When Jaguar needed a V6 engine, they turned to what they already had and what they already knew. Using the existing AJ133 Jaguar V8, engineers developed a V6 engine with a V8's architecture.

Although it's not at all uncommon for manufacturers to use parts interchangeably between engines or get a little outside of the box with an engine design, this particular example takes things a little bit further.

The V6 variant of this engine actually shares the exact same engine block as the V8. Instead of using the same architecture and shortening the engine block, Jaguar simply left out two cylinders at the back of the engine. It certainly makes production line interchangeability very efficient, given that it means the exact same engine mounts, transmission, and accessories fit both engines.

However, it isn't quite as simple as removing two cylinders from the engine. Let's take a look at how Jaguar made this V6 engine come to be.

A Little More Than Just Removing Two Cylinders

Obviously, you can't just take two sets of rods and pistons out of a V8 and expect it to run perfectly fine as a V6. In essence, though, that is what Jaguar did.

With the cylinder heads removed, you can see the spots where cylinder sleeves would go if it were a V8. It does look a little odd and definitely takes up more space than needed. One might assume that the extra engine block weight might be a bit annoying for chassis engineers, too, but the bigger weight penalty comes with the crankshaft.

Since the engine block remains the same length overall, the crankshaft does as well. Given that it is missing two crank pins and the accompanying throws, a pretty hefty counterweight was added to the back of the crankshaft to keep things smooth throughout the engine's operation. That, however, isn't the only modification that was made to the crankshaft to make this work.

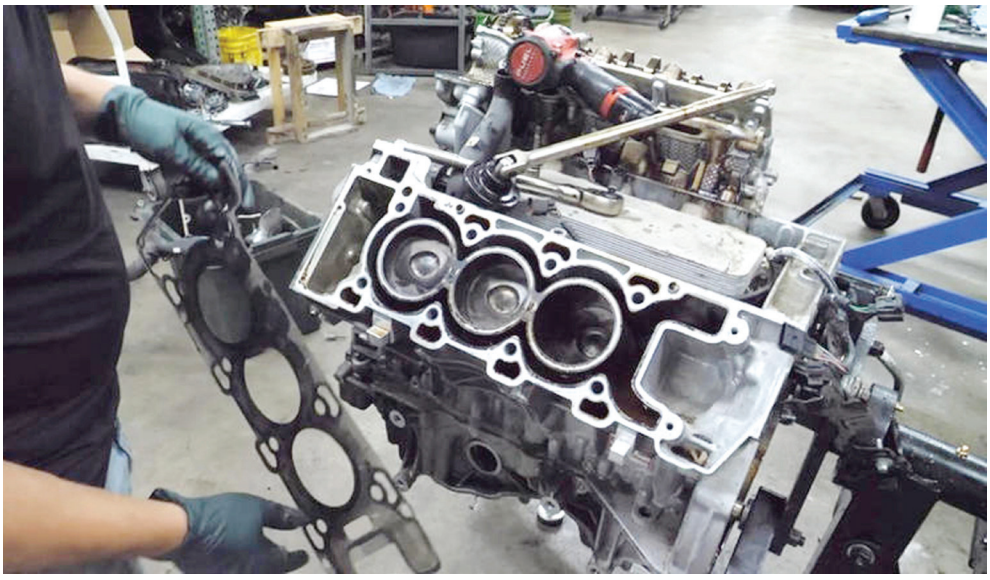
90-Degree Angle Added Complications

The vast majority of V-shaped 6-cylinder (and V12) engines use a 60-degree angle. However, the Jaguar V8 use a 90-degree angle to allow more room between the cylinder heads for the intake manifold and supercharger system.

Any V-8 engine is well balanced when its two-cylinder banks form a 90-degree V. And V-6s tend to be best off when that V is set at 60 degrees. But the explanation of why all this is true, well, that's a bit convoluted.

The forces that impact engine balance come from three sources.

1. The rotation of mass that is offset from the main bearing centre line (the mass at each crank throw and counterweight);
2. Reciprocating (up and down) forces due to the continual acceleration and deceleration of each piston assembly;
3. The firing forces in each cylinder."



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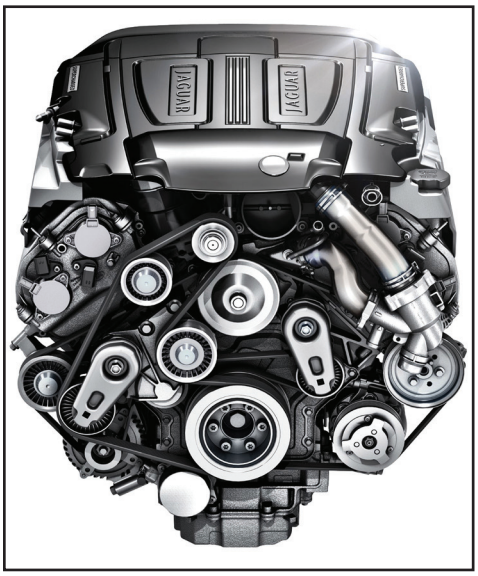


The Jaguar V6 (AJ126) as used in the XE, XF, F-Type and F-Pace. It was succeeded by the Ingenium AJ300 inline-6 engine.

The first two of these forces - rotational (1) and reciprocating (2) - can often be balanced through engine configuration, as in, for example, a 90-degree V8.

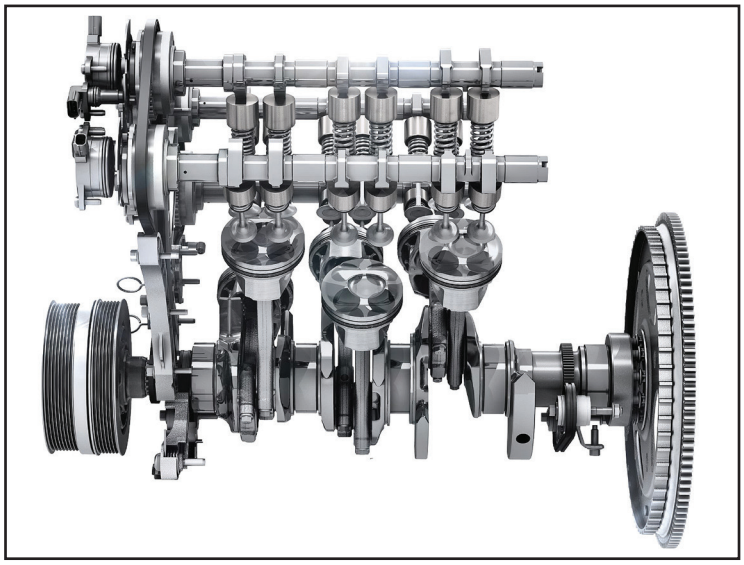
By adding a piston at a 90-degree angle (creating a 90-degree V) allows the counterweight to balance both pistons through their travel. The counterweight cancels the up-and-down motion of one piston, and 90-degrees later, cancels the motion of the other piston. The counterweight is balanced throughout its motion.

A 90-degree V-8 has balanced rotational (1) and reciprocating (2) forces because it has four balanced 90-degree Vs.

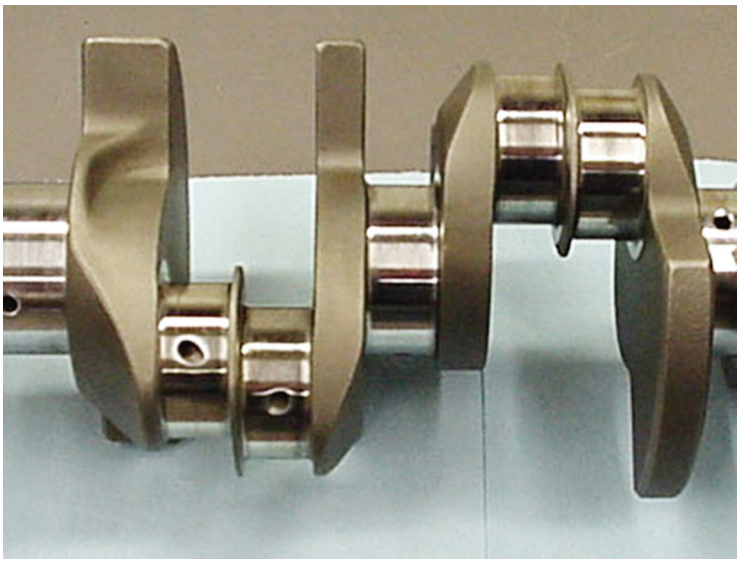
The angle of the V is critical to the third force. And there's an equation to help determine which configurations will work best.

In an engine, an individual piston fires every 720 degrees (two crankshaft rotations). If you divide that by the number of cylinders, you get a figure that represents the optimal degrees of crankshaft rotation between cylinder firings.

A V-8 fires a cylinder every time the crankshaft turns 90 degrees (720/8=90). To balance the firing force, a cylinder has to fire every time the crankshaft rotates 90 degrees. Since the bank angle is 90 degrees and the firing forces occur in 90-degree intervals, the cross-plane V-8 balances all three of the forces.



The unusually long crankshaft for a V6 allows the use of five main bearings with the redundant journal used as a balancing element. The four camshafts incorporated variable camshaft timing (VCT).



Getting around the problem of uneven firing intervals is achieved by separating adjoining connecting rod journals and offsetting them so that each cylinder fires every 120 degrees of rotation.

A 90-Degree V-6 Engine Isn't Quite as Successful.

Together with the counterweight that was added to the back of the crankshaft, the rotational (1) and reciprocating (2) forces in the Jaguar 90-degree V6 engine are balanced. However, the firing forces are not.

A V-6 fires a cylinder every time the crankshaft turns 120 degrees (720/6=120). That would imply a 120-degree angle between the banks, but that configuration is impractical for packaging reasons. The 60-degree bank angle is a good compromise for packaging, and because the firing events occur in degrees (120) that are evenly divisible by the angle of the V (60), the firing forces remain balanced.

But 90-degree V6 engines have unbalanced firing pulses because 120 isn't evenly divisible by 90. So how did Jaguar get away with 90-degree V-6?

Because of the firing imbalance, Jaguar used a special crankshaft called a "split-pin" or "split-journal" unit that mounted the big ends of the paired connecting rods to crank journals that had been split and slightly offset so that the engine could achieve 120-degree firing despite its V angle.

In addition, each end of the crankshaft has a counterweight to ensure the engine is as smooth as possible.

It certainly isn't the most practical approach to engine design that the world has seen. It is, however, functional and clever.

How Complicated is a AJ126 Engine?

Below is a link to a video of an overfilled AJ126 engine teardown. The AJ126 does not have a dipstick! Modern engines are equipped with sensors and electronic systems that monitor various parameters, including oil levels.

Although having too little oil can be catastrophic, having too much oil is just as bad, as this can create oil foaming that in turn results in the oil pump sucking air and not oil. As it is the AJ126 engine had a problem and has a structural windage tray bolted to the bottom of the cylinder block to help reduce oil foaming.

The video also demonstrates how complicated new engines are. Even though the video is sped up at times, it still takes almost an hour to strip the engine completely.

Grab a coffee and sit back and watch the teardown: *AJ126 V6 stripdown*

It makes one appreciate how simple pushrod and XJ engines are! ■

To see a V6 engine stripdown goto: AJ126 V6 stripdown

Editor: Information for this article sourced from Car & Driver (The Physics of: Engine Cylinder-Bank Angles), Motor1.com (Jaguar Engine Teardown Reveals The Dangers Of Overfilling Your Oil), SlashGear (This Strange V6 Jaguar Engine Uses A V8 Block, Here's How).