Celebrating 40 years - The AJ6/AJ16 Engine

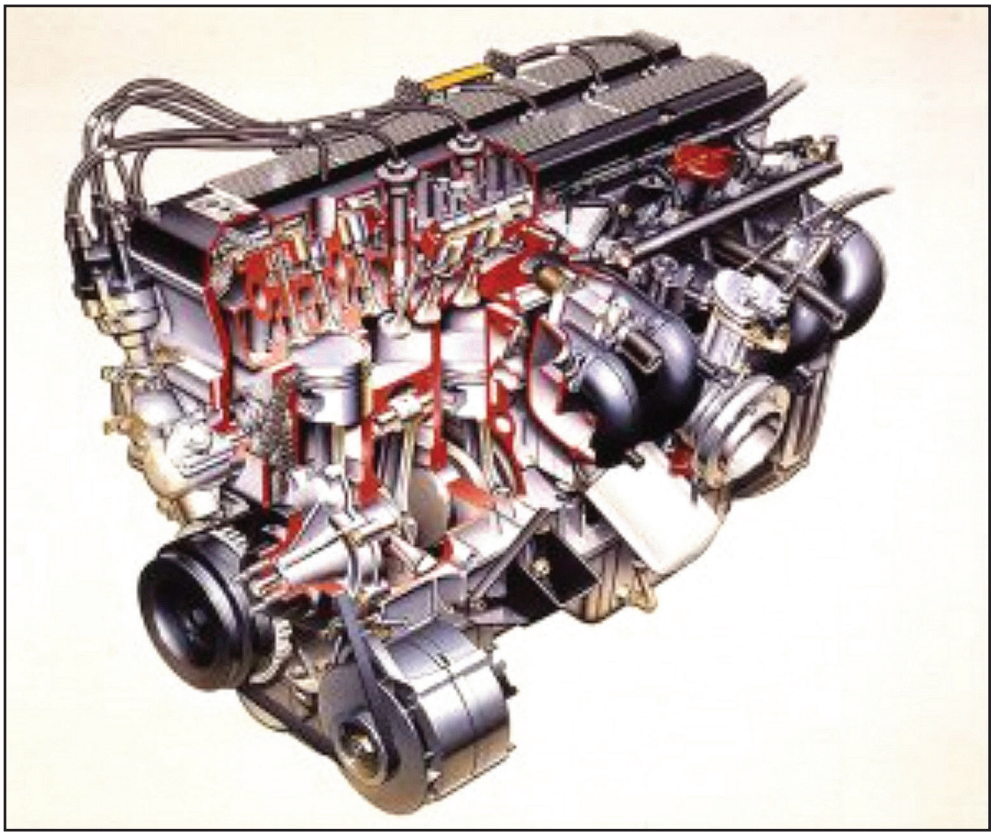
The 1984 ground breaking AJ6, used in the XJ-S and later developed into the super-refined AJ16, has become a paragon of reliability.

XJ-S - 1984 AJ6

It may not seem it today, but back in 1984 the new Jaguar AJ6 represented just as significant an advance in technology as the legendary XK and V12 power plants that came before it. Here was an all-alloy Jaguar engine with twin cams and 24 valves, at a time when Mercedes was about to revert from a twin cam eight valve back to a single cam engine, while BMWs forthcoming 24-valve design - when it did appear - would be restricted to the range-topping M5.

Continuing a Jaguar tradition, the new AJ6 engine was introduced in the relatively low volume XJ-S before its widespread use in the XJ40 saloon.

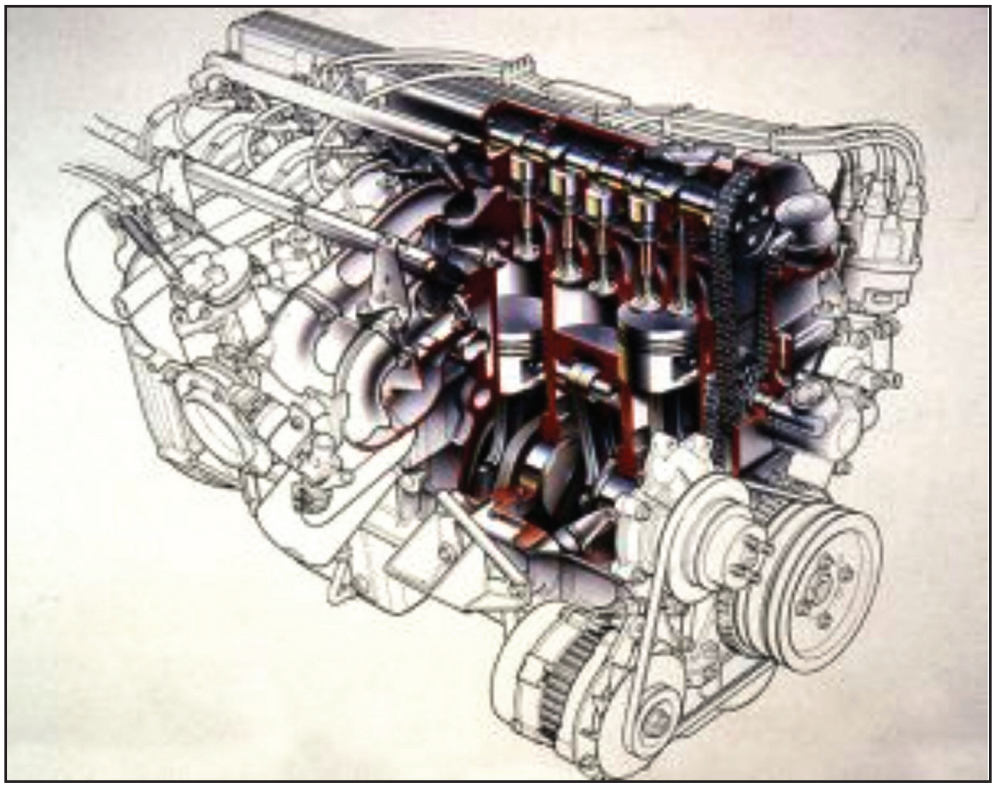
Unfortunately, long delays in the XJ40 project getting to the production stage meant the engine, when installed in the XJ-S, initially had to make do with an adapted V12 injection system and, more significantly, also cope without an automatic option, therefore limiting its appeal. There were also initial concerns in the press regarding its refinement, though these were soon allayed with new cam followers and revised camshafts, the first of many updates to occur over the next decade.



Cutaway of the 24 valve DOHC Jaguar AJ6 4.0 Litre engine

XJ40 -1986 AJ6

With the launch of the XJ40 came the AJ6 engine that Jaguar had always intended, with Lucas/Bosch microprocessor-controlled engine management, mated to a four-speed automatic transmission. A less successful offshoot was the single cam 2.9-litre engine with less power, less refinement and only marginally better fuel economy.



The 2.9 litre AJ6 engine used a SOHC head from the Jaguar V12 engine

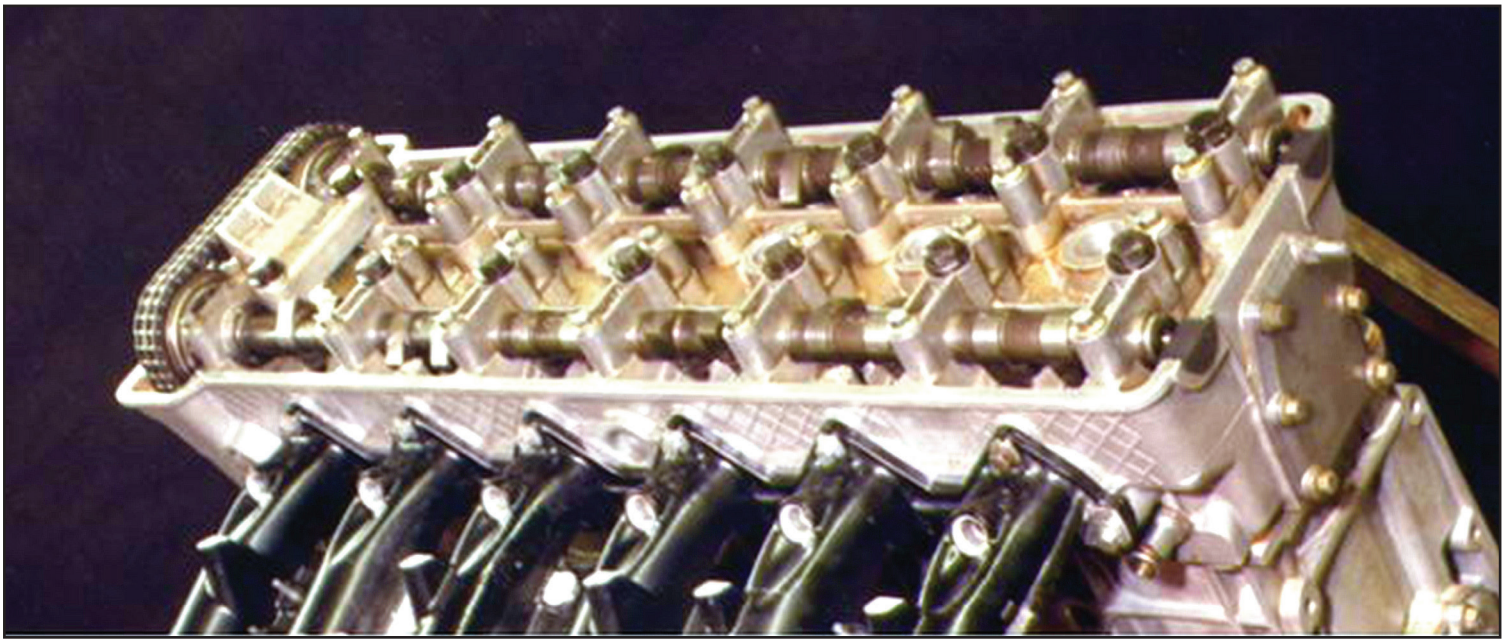
The 3.6 might have out-powered the old 4.2 XK on paper but it did trail it in low-down torque - a Jaguar hallmark - and this issue was addressed with the 4.0 AJ6 of 1990 (a new 24 valve 3.2 replaced the 2.9 a year later), which featured a new, longer stroke forged steel crank and revised pistons.

XJ-S 1994 AJ16

The AJ16 engine of 1994, again introduced in the XJ-S ahead of the saloon, was claimed by Jaguar to be entirely new.

It was, in fact, a heavily redesigned AJ6, with an almost entirely new cylinder head incorporating lighter valve gear and extra strengthening. The mechanical changes, combined with a new sequential fuel injection system, created one of the most refined six-cylinder engines on the market boosted to almost V12 levels of performance in supercharged XJR6 form.

Perhaps the most significant attribute of the AJ6/16, though, has been its sheer reliability and longevity; short of deliberate, prolonged neglect they just keep running, usually covering several



Head bolts of an AJ6 engine passing through cam bearing caps.

hundred thousand miles with nothing more serious than the odd head gasket, chain tensioner or water pump issue.

In fact, when judged in terms of maintenance cost per-mile travelled it has arguably been the best engine produced by Jaguar.

AJ6 Design History

The AJ6 engine can be thought of as almost a hybrid, owing much to both the old XK twin cam and the later V12. It actually started out as a four-valve conversion based on an updated version of the XK cylinder block but ended up as a completely fresh design using the V12 bore spacing, making possible fitment of the HE type of cylinder head to create the 2.9 to meet a perceived economy market. The direct connection to the XK was therefore broken and attention moved to use of modern techniques and materials.

Aluminium Block

Despite being cast in aluminium the AJ6 cylinder block is extremely stiff and rugged, having been designed with the possibility in mind that there might be a diesel version at some future date.

This same unfulfilled requirement was the reason for the almost square bore/stroke ratio, which of course became considerably under-square for the long stroke 4 litre and must also have influenced the decision to spread the valves at a relatively wide angle of 47 degrees.

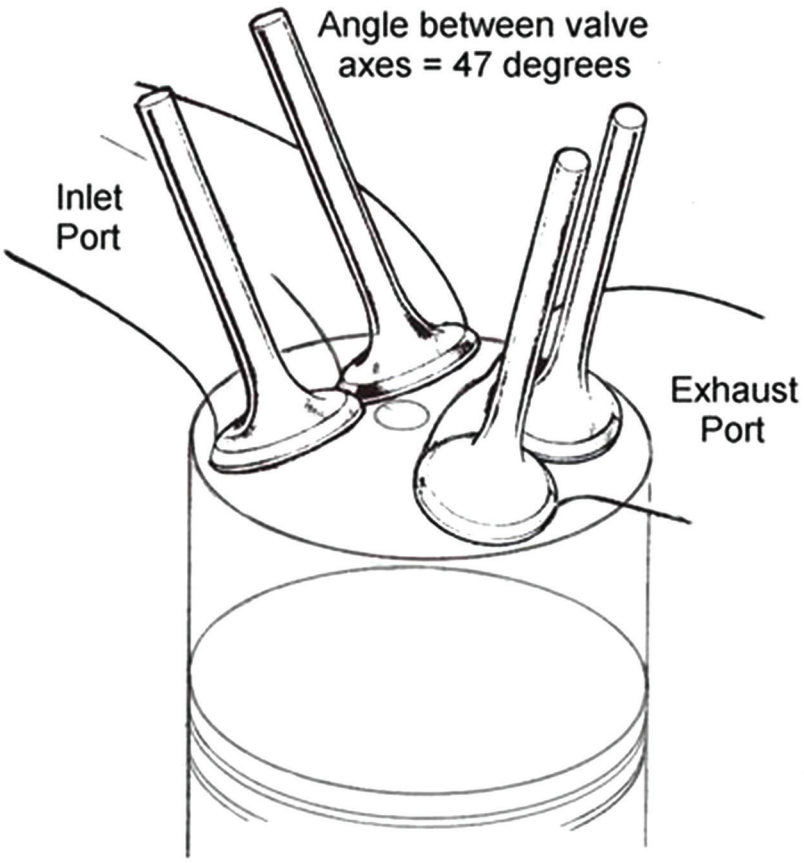
Cast Iron Cylinder Liners

Much thought was given at the time to dispensing with conventional iron lined cylinders and using either the Nikasil process of plated cylinder bores or casting in a hypereutectic, high-silicon, alloy treated to produce a hard-wearing surface.

Considering the relatively high sulphur content of fuels at the time, and subsequent related problems with other engines using Nikasil, it is perhaps fortuitous that more conventional shrink fit, centrifugally cast, iron liners were decided upon instead.

Four Valves Per Cylinder

The AJ6 engine was the first Jaguar production engine to use the four valves per cylinder layout that is now regarded



4 valve layout of an AJ6 engine

as being the best way to achieve high efficiencies of both combustion and gas flow.

The Jaguar design team had a lot of four valve experience progressing from the victorious Coventry Climax F1 V8, the Lotus 2 litre (also used in the Jensen Healey) and various four valve V12 and 6-cylinder experimental prototypes.

Angle Layout - 30 or 47 Degrees?

It is known that the ideal included angle between the valves for the four-valve layout should not exceed about 30 degrees and most racing engines are designed to be less than that. However, such a narrow valve angle means the camshafts are likely to fall almost exactly over the axes of the head bolts, so to ease assembly mass produced four valve engines sometimes use wider splayed valves than the ideal.

The angle between the valves of the AJ6 engine is 47 degrees which leaves room to bring the head bolts up just inside the camshafts and through the camshaft bearings, making them readily accessible, but at a price of complicating any repair work.

The relatively long stroke tends to alleviate any compromise of combustion efficiency from the deeper combustion chamber and combined with very efficient porting results in an engine with very good all-round performance.

General Maintenance

Even a neglected AJ6/16 will usually outlast the car in which it was fitted. But that is, of course, no justification for ignoring basic servicing, which should be carried out every 10,000 miles (16,000km) or at least once a year even with minimal use.

Replace the air filter every second service (S/C AJ16, every service) and the plugs every third.

Fuel filters should be changed every 60,000 miles (100,000km) and the belts as soon as they begin to crack or show any signs of damage.

Quite often the air-con and (where fitted) supercharger idler pulleys will require replacement at the same time as the belt.

For all its advanced features, the engine still remains relatively unstressed by modern standards and so a good quality oil such as a 10W-40 or 10W-50 synthetic oil is the preferred grade of oil for the majority of climates. However, be sure to replace the bonded steel/rubber sump washer every time the oil is changed, or there will almost certainly be a leak. The screw on oil filters used on the (later) XK, VI 2 and AJ6/16 engines are all interchangeable.

The ignition system on all but the earliest cars is ECU controlled and therefore not adjustable, but check the distributor cap carefully on AJ6 engines as they are prone to cracking internally so causing a misfire, while the plug lead boots on early cars lacked vent holes where they seal against the cam cover and can blow off should fuel vapours ignite.

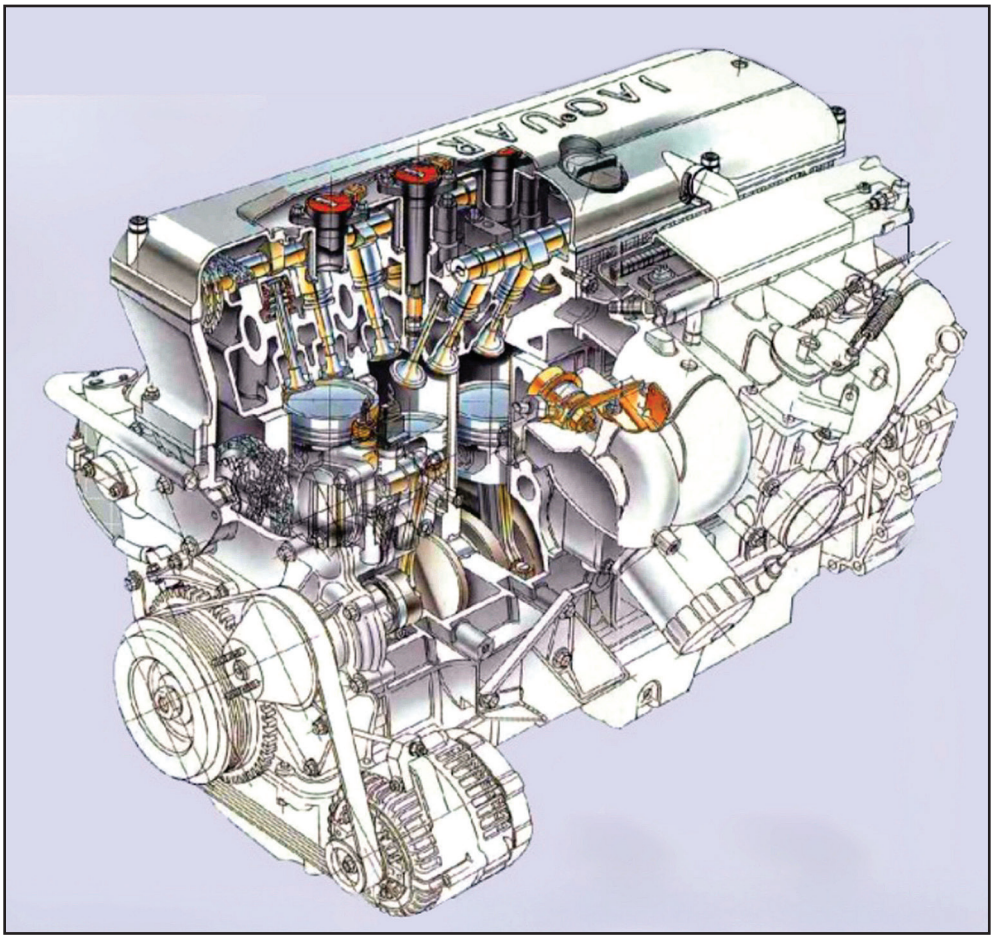
Staying with spark plugs, the supercharged 4.0 AJ16 has a tendency to foul the recommended Champion RC9YCs, causing a lumpy idle, and so for all uses other than flat out racing the Champion RCI 2YC is a much better bet.

The 2.9-litre cars inherit the V12 cylinder head, with its mesh breather at the front; if oil leaks are to be avoided the mesh should be removed regularly and cleaned.

Last, but certainly not least, remember that where oxygen sensors are fitted these are in fact consumable items, gradually falling off in accuracy after about five years, with a corresponding increase in fuel consumption.

Genuine sensors can be prohibitively expensive, but buy the exact same item in an NTK box and the price falls significantly. (Repco).

With all that aluminium, corrosion can be a problem if the correct concentration of antifreeze/inhibitor is not maintained; it often occurs where the rubber hoses contact the alloy housings, rendering items like the thermostat outlet and water pump backing plate unserviceable before any damage is visible. Check regularly the large bore hose feeding coolant from the rear of the pump to the cylinder block, as it can deteriorate unnoticed, hidden as it is under the inlet manifold.



The AJ6 eventually evolved into the AJ16 as shown here. It was called the AJ16 to reflect the major differences between it and the original AJ6. Both the 3.2 & 4.0 both featured coil-on-plug distributorless ignition, new engine management systems, magnesium alloy valve covers, revised pistons and other detail changes.

Running Repairs

Along with a leaking head gasket the most common AJ6/16 affliction is failure of the timing chain tensioners. They are operated hydraulically, but with a ratchet mechanism to allow for chain wear and ensure that tension is maintained when the engine is not running. When the ratchet fails to lock positively, the slipper (against which the chain runs) tends to chatter on start up until sufficient oil pressure has built up; causing an audible rattle, significant damage to the slipper rubber and, if ignored long enough, can allow one of the cam sprockets to skip a tooth.

The upper tensioner, mounted in the cylinder head behind the distributor/ timing sensor, can be replaced with only the cam cover removed. However, if damage to the slipper has occurred the front timing cover and sump will also have to come off, in which case the lower tensioner should also be replaced while accessible. Many upper tensioners have already been replaced, the revised design lacking the removable plug fitted to the original.

Cam cover oil leaks are quite common on AJ6 engines, especially around the spark plug recesses; a new set of rubber seals provide a cheap and easy fix, while the later AJ16 cam cover has extra fixings to help prevent the leaks in the first place.

Another common oil leak is from the blanking plate at the oil filter housing on engines where no oil cooler is fitted - the four O-rings are the same as for a Series 3 XJ and take only a few minutes to fit.

While on the subject of leaks, the AJ6 does have a reputation for blowing out exhaust manifold gaskets, a problem fixed on the AJ16 with extra mounting bolts. Both engines, however, tend to suffer from cracked exhaust manifolds, requiring replacement or the services of a skilled welder.

Though not a 'fault' as such, reduced engine vacuum as a result of general engine wear can cause the early Digital P injected XJ-S (which use vacuum to sense load) to run excessively rich — requiring the ECU to be recalibrated.

Also predominately affecting earlier cars is failure of the throttle position sensor (TPS), which can wear the potentiometer tracks in the heavily used idle/light load area and cause flat spots.

The crank angle sensors (post '86) can also fail, leaving the engine to crank without fuel or spark.

AJ16S. A supercharged version of the 4.0 litre AJ16 was released in 1994 in the X300 XJR6 which used an Eaton M90 blower to boost output to 322hp and 378 lb-ft)

Major Overhaul

While there really should be no reason ever to rebuild an AJ6/16 completely, they do suffer from the occasional blown head gasket, either between the back two cylinders (3, 6), at the oil return, or eventually along each side where the coolant passages are located.

Unless ignored for too long replacement is simply a matter of lifting the head, cleaning everything up and fitting a new gasket. Even the stripping down procedure is easier than on earlier cars as both the inlet and exhaust manifolds can be unbolted from the head and pulled to one side; lifting the head is also easier with bolts replacing the seizure prone studs formerly used by Jaguar.

With the cylinder head bolts passing through the cam bearing caps, clearance adjustment in situ, while possible, is a very complicated and time consuming.

So, if the head has to come off, it makes sense to overhaul it as well. Normally all that is needed is a thorough cleanup and lapping in of the valves (the inlets do suffer from carbon build-up), together with as light as possible a skim of the head face.

It has been found that clearances can close up slightly when the head is tensioned, however the Jaguar workshop manual states clearly that when setting the clearances the cam caps should be under no head bolt tension.

Finally, it should be mentioned that with the AJ6 engine, Jaguar almost completely did away with conventional gaskets, relying instead on rubber seals and machined surfaces sealed with jointing compound; the system works well as long as everything is spotlessly clean and good quality sealant is used. ■

Editor: Information for this article sourced from UK AJ6 Engineering and UK Jaguar World Magazine, words by Garreth Coomber.