

These are the main reasons why supercharging was chosen for Jaguar's performance petrol engines. The AJD-V6, however, has two small turbos that spin up faster than a single large one, and they incorporate electrically adjustable vanes to direct the exhaust gasses to differing zones on the turbine blades. The result is that they keep the boost level constant across most of the engine range.

There have been some reliability issues with the electric actuators in these turbos requiring replacement units.

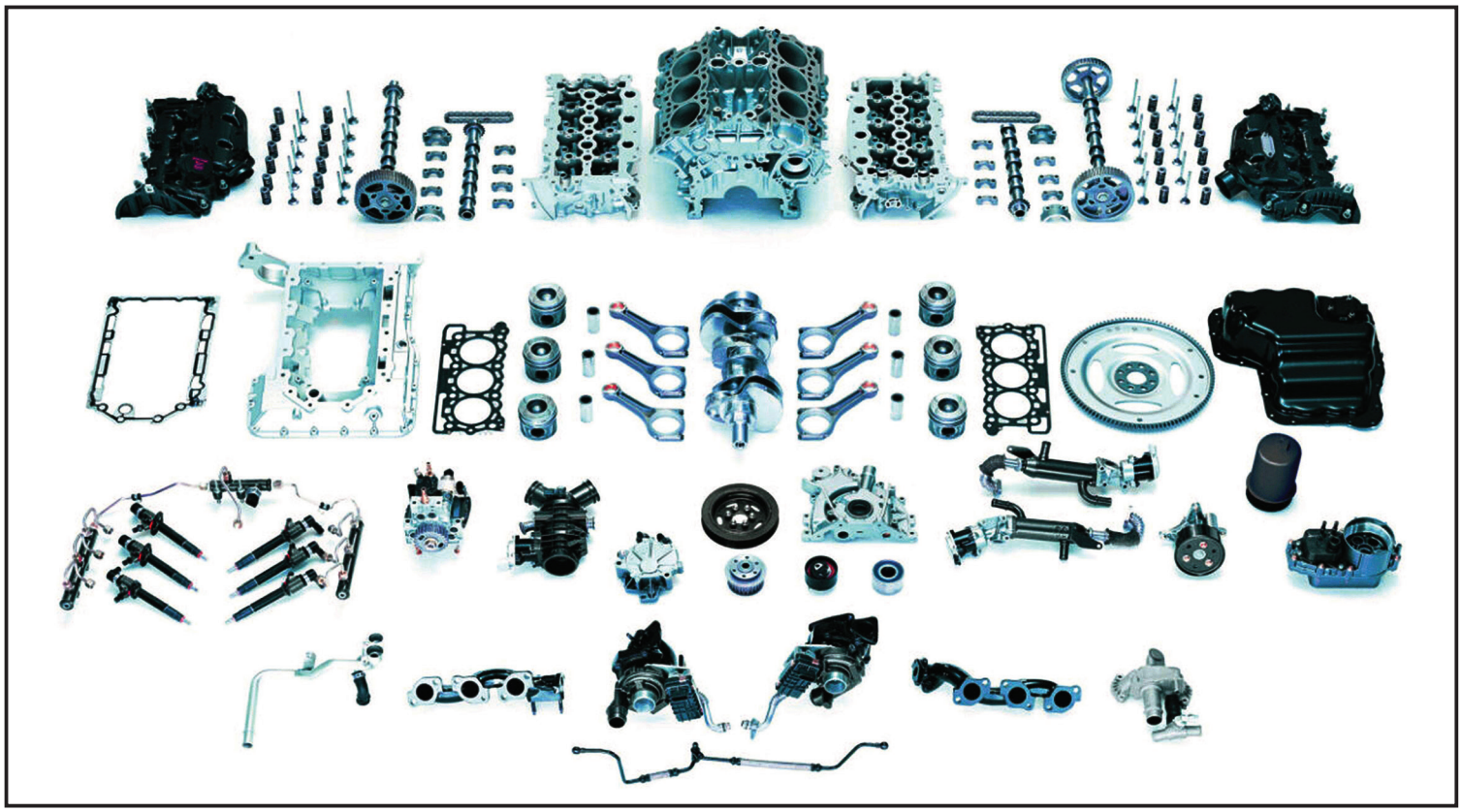
However, the engines are generally reliable solid units, provided they are regularly serviced, maintained and get regular long runs.

AJD-V6 3.0 Litre

Up-rated to 3 litres in 2009, the V6 diesel would live on in the XF and the X351 XJ where it would in fact become the mainstay power plant in terms of sales volume.

The V6 diesel remained in other JLR products until the firm's own Ingenium engines were ready in 2015, but in its decade-long production life the AJ diesel allowed Jaguar to leapfrog from catch-up to the front of the class in diesel power. ■

Editor: Information for this article sourced from Prestige & Performance Car, Jaguar World Magazine and Auto Express.



The AJD-V6 looks quite simple when it is all pulled apart.